AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court Eastern District of Texas, Marshall Division on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
2:16cv00754	7/13/2016	Eastern District of Texas, Marshall Division

PLAINTIFF	DEFENDANT
NOKIA SOLUTIONS AND NETWORKS US LLC AND NOKIA SOLUTIONS AND NETWORKS OY	HUAWEI TECHNOLOGIES CO. LTD. AND HUAWEI DEVICE USA, INC.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	9,185,688	11/10/2015	Pajukoski et al.
2	9,148,877	9/29/2015	Pajukoski et al.
3	8,437,416	5/7/2013	Tiirola et al.
4			
5			

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**

Print Save As... Reset

HUAWEI 1028

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO.	: 9,148,877 B2
APPLICATION NO.	: 14/051646
DATED	: September 29, 2015
INVENTOR(S)	: Pajukoski et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the Claims

Claim 14, col. 16, line 21 “link” should be deleted and --uplink-- should be inserted.

Signed and Sealed this
Ninth Day of February, 2016

Michelle K. Lee

Michelle K. Lee
Director of the United States Patent and Trademark Office

OPAP AKKIMA-11
NOV 12 2015
PATENT & TRADEMARK OFFICE

CJC

IN THE U.S. PATENT AND TRADEMARK OFFICE

In re U.S. Patent Application of:

APPLICANT: Pajukoski et al PATENT NO. 9,148,877 B2

SERIAL NO.: 14/051,646 ART UNIT: 2477

FILED: 10/11/2013 EXAMINER: Thompson, Jr, Otis L.

TITLE: PROVIDING IMPROVED SCHEDULING REQUEST SIGNALING WITH ACK/NACK OR CQI

ATTORNEY DOCKET NO.: 863.0076.U2(US)

Customer No.: 29,683

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Attention: Certificate of Correction Branch

Request for Certificate of Correction
(Office Mistake)
35 U.S.C. §254 (37 C.F.R. §1.322)

Sir:

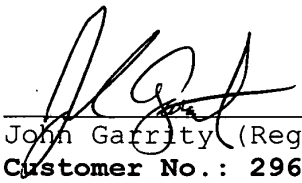
This is a request for a Certificate of Correction (MPEP 1480) in regard to the above-identified patent. Attached is a Form PTO-1050. The mistake(s), incurred through the fault of the Patent and Trademark Office, is clearly disclosed by the records of the Office as indicated by the following description:

In the claims:

Claim 14, col. 16, line 21 "link" should be deleted and --uplink-- should be inserted. Please refer to the Amendment filed on February 23, 2015. Originally claim 15; renumbered upon issue as claim 14.

The Office is requested to issue a Certificate of Correction.

Respectfully submitted,



11/4/2015

John Garrity (Reg. No. 60,470) Date

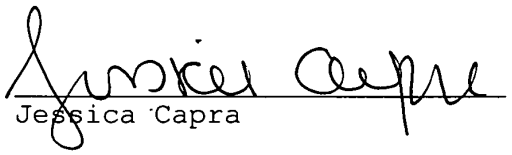
Customer No.: 29683
Harrington & Smith,
Attorneys at Law, LLC
4 Research Drive
Shelton, CT 06484-6212
203-925-9400

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail on the date shown below in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

11.4.2015

Date



Jessica Capra

PTO/SB/44 (09-07)
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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.
(Also Form PTO-1050)

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 9,148,877 B2

APPLICATION NO.: 14/051,646

ISSUE DATE : September 29, 2015

INVENTOR(S) : Pajukoski et al

It is certified that an error appears or errors appear in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Claim 14, col. 16, line 21 "link" should be deleted and --uplink-- should be inserted.

MAILING ADDRESS OF SENDER (Please do not use customer number below):

Harrington & Smith, Attorneys at Law, LLC
4 Research Drive
Shelton, CT 06484

This collection of information is required by 37 CFR 1.322, 1.323, and 1.324. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 1.0 hour to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Attention Certificate of Corrections Branch, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/051,646	09/29/2015	9148877	863.0076.U2(US)	6128

29683 7590 09/09/2015

HARRINGTON & SMITH
4 RESEARCH DRIVE, Suite 202
SHELTON, CT 06484-6212

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Nokia Solutions and Networks Oy, Espoo, FINLAND;
Kari P. Pajukoski, Oulu, FINLAND;
Esa T. Tiirola, Kempele, FINLAND;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

INFORMATION DISCLOSURE CITATION FORM FOR PATENT APPLICATION (FORM PTO-1449) (Substitute)	Docket No.: 863.0076.U2(US) Serial No. Applicant(s): Kari Pajukoski et al. Filing Date: herewith Group:

U.S. PATENT DOCUMENTS

Examiner Initials	Document Number (Number-Kind Code)	Publication Date (MM-DD-YYYY)	Name of Patentee or Applicant	Class	Sub-class
	US-2007/0133458 A1	06-14-2007	Chandra et al.	370	329
	US-2003/0228876 A1	12-11-2003	Hwang	455	522
	US-2005/0047393 A1	03-03-2005	Liu	370	352
	US-2007/0171849 A1	07-26-2007	Zhang et al.	370	310
	US-2009/0022110 A1	01-2009	Muharenovic et al.	370	336
	US-2009/0316811	12-2009	Maeda et al.	375	250
	US-2008/0316959	12-2008	Bachi et al.	370	329
	US-2009/0022135	01-2009	Papasakellariou et al.	370	344
	US-2009/0046667	02-2009	Pelletier et al.	370	335
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FOREIGN PATENT DOCUMENTS

Examiner Initials	Document Number (Country Code-Number-Kind Code)	Publication Date (MM-DD-YYYY)	Name Of Patentee of Applicant	Translation? Yes/No/n/a
Change(s) applied to document, /R.T.H./ 6/2/2015	WO ~~2007/1 547~~-A2 2007100547	09-07-2007	International Digital Technology Corporation	
	JP-2009/049578-A	03-05-2009	KDDI Corp	Abstract
	RU-2305372-C2	08-27-2007	Samsung Electronics Co., Ltd.	Abstract
	WO-2004/110081-A1	12-16-2004	Nokia Corporation	
	WO-2005/015942-A1	02-17-2005	Qualcomm Incorporated	
	WO-2007/044414-A1	04-19-2007	Inter-Digital Technology Corporation	
	WO-2007/008123-A1	01-18-2007	Telefonaktiebolaget LM Ericsson	

OTHER DOCUMENTS (Author (Capitalize), Title, Date, Pages, Etc., if known)

	"X2 downlink forwarding delay", NEC, 3GPP TSG-RAN WG2#59bis, October 2007, R2-074139, 4 pgs.
	"Multiplexing of Scheduling Request and ACK/NACK and/or CQI", Nokia Siemens Networks, 3GPP TSG RAN WG1#49bis, R1-073011, 3 pgs.
	"Handling NAS message during HO", Alcatel-Lucent, 3 GPP TSG RAN WG2 #59bis, October 2007, R2-074333, 2 pgs.
	3GPP TSG RAN WG1 #48bis, R1-071662, St. Julians, Malta, March 26-30, 2007, Nokia Siemens, "Uplink Scheduling Request for LTE", 4 pgs.

Examiner's Signature: /Otis Thompson, Jr/	Date Considered: 07/30/2014

Initial if reference was considered, whether or not citation is in conformance with MPEP. Mark through citation if not considered. Include a copy of this citation form with your next correspondence to the Applicant(s).

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /O.T./

OPAS AKIMA-18 MAY 13 2015 PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.: 14/051,646 Conf. No.: 6128
Applicant(s): Kari P. Pajukoski, et al.
Filed: October 11, 2013
Art Unit: 2477
Examiner: Thompson, Jr., Otis I.
Title: Providing Improved Scheduling Request Signalling With ACK/NACK or CQI
Attorney Docket No.: 863.0076.U2(US)
Customer No.: 29683

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Supplemental Information Disclosure Statement

(37 C.F.R. §1.97(d))

Sir:

The following information is being disclosed to the U.S. Patent and Trademark Office as information that may be material to the examination of the above-identified patent application.

Enclosed is a Form PTO1449, which lists the art not previously cited in the present U.S. patent application.

Please charge Deposit Account No. 50-1924 the petition fee under 37 C.F.R. §1.17(p) of $180.00. Applicants' Attorney hereby petitions for consideration of this Information Disclosure Statement under 37 C.F.R. §1.97(d)(2). Please charge any fee deficiency to Deposit Account No. 50-1924.

05/13/2015 ZJUHAR1 00000010 501924 14051646
01 FC:1806 180.00 DA

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /O.T./

The filing of this Statement is not to be construed as a representation that a search has been made regarding the claimed invention (37 C.F.R. §1.97(g)) or that no other possible material information exists. In addition, the filing of this Statement is not to be construed to be an admission that the information cited in the Statement is, or is considered to be, material to Patentability (37 C.F.R. §1.97(h)).

Respectfully submitted,

/John A. Garrity/ 5/8/2015

John A. Garrity (Reg. No. 60,470) Date

Customer No.: 29683
Harrington & Smith, Attorneys At Law, LLC
4 Research Drive
Shelton, CT 06484-6212
203-925-9400

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail on the date shown below in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

5/11/2015 /Elaine F. Mian/

Date Elaine F. Mian

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /O.T./

INFORMATION DISCLOSURE CITATION FORM FOR PATENT APPLICATION (FORM PTO-1449) (Substitute)	Docket No. 863.0076.U2(US) Serial No.: 14/051,646 Applicant(s): Kari P. Pajukoski, et al. Filing Date: October 11, 2013 Group: 2477

OPAP AKIMA-18 MAY 13 2015 PATENT & TRADEMARK OFFICE

U.S. PATENT DOCUMENTS

Examiner Initials	Document Number (Number-Kind Code)	Publication Date (MM-DD-YYYY)	Name of Patentee or Applicant	Class	Sub-class
	US-2009/0109908 A1	04-30-2009	Bertrand et al.	370	329
	US-7,852,883 B2	12-14-2010	Kwak et al.	370	522
	US-8,200,252 B2	06-12-2012	Lee et al.	455	458
	US-8,254,244 B2	08-28-2012	Montojo et al.	370	207
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FOREIGN PATENT DOCUMENTS

Examiner Initials	Document Number (Country Code-Number-Kind Code)	Publication Date (MM-DD-YYYY)	Name Of Patentee of Applicant	Translation? Yes/No/n/a
	EP-2 109 946-B1	05-08-2013	LG Electronics Inc.	
	EP-2 117 246-A1	11-11-2009	NTT DoCoMo, Inc.	
	WO-2004/102980-A2	11-25-2004	Motorola Inc.	
	WO-2007/081564-A2	07-19-2007	Inter-Digital Technology Corporation	
	WO-2007/130324-A2	11-15-2007	Inter-Digital Technology Corporation	
	WO-2007/130324-A3	11-15-2007	Inter-Digital Technology Corporation	
	WO-2009/022866-A1	02-19-2009	LG Electronics Inc.	

OTHER DOCUMENTS (Author (Capitalize), Title, Date, Pages, Etc., if known)

	"Data-non-associated control signal transmission without UL data", Nokia Siemens, 3GPP TSG RAN WG1 Meeting #48bis, R1-071676, Mach 2007, 6 pgs.
	"Multiplexing of Scheduling Request Indicator", Huawei, 3GPP TSG-RAN-WG1 Meeting #49bis, R1-072895, June 2007, 4 pgs.
	"Multiplexing the Scheduling Request in the Uplink", Alcatel-Lucent, 3GPP TSG-RAN WG1 #49bis, R1-073066, June 2007, 4 pgs.
	"Proposed Scheduling Request (SR) structure and multiplexing with PUCCH", LG Electronics, 3GPP TSG RAN WG1 #50, R1073485, August 2007, 6 pgs.

Examiner's Signature: /Otis Thompson, Jr/ Date Considered: 08/31/2015

Initial if reference was considered, whether or not citation is in conformance with MPEP. Mark through citation if not considered. Include a copy of this citation form with your next correspondence to the Applicant(s).

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /O.T./

Best Available Copy

FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

29683 7590 05/13/2015
HARRINGTON & SMITH
4 RESEARCH DRIVE, Suite 202
SHELTON, CT 06484-6212

OPAP ASSEMA-10 AUG 11 2015 PATENT & TRADEMARK OFFICE

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

Elaine F. Mian	(Depositor's name)
Elaine F. Mian	(Signature)
8/6/2015	(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/051,646	10/11/2013	Kari P. Pajukoski	863.0076.U2(US)	6128

TITLE OF INVENTION: PROVIDING IMPROVED SCHEDULING REQUEST SIGNALING WITH ACK/NACK OR CQI

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	08/13/2015

EXAMINER	ART UNIT	CLASS-SUBCLASS
THOMPSON, JR, OTIS L	2477	370-329000

08/12/2015 MBLANCO1 00000005 501924 14051646
01 FC:1501 960.00 DA

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
☒ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 Harrington & Smith
2
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)
PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Nokia Solutions and Networks Oy
(B) RESIDENCE: (CITY and STATE OR COUNTRY): Espoo, Finland

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☒ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
☐ A check is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☒ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number 50-1924 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
☐ Applicant certifying micro entity status. See 37 CFR 1.29
NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
☐ Applicant asserting small entity status. See 37 CFR 1.27
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
☐ Applicant changing to regular undiscounted fee status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date 7/8/2015
Typed or printed name John A Gorrie Registration No. 60,470

PTOL-85 Part B (10-13) Approved for use through 10/31/2013 OMB 0651-0033 U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

OPAP AUG 11 2015 AKIMA-10 U.S. PATENT & TRADEMARK OFFICE

PTO/SB/47 (09-06)
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"FEE ADDRESS" INDICATION FORM

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- OR -

Fax to:
571-273-6500

INSTRUCTIONS: The issue fee must have been paid for application(s) listed on this form. In addition, only an address represented by a Customer Number can be established as the fee address for maintenance fee purposes (hereafter, fee address). A fee address should be established when correspondence related to maintenance fees should be mailed to a different address than the correspondence address for the application. **When to check the first box below**: If you have a Customer Number to represent the fee address. **When to check the second box below**: If you have no Customer Number representing the desired fee address, in which case a completed Request for Customer Number (PTO/SB/125) must be attached to this form. For more information on Customer Numbers, see the Manual of Patent Examining Procedure (MPEP) § 403.

For the following listed application(s), please recognize as the "Fee Address" under the provisions of 37 CFR 1.363 the address associated with:

☑ Customer Number: 00287

OR

☐ The attached Request for Customer Number (PTO/SB/125) form.

PATENT NUMBER (if known)	APPLICATION NUMBER
	14/051,646

Completed by (check one):

☐ Applicant/Inventor

☑ Attorney or Agent of record 60,470 (Reg. No.)

☐ Assignee of record of the entire interest. See 37 CFR 3.71. Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96)

☐ Assignee recorded at Reel _____ Frame_____

Signature

John A. Garrity
Typed or printed name

203-925-9400
Requester's telephone number

8/6/2015
Date

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more that one signature is required, see below*.

☐ * Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.363. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1. 11 and 1.14. This collection is estimated to take 5 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313- 1450. DO NOT SEND COMPLETED FORMS TO THIS ADDRESS.
SEND TO: Mail Stop M Correspondence, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

OPAP AKIMA-2
JUL 13 2015
PATENT & TRADEMARK OFFICE

IN THE U.S. PATENT AND TRADEMARK OFFICE

In re U.S. Patent Application of:

APPLICANTS: Kari P. Pajukoski et al.

SERIAL NO.: 14/051,646 FILING DATE: October 11, 2013

EXAMINER: Thompson, Jr, Otis L ART UNIT: 2477

ATTORNEY'S DOCKET NO.: 863.0076.U2 (US)

TITLE: PROVIDING IMPROVED SCHEDULING REQUEST SIGNALING WITH ACK/NACK OR CQI

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

RESPONSE TO NOTICE REQUIRING
INVENTOR'S OATH OR DECLARATION

This paper is herewith filed in response to the Notice Requiring Inventor's Oath or Declaration received June 10, 2015 for the above-captioned U.S. Patent Application. This Response is submitted separate from payment of the Issue Fee.

Attached please find a copy of the Inventor's Oath or Declaration taken from PAIR as filed on November 4, 2013. As indicated in the Interview Summary below as this Inventor's Oath or Declaration is on PAIR, the Notice Requiring Inventor's Oath or Declaration appears to be in error. Still to avoid any unforeseen issues the Applicant's Representative is submitting this same Inventor's Oath or Declaration. Please accept this Response and the attached Oath or Declaration as meeting any response needed for the Notice Requiring Inventor's Oath or Declaration. The Issue Fee will be provided in a separate filing.

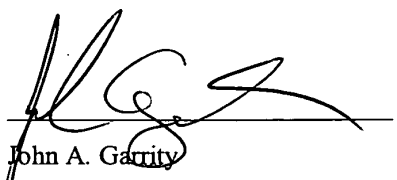
INTERVIEW SUMMARY

This Interview Summary is regarding an Applicant initiated Interview held on Thursday, June 11, 2015 and July 7, 2015 with the following attendees: Examiner Otis L. Thompson, Jr and Applicant's Representative John A. Garrity Registration No. 60,470. The Applicant's

representative contacted Examiner Thompson on June 11, 2015 regarding a Notice Requiring Inventor's Oath or Declaration that was received for the Application. The Applicant's Representative identified that the Oath or Declaration for the Application was filed as shown on PAIR and dated November 4, 2013. The Examiner indicated that the Oath or Declaration on PAIR looked correct and that the Notice Requiring Inventor's Oath or Declaration was apparently incorrect. The Examiner said that he would notify the department responsible, and for us to check back in 7-10 business days to confirm the Notice Requiring Inventor's Oath or Declaration was removed. On July 7, 2015 the Applicant's Representative called the Examiner back regarding the Notice Requiring Inventor's Oath or Declaration. The Applicant's Representative indicated to the Examiner that the Notice Requiring Inventor's Oath or Declaration was no longer showing on PAIR. The Applicant's Representative asked the Examiner to confirm that the Notice Requiring Inventor's Oath or Declaration for the Application was no longer pending such that there was no longer a required Response to the Notice. The Examiner confirmed that the Notice Requiring Inventor's Oath or Declaration was no longer on PAIR, and the Examiner again indicated that the Inventor's Oath or Declaration filed November 4, 2013 looked correct. Still in this Response the Inventor's Oath or Declaration filed November 4, 2013 is again provided to the USPTO in response to the Notice Requiring Inventor's Oath or Declaration. The Examiner is sincerely thanked for his time and efforts in this regard. This Response is seen to be a complete Response to any PTOL 214 or other form associated with this Interview.

If any issues remain please feel free to contact the Applicant's Representative at the number below.

Respectfully submitted:



7/7/2015

John A. Garrity Date

Reg. No.: 60,470 Customer No.: 29,683

HARRINGTON & SMITH ATTORNEYS AT LAW, LLC

4 Research Drive, Shelton, CT 06484-6212

Telephone: (203)925-9400 Facsimile: (203)944-0245 email: jgarrity@hspatent.com

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to: Commissioner for Patents, P.O. BOX 1450, Alexandria, VA 22313-1450.

7/7/2015 Elaine F. Mion

Date Name of Person Making Deposit

Best Available Copy

OPAP AKIMA-16 NOV 04 2013 CANCELLED PATENT & TRADEMARK OFFICE

OPAP AKIMA-2 JUL 13 2015 PATENT & TRADEMARK OFFICE

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter, which is claimed and for which a patent is sought on the invention entitled:

PROVIDING IMPROVED SCHEDULING REQUEST SIGNALING WITH ACK/NACK OR CQI

the specification of which:

(check one) ☐ is attached hereto.

☒ was filed on **11.10.2013** as U.S. Application Serial No. **14/051,646**, and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to the patentability of this application as defined in Title 37, Code of Federal Regulations, §1.56

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate(s) listed below and have also identified below any foreign application(s) for patent or inventor's certificate(s) having a filing date before that of the application on which priority is claimed:

Prior foreign applications			Priority Claimed	
(Number)	(Country)	(Day Month Year Filed)	☐ Yes	☐ No

Best Available Copy

I hereby claim the benefit under Title 35, United States Code, §119(e) of the United States provisional patent application(s) listed below:

61/001,207	30.10.2007
(Application Serial No.)	(Filing Date)

I hereby claim benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

12/290,547	30.10.2008	Pending
(Application Serial No.)	(Filing Date)	(Status)

POWER OF ATTORNEY: As a named inventor I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the U.S. Patent and Trademark Office connected therewith:

And all attorneys or agents associated with Customer No.: **29,683**

Harrington & Smith, Attorneys at Law, LLC.
4 Research Drive Shelton, Connecticut 06484-6212 UNITED STATES OF AMERICA
Telephone: +1 203 925 9400 and Facsimile +1 203 944 0245

Or

Customer No. 29,683

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Best Available Copy

Authorization To Permit Access To Application by Participating Offices

☒ The undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the above-identified patent application is filed access to the above-identified patent application. See 37 CFR 1.14(c) and (h).

This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the above-identified patent application is filed to have access to the above-identified patent application. In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the above-identified patent application with respect to: 1) the above-identified patent application-as-filed; 2) any foreign application to which the above-identified patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the above-identified patent application; and 3) any U.S. application-as-filed from which benefit is sought in the above-identified patent application. In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing the Authorization to Permit Access to Application by Participating Offices.

Best Available Copy

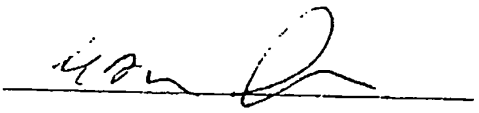
(1) FULL NAME OF INVENTOR:

LAST NAME:	**Pajukoski**
FIRST NAME	**Kari Pekka**
RESIDENCE:	
CITY:	**Oulu,**
STATE OR COUNTRY:	**FINLAND**
CITIZENSHIP:	**FI**
POST OFFICE ADDRESS:	**Purantie 3,** **90240 Oulu,** **FINLAND**

Signature _____ Date _____

(2) FULL NAME OF INVENTOR:

LAST NAME:	**Tiirola**
FIRST NAME	**Esa Tapani**
RESIDENCE:	
CITY:	**Kempele,**
STATE OR COUNTRY:	**FINLAND**
CITIZENSHIP:	**FI**
POST OFFICE ADDRESS:	**Porttikellonkuja 12, 90450 Kempele, FINLAND**

Signature  Date 15.10.2013

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

29683 7590 05/13/2015

HARRINGTON & SMITH
4 RESEARCH DRIVE, Suite 202
SHELTON, CT 06484-6212

EXAMINER
THOMPSON, JR, OTIS L

ART UNIT	PAPER NUMBER
2477	

DATE MAILED: 05/13/2015

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/051,646	10/11/2013	Kari P. Pajukoski	863.0076.U2(US)	6128

TITLE OF INVENTION: PROVIDING IMPROVED SCHEDULING REQUEST SIGNALING WITH ACK/NACK OR CQI

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	08/13/2015

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

29683 7590 05/13/2015
HARRINGTON & SMITH
4 RESEARCH DRIVE, Suite 202
SHELTON, CT 06484-6212

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/051,646	10/11/2013	Kari P. Pajukoski	863.0076.U2(US)	6128

TITLE OF INVENTION: PROVIDING IMPROVED SCHEDULING REQUEST SIGNALING WITH ACK/NACK OR CQI

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	08/13/2015

EXAMINER	ART UNIT	CLASS-SUBCLASS
THOMPSON, JR, OTIS L	2477	370-329000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
❑ Issue Fee
❑ Publication Fee (No small entity discount permitted)
❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): (**Please first reapply any previously paid issue fee shown above**)
❑ A check is enclosed.
❑ Payment by credit card. Form PTO-2038 is attached.
❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
❑ Applicant certifying micro entity status. See 37 CFR 1.29
NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
❑ Applicant asserting small entity status. See 37 CFR 1.27
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
❑ Applicant changing to regular undiscounted fee status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/051,646	10/11/2013	Kari P. Pajukoski	863.0076.U2(US)	6128

29683 7590 05/13/2015

HARRINGTON & SMITH
4 RESEARCH DRIVE, Suite 202
SHELTON, CT 06484-6212

EXAMINER	
THOMPSON, JR, OTIS L	

ART UNIT	PAPER NUMBER
2477	

DATE MAILED: 05/13/2015

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

Notice Requiring Inventor's Oath or Declaration	Application No. 14/051,646	Applicant(s) Kari P. Pajukoski	
	Examiner THOMPSON, JR, OTIS L	Art Unit 2477	

This notice is an attachment to the Notice of Allowability (PTOL-37), or the Notice of Allowability For A Design Application (PTOL-37D).

An inventor's oath or declaration in compliance with 37 CFR 1.63 or 1.64 executed by or with respect to each inventor has not yet been submitted.

An oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each inventor (for any inventor for which a compliant oath, declaration, or substitute statement has not yet been submitted) MUST be filed no later than the date on which the issue fee is paid. See 35 U.S.C. 115(f). Failure to timely comply will result in ABANDONMENT of this application.

A properly executed inventor's oath to declaration has not been received for the following inventor(s):

If applicant previously filed one or more oaths, declarations, or substitute statements, applicant may have received an informational notice regarding deficiencies therein.

The following deficiencies are noted:

INFORMAL ACTION PROBLEMS

- A properly executed inventor's oath or declaration has not been received for the following inventor(s): **Kari P. Pajukoski** and **Esa T. Tiirola**.
  Applicant may submit the inventor's oath or declaration at any time before the Notice of Allowance and Fee(s) Due, PTOL-85, is mailed.

Questions relating to this Notice should be directed to the Application Assistance Unit at 571-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 14/051,646	Applicant(s) PAJUKOSKI ET AL.	
	Examiner OTIS L. THOMPSON, JR	Art Unit 2477	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *communications filed 2/23/2015*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-7,9-24,35,36,38-43,45,46 and 50-61 (Renumbered 1-45 respectively)*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☒ Examiner's Amendment/Comment
6. ☒ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/OTIS L THOMPSON, JR/
Primary Examiner, Art Unit 2477

1. The present application is being examined under the pre-AIA first to invent provisions.

DETAILED ACTION

EXAMINER'S AMENDMENT

1. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with John Garrity, Reg. No. 60,470 on May 11, 2015.

The application has been amended as follows:

In the Claims:

7. (Currently Amended) The method of claim 1, where the unmodulated sequence comprises reference signals and the acknowledgement data [[is]] comprises a BPSK/QPSK modulated sequence.

19. (Currently Amended) The apparatus of claim 16, where the [[the]] acknowledgment with the scheduling request is transmitted on a physical uplink control channel.

21. (Currently Amended) The apparatus of claim 15, where the unmodulated sequence comprises reference signals and the acknowledgement data [[is]] comprises a BPSK/QPSK modulated sequence.

35. (Currently Amended) A method comprising:

receiving information on a scheduling resource on a physical uplink control channel; and

determining that the information received on the scheduling resource comprises an acknowledgment transmission, where the acknowledgement transmission comprises an unmodulated sequence in addition to acknowledgement data, and where the acknowledgment transmission is communicated on the scheduling resource if there is also a scheduling request combined with the acknowledgment transmission on the scheduling resource, else the acknowledgment transmission is communicated on another resource.

37. (Cancelled)

39. (Currently Amended) The method of claim [[31]]35 where the information is received from an evolved universal terrestrial radio access network.

40. (Currently Amended) A non-transitory computer readable medium encoded with a computer program executable by a processor to perform actions comprising:

receiving information on a scheduling resource on a physical uplink control channel; and

determining that the information received on the scheduling resource comprises an acknowledgment transmission, where the transmission comprises an unmodulated sequence in addition to acknowledgement data, and where the acknowledgment transmission is communicated on the scheduling resource if there is also a scheduling request combined with the acknowledgment transmission on the scheduling resource, else the acknowledgment transmission is communicated on another resource.

42. (Currently Amended) An apparatus comprising:

at least one processor; and

at least one memory including computer program code, where the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to at least:

receive information on a scheduling resource on a physical uplink control channel; and

determine that the information received on the scheduling resource comprises an acknowledgment data transmission, where the acknowledgement data transmission comprises an unmodulated sequence in addition to acknowledgment data, and where the acknowledgment data transmission is communicated on the scheduling resource if there is also a scheduling request combined with the acknowledgment data transmission on the scheduling resource, else the acknowledgment data transmission is communicated on another resource.

43. (Currently Amended) The apparatus of claim 42, where the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to respond accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment data transmission.

44. (Cancelled)

Allowable Subject Matter

2. Claims 1-7, 9-24, 35, 36, 38-43, 45, 46, and 50-61 are allowed (Renumbered 1-45 respectively).

3. The following is an examiner's statement of reasons for allowance: the prior art does not teach or adequately suggest an unmodulated sequence in addition to acknowledgement data being sent on a physical uplink control channel.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to OTIS L. THOMPSON, JR whose telephone number is (571)270-1953. The examiner can normally be reached on Monday to Thursday 7:30 am to 5:00 pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chirag Shah can be reached on (571)272-3144. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/OTIS L THOMPSON, JR/
Primary Examiner, Art Unit 2477
May 11, 2015

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14051646	PAJUKOSKI ET AL.
	Examiner	Art Unit
	OTIS L THOMPSON, JR	2477

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
370	310-350 with text in EAST	7/30/2014	OT

SEARCH NOTES		
Search Notes	Date	Examiner
Double Patenting Search	7/30/2014	OT
EAST Text Search	7/30/2014	OT
Prior art consideration from parent case	7/30/2014	OT
EAST Text Search	4/13/2015	OT
EAST Text Search	4/28/2015	OT
EAST Text Search	5/6/2015	OT
Interference Text Search	5/11/2015	OT
Double Patenting Search	5/11/2015	OT

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
H04W72	0413 with text in EAST	5/11/2015	OT

	/OTIS L THOMPSON, JR/ Primary Examiner.Art Unit 2477

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14051646	PAJUKOSKI ET AL.
	Examiner	Art Unit
	OTIS L THOMPSON, JR	2477

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/30/2014	05/11/2015							
1	1	✓	=							
2	2	✓	=							
3	3	✓	=							
4	4	✓	=							
5	5	✓	=							
6	6	✓	=							
7	7	✓	=							
	8	✓	-							
8	9	✓	=							
9	10	✓	=							
10	11	✓	=							
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12	13	✓	=							
13	14	✓	=							
14	15	✓	=							
15	16	✓	=							
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	29	✓	-							
	30	✓	-							
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	32	✓	-							
	33	✓	-							
	34	✓	-							
24	35	✓	=							
25	36	✓	=							

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14051646	PAJUKOSKI ET AL.
	Examiner	Art Unit
	OTIS L THOMPSON, JR	2477

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
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26	38	✓	=							
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Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14051646	PAJUKOSKI ET AL.
	Examiner	**Art Unit**
	OTIS L THOMPSON, JR	2477

CPC						
Symbol					**Type**	**Version**
H04W		72	/	0413	F	2013-01-01
H04L		1	/	0025	I	2013-01-01
H04L		1	/	0026	I	2013-01-01
H04L		1	/	1671	I	2013-01-01
H04W		28	/	06	A	2013-01-01
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CPC Combination Sets							
Symbol				**Type**	**Set**	**Ranking**	**Version**
			/				
			/				

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	45	
/OTIS L THOMPSON, JR/ Primary Examiner.Art Unit 2477	05/11/2015	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	8

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14051646	PAJUKOSKI ET AL.
	Examiner	Art Unit
	OTIS L THOMPSON, JR	2477

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION									
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED				
		H	0	4	W	4 / 00 (2009.01.01)					
CROSS REFERENCE(S)											
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)										

NONE (Assistant Examiner) (Date)	Total Claims Allowed: 45	
/OTIS L THOMPSON, JR/ Primary Examiner.Art Unit 2477 05/11/2015 (Primary Examiner) (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 8

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14051646	PAJUKOSKI ET AL.
	Examiner	**Art Unit**
	OTIS L THOMPSON, JR	2477

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
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14	15	-	31	-	47										
15	16	-	32	-	48										

NONE (Assistant Examiner)	(Date)	**Total Claims Allowed:** 45	
/OTIS L THOMPSON, JR/ Primary Examiner.Art Unit 2477 (Primary Examiner)	05/11/2015 (Date)	O.G. Print Claim(s) 1	O.G. Print Figure 8

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	241	((Kari) near2 (Pajukoski)).INV.	US-PGPUB; USPAT; USOCR	ADJ	ON	2015/05/11 10:31
L2	272	((Esa) near2 (Tiirola)).INV.	US-PGPUB; USPAT; USOCR	ADJ	ON	2015/05/11 10:31
L3	302	l1 or l2	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/05/11 10:31
L4	4	l3 and unmodulat$3.clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/05/11 10:31
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S96	60	pucch same (ack or acknowledg$5 or reply$3 or response or respond$3 or nack or negative acknowledg$5) same (unmodulat$3 or un modulat$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/04/13 11:18
S97	2308	pucch same (ack or acknowledg$5 or reply$3 or response or respond$3 or nack or negative acknowledg$5) same schedul$3 request	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/04/13 11:20
S98	394	pucch same (ack or acknowledg$5 or reply$3 or response or respond$3 or nack or negative acknowledg$5) same schedul$3 request same modulat$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/04/13 11:22
S99	4	pucch same (ack or acknowledg$5 or reply$3 or response or respond$3 or nack or negative acknowledg$5) same schedul$3 request same modulat$3 with (need$3 or necessity or necessar$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/04/13 11:23
S100	46	pucch same (ack or acknowledg$5 or reply$3 or response or respond$3 or	US-PGPUB; USPAT;	ADJ	ON	2015/04/13 11:24

		nack or negative acknowledg$5) same modulat$3 with (need$3 or necessity or necessar$3)	USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			
S101	1526	pucch same (ack or acknowledg$5 or reply$3 or response or respond$3 or nack or negative acknowledg$5) same $5modulat$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/04/13 11:26
S102	2787	(ack or acknowledg$5 or reply$3 or response or respond$3) same unmodulat$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/04/28 13:47
S103	57	(ack or acknowledg$5 or reply$3 or response or respond$3) same unmodulat$3 same (schedul$3 request$3 or sr)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/04/28 13:49
S104	241	((Kari) near2 (Pajukoski)).INV.	US-PGPUB; USPAT; USOCR	ADJ	ON	2015/04/28 14:05
S105	272	((Esa) near2 (Tiirola)).INV.	US-PGPUB; USPAT; USOCR	ADJ	ON	2015/04/28 14:06
S106	4	(S104 or S105) and unmodulat$3.clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/04/28 14:06
S107	2	("8638729").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2015/04/28 14:07
S109	726	(sr or schedul$ request$3) with (ack or nack or acknowledg$5 or reply$3 or response or resopnd$3) with (combin$5 or merg$3 or together or group$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/05/06 09:36
S110	140	S109 same pucch	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/05/06 09:36
S111	37	S110 same $3modulat$3	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/05/06 09:36
S112	165	pucch same (unmodulat$3 or un modulat$3 or nonmodulat$3 or non	US-PGPUB; USPAT;	ADJ	ON	2015/05/06 09:40

		modulat$3)	USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB			
S113	143	S112 same (ack or nack or acknowledg$5 or reply$3 or response or resopnd$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/05/06 09:41
S114	1248	(unmodulat$3 or un modulat$3 or nonmodulat$3 or non modulat$3) with (ack or nack or acknowledg$5 or reply$3 or response or resopnd$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/05/06 09:50
S115	116	S114 same (sr or schedul$3 request)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2015/05/06 10:00

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
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L6	71	((Kari) near2 (Pajukoski)).INV.	USPAT; UPAD	ADJ	ON	2015/05/11 10:35
L7	87	l5 or l6	USPAT; UPAD	ADJ	ON	2015/05/11 10:35
L8	917	H04w72/0413.cpc.	USPAT; UPAD	ADJ	ON	2015/05/11 10:35
L9	1	l8 and acknowledg$5.clm. and unmodulat$3.clm.	USPAT; UPAD	ADJ	ON	2015/05/11 10:36
L10	1	l8 and unmodulat$3.clm.	USPAT; UPAD	ADJ	ON	2015/05/11 10:36
L11	1337	unmodulat$3.clm.	USPAT; UPAD	ADJ	ON	2015/05/11 10:36
L12	11	acknowledg$5.clm. and unmodulat$3.clm.	USPAT; UPAD	ADJ	ON	2015/05/11 10:36
L13	3	acknowledg$5.clm. and unmodulat$3.clm. and schedul$3.clm.	USPAT; UPAD	ADJ	ON	2015/05/11 10:36

5/11/2015 11:06:39 AM
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OPAP AKIMA-18 MAY 13 2015 PATENT & TRADEMARK OFFICE

DFU

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.: 14/051,646 Conf. No.: 6128
Applicant(s): Kari P. Pajukoski, et al.
Filed: October 11, 2013
Art Unit: 2477
Examiner: Thompson, Jr., Otis I.
Title: Providing Improved Scheduling Request Signalling With ACK/NACK or CQI
Attorney Docket No.: 863.0076.U2(US)
Customer No.: 29683

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Supplemental Information Disclosure Statement

(37 C.F.R. §1.97(d))

Sir:

The following information is being disclosed to the U.S. Patent and Trademark Office as information that may be material to the examination of the above-identified patent application.

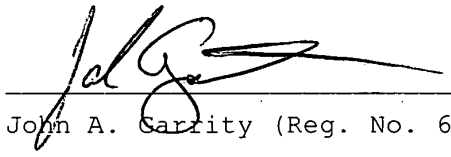
Enclosed is a Form PTO1449, which lists the art not previously cited in the present U.S. patent application.

Please charge Deposit Account No. 50-1924 the petition fee under 37 C.F.R. §1.17(p) of $180.00. Applicants' Attorney hereby petitions for consideration of this Information Disclosure Statement under 37 C.F.R. §1.97(d)(2). Please charge any fee deficiency to Deposit Account No. 50-1924.

05/13/2015 ZJUHAR1 00000010 501924 14051646
01 FC:1806 180.00 DA

The filing of this Statement is not to be construed as a representation that a search has been made regarding the claimed invention (37 C.F.R. §1.97(g)) or that no other possible material information exists. In addition, the filing of this Statement is not to be construed to be an admission that the information cited in the Statement is, or is considered to be, material to Patentability (37 C.F.R. §1.97(h)).

Respectfully submitted,



5/8/2015

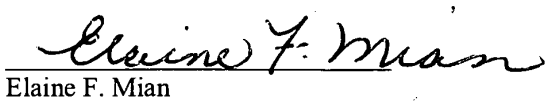
John A. Garrity (Reg. No. 60,470) Date

Customer No.: 29683
Harrington & Smith, Attorneys At Law, LLC
4 Research Drive
Shelton, CT 06484-6212
203-925-9400

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail on the date shown below in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

5/11/2015
Date



Elaine F. Mian

INFORMATION DISCLOSURE CITATION FORM FOR PATENT APPLICATION (FORM PTO-1449) (Substitute)	Docket No. 863.0076.U2(US)	Serial No.: 14/051,646
	Applicant(s): Kari P. Pajukoski, et al.	
	Filing Date: October 11, 2013	Group: 2477

OPAP ASKMA-18 MAY 1 3 2015 PATENT & TRADEMARK OFFICE

U.S. PATENT DOCUMENTS

Examiner Initials	Document Number (Number-Kind Code)	Publication Date (MM-DD-YYYY)	Name of Patentee or Applicant	Class	Sub-class
	US-2009/0109908 A1	04-30-2009	Bertrand et al.	370	329
	US-7,852,883 B2	12-14-2010	Kwak et al.	370	522
	US-8,200,252 B2	06-12-2012	Lee et al.	455	458
	US-8,254,244 B2	08-28-2012	Montojo et al.	370	207
	US-				
	US-				
	US-				
	US-				
	US-				
	US-				
	US-				
	US-				
	US-				
	US-				
	US-				
	US-				

FOREIGN PATENT DOCUMENTS

Examiner Initials	Document Number (Country Code-Number-Kind Code)	Publication Date (MM-DD-YYYY)	Name Of Patentee of Applicant	Translation? Yes/No/n/a
	EP-2 109 946-B1	05-08-2013	LG Electronics Inc.	
	EP-2 117 246-A1	11-11-2009	NTT DoCoMo, Inc.	
	WO-2004/102980-A2	11-25-2004	Motorola Inc.	
	WO-2007/081564-A2	07-19-2007	Inter-Digital Technology Corporation	
	WO-2007/130324-A2	11-15-2007	Inter-Digital Technology Corporation	
	WO-2007/130324-A3	11-15-2007	Inter-Digital Technology Corporation	
	WO-2009/022866-A1	02-19-2009	LG Electronics Inc.	

OTHER DOCUMENTS (Author (Capitalize), Title, Date, Pages, Etc., if known)

	"Data-non-associated control signal transmission without UL data", Nokia Siemens, 3GPP TSG RAN WG1 Meeting #48bis, R1-071676, Mach 2007, 6 pgs.
	"Multiplexing of Scheduling Request Indicator", Huawei, 3GPP TSG-RAN-WG1 Meeting #49bis, R1-072895, June 2007, 4 pgs.
	"Multiplexing the Scheduling Request in the Uplink", Alcatel-Lucent, 3GPP TSG-RAN WG1 #49bis, R1-073066, June 2007, 4 pgs.
	"Proposed Scheduling Request (SR) structure and multiplexing with PUCCH", LG Electronics, 3GPP TSG RAN WG1 #50, R1073485, August 2007, 6 pgs.

Examiner's Signature:	Date Considered:

Initial if reference was considered, whether or not citation is in conformance with MPEP. Mark through citation if not considered. Include a copy of this citation form with your next correspondence to the Applicant(s).

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 109 946 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
08.05.2013 Bulletin 2013/19

(21) Application number: **08793104.4**

(22) Date of filing: **07.08.2008**

(51) Int Cl.:
H04L 1/18 *(2006.01)*

(86) International application number:
PCT/KR2008/004590

(87) International publication number:
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(54) **METHOD OF TRANSMITTING UPLINK CONTROL SIGNALS IN WIRELESS COMMUNICATION SYSTEM**

VERFAHREN ZUR ÜBERTRAGUNG VON AUFWÄRTSSTEUERUNGSSIGNALEN IN EINER DRAHTLOSEN KOMMUNIKATIONSANORDNUNG

PROCÉDÉ DE TRANSMISSION DE SIGNAUX DE COMMANDE DE LIAISON MONTANTE DANS UN SYSTÈME DE COMMUNICATION SANS FIL

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Description

Technical Field

[0001] The present invention relates to wireless communications, and more particularly, to a method of transmitting uplink control signals in a wireless communication system.

Background Art

[0002] In order to maximize efficiency of a limited radio resource in a wideband wireless communication system, methods for more effectively transmitting data in time, spatial, and frequency domains have been provided.

[0003] Orthogonal frequency division multiplexing (OFDM) uses a plurality of orthogonal subcarriers. Further, the OFDM uses an orthogonality between inverse fast Fourier transform (IFFT) and fast Fourier transform (FFT). A transmitter transmits data by performing IFFT. A receiver restores original data by performing FFT on a received signal. The transmitter uses IFFT to combine the plurality of subcarriers, and the receiver uses FFT to split the plurality of subcarriers. According to the OFDM, complexity of the receiver can be reduced in a frequency selective fading environment of a broadband channel, and spectral efficiency can be increased when selective scheduling is performed in a frequency domain by using a channel characteristic which is different from one subcarrier to another. Orthogonal frequency division multiple access (OFDMA) is an OFDM-based multiple access scheme. According to the OFDMA, efficiency of radio resources can be increased by allocating different subcarriers to multiple users.

[0004] To maximize efficiency in the spatial domain, the OFDM/OFDMA-based system uses a multiple-antenna technique which is used as a suitable technique for high-speed multimedia data transmission by generating a plurality of time/frequency domains in the spatial domain. The OFDM/OFDMA-based system also uses a channel coding scheme for effective use of resources in the time domain, a scheduling scheme which uses a channel selective characteristic of a plurality of users, a hybrid automatic repeat request (HARQ) scheme suitable for packet data transmission, etc.

[0005] In order to implement various transmission or reception methods to achieve high-speed packet transmission, transmission of a control signal on the time, spatial, and frequency domains is an essential and indispensable factor. A channel for transmitting the control signal is referred to as a control channel. An uplink control signal may be various such as an acknowledgement (ACK)/negative-acknowledgement (NACK) signal as a response for downlink data transmission, a channel quality indicator (CQI) indicating downlink channel quality, a precoding matrix index (PMI), a rank indicator (RI), etc.

[0006] One example of the uplink control signal is a scheduling request. The scheduling request is used when a user equipment (UE) requests a base station (BS) to allocate an uplink radio resource. The scheduling request is a sort of preliminary information exchange for data exchange. In order for the UE to transmit uplink data to the BS, radio resource allocation is first requested by using the scheduling request. When the BS allocates the uplink radio resource in response to the scheduling request, the UE transmits the uplink data by using the allocated radio resource.

[0007] Compatibility with another control channel for transmitting another control signal has to be taken into consideration when the scheduling request needs to be transmitted on an uplink control channel. UE capacity capable of transmitting the scheduling request has to be also taken into consideration. A case where the scheduling request is transmitted simultaneously with other control signals has to be also taken into consideration. For example, the scheduling request and ACK/NACK signals may be simultaneously transmitted by one UE.

[0008] Accordingly, there is a need for a control channel having an effective structure for simultaneously transmitting a scheduling request and other control signals.

[0009] The 3GPP draft R1-073066 relates to "Multiplexing the scheduling request in the uplink" and the 3GPP draft R1-073011 relates to "Multiplexing of scheduling request and ACK/NACK and/or CQI".

Disclosure of Invention

Technical Problem

[0010] The present invention provides a method of transmitting a plurality of multiplexed uplink control signals.

[0011] The present invention also provides a method of transmitting a scheduling request for requesting uplink radio resource allocation together with other control signals through one uplink control channel.

Technical Solution

[0012] Some aspects of the invention are provided in claims 1, 13 and 15.

[0013] In an aspect, a method of transmitting uplink control signals in a wireless communication system as claimed

in claim 1 is provided channel in one subframe, and when both the ACK/NACK signal and the scheduling request are transmitted in same subframe, transmitting the ACK/NACK signal on the uplink control channel which is configured by the scheduling request resource for the positive transmission of the scheduling request and transmitting the ACK/NACK signal on the uplink control channel which is configured by the ACK/NACK resource for the negative transmission of the scheduling request.

[0014] The uplink control channel may be configured by dividing the plurality of SC-FDMA symbols in the slot into a first set of SC-FDMA symbols and a second set of SC-FDMA symbols, spreading a control signal with each of first frequency domain sequences, the first frequency domain sequences being generated by cyclic shifts of a base sequence, wherein the control signal corresponds to the scheduling request or the ACK/NACK signal, mapping the spread control signals to each SC-FDMA symbol in the first set, mapping each of second frequency domain sequences to each SC-FDMA symbol in the second set, the second frequency domain sequence being generated by cyclic shifts of the base sequence, spreading the mapped control signals in the first set with a first orthogonal sequence, the first orthogonal sequence having a length equal to the number of SC-FDMA symbols in the first set, and spreading the mapped second frequency domain sequences in the second set with a second orthogonal sequence, the second orthogonal sequence having a length equal to the number of SC-FDMA symbols in the second set.

[0015] In another aspect, at transmitter for uplink control signals in a wireless communication system as claimed in claim 13 is provided.

[0016] In still another aspect, a mobile terminal as claimed in claim 15 is provided.

Advantageous Effects

[0017] A scheduling request and an acknowledgment (ACK)/negative-acknowledgement (NACK) signal can be simultaneously transmitted in the same subframe without interference with other control channels. Even when the scheduling request is simultaneously transmitted with other control signals, there is no performance deterioration in detection of the control signals. The scheduling request can be transmitted while minimizing decrease in capability of the control channels.

Brief Description of the Drawings

[0018]

FIG. 1 shows a wireless communication system.
FIG. 2 is a block diagram showing a transmitter according to an embodiment of the present invention.
FIG. 3 shows an exemplary structure of a radio frame.
FIG. 4 shows an exemplary subframe.
FIG. 5 shows a structure of an acknowledgement (ACK)/negative-acknowledgement (NACK) channel.
FIG. 6 shows an example of a configuration of a scheduling request channel for coherent detection according to an embodiment of the present invention.
FIG. 7 shows an example of a configuration of a scheduling request channel for coherent detection according to another embodiment of the present invention.
FIG. 8 shows an example of a configuration of a scheduling request channel for coherent detection according to another embodiment of the present invention.
FIG. 9 shows an example of transmission of a scheduling request.
FIG. 10 shows an example of a configuration of a scheduling request channel for non-coherent detection according to an embodiment of the present invention.
FIG. 11 shows an example of a configuration of a scheduling request channel for non-coherent detection according to another embodiment of the present invention.
FIG. 12 shows an example of a configuration of a scheduling request channel for non-coherent detection according to another embodiment of the present invention.
FIG. 13 shows an example of transmission of a scheduling request.
FIG. 14 shows an example of a configuration of a scheduling request channel according to an embodiment of the present invention.
FIG. 15 shows an example of transmission of a scheduling request.
FIG. 16 shows an example of transmission of a scheduling request of slot-based hopping.
FIG. 17 shows an example of a slot structure for transmitting a scheduling request.

Mode for the Invention

[0019] FIG. 1 shows a wireless communication system. The wireless communication system can be widely deployed

to provide a variety of communication services, such as voices, packet data, etc.

[0020] Referring to FIG. 1, the wireless communication system includes at least one user equipment (UE) 10 and a base station (BS) 20. The UE 10 may be fixed or mobile, and may be referred to as another terminology, such as a mobile station (MS), a user terminal (UT), a subscriber station (SS), a wireless device, etc. The BS 20 is generally a fixed station that communicates with the UE 10 and may be referred to as another terminology, such as a node-B, a base transceiver system (BTS), an access point, etc. There are one or more cells within the coverage of the BS 20.

[0021] Hereinafter, a downlink is defined as a communication link from the BS 20 to the UE 10, and an uplink is defined as a communication link from the UE 10 to the BS 20. In the downlink, a transmitter may be a part of the BS 20, and a receiver may be a part of the UE 10. In the uplink, the transmitter may be a part of the UE 10, and the receiver may be a part of the BS 20.

[0022] FIG. 2 is a block diagram showing a transmitter according to an embodiment of the present invention.

[0023] Referring to FIG. 2, a transmitter 100 includes a transmit (Tx) processor 110, a discrete Fourier transform (DFT) unit 120 that performs DFT, and an inverse fast Fourier transform (IFFT) unit 130 that performs IFFT. The DFT unit 120 performs DFT on data processed by the Tx processor 110 and outputs a frequency domain symbol. The data input to the DFT unit 120 may be a control signal and/or user data. The IFFT unit 130 performs IFFT on the received frequency domain symbol and outputs a Tx signal. The Tx signal is a time domain signal and is transmitted through a Tx antenna 190. A time domain symbol output from the IFFT unit 130 is referred to as an orthogonal frequency division multiplexing (OFDM) symbol. Since IFFT is performed after DFT spreading, the time domain symbol output from the IFFT unit 130 is also referred to as a single carrier-frequency division multiple access (SC-FDMA) symbol. SC-FDMA is a scheme in which spreading is achieved by performing DFT at a previous stage of the IFFT unit 130 and is advantageous over the OFDM in terms of decreasing a peak-to-average power ratio (PAPR).

[0024] Although the SC-FDMA scheme is described herein, multiple access schemes used in the present invention are not limited thereto. For example, various multiple access schemes may be used such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), single-carrier FDMA (SC-FDMA), orthogonal frequency division multiple access (OFDMA), etc.

[0025] Different multiple access schemes may be used for uplink and downlink in the wireless communication system. For example, the SC-FDMA scheme may be used for uplink, and the OFDMA scheme may be used for downlink.

[0026] FIG. 3 shows an exemplary structure of a radio frame.

[0027] Referring to FIG. 3, the radio frame includes 10 subframes. One subframe can include two slots. One slot can include a plurality of OFDM symbols in a time domain and at least one subcarrier in a frequency domain. The slot is a unit of radio resource allocation in the time domain. For example, one slot can include 7 or 6 OFDM symbols.

[0028] The radio frame structure is shown for exemplary purposes only, and thus the number of subframes included in the radio frame or the number of slots included in the subframe or the number of OFDM symbols included in the slot is not limited thereto.

[0029] FIG. 4 shows an exemplary subframe. The subframe may be an uplink subframe using SC-FDMA.

[0030] Referring to FIG. 4, the uplink subframe can be divided into two parts, that is, a control region and a data region. Since the control region and the data region use different frequency bands, frequency division multiplexing (FDM) have been achieved.

[0031] The control region is used to transmit only a control signal and is generally assigned to a control channel. The data region is used to transmit data and is generally assigned to a data channel. An uplink control channel assigned to the control region is referred to as a physical uplink control channel (PUCCH). An uplink data channel assigned to the data region is referred to as a physical uplink shared channel (PUSCH). The control channel transmits the control signal. The data channel transmits the user data. The control signal includes a plurality of signals other than the user data. That is, the control signal includes an acknowledgement (ACK)/negative-acknowledgement (NACK) signal, a channel quality indicator (CQI), a precoding matrix index (PMI), a rank indicator (RI), a scheduling request, etc.

[0032] Only the control signal is carried on the control region. The user data and the control signal can be carried together on the data region. That is, when a UE transmits only the control signal, the control region can be assigned to transmit the control signal. In addition, when the UE transmits both the data and the control signal, the data region can be assigned to transmit the data and the control signal. In an exceptional case, even if only the control signal is transmitted, the control signal may be transmitted in a large amount or the control signal may be not suitable to be transmitted through the control region. In this case, a radio resource can be assigned to the data region to transmit the control signal.

[0033] To maintain a single carrier property, the UE cannot simultaneously transmit the PUSCH and the PUCCH. This also means that one UE cannot simultaneously transmit two different PUCCHs in the same subframe.

[0034] Two slots within a subframe is frequency hopped. That is, a first slot of the two slots is assigned to a first frequency band, and a second slot thereof is assigned to a second frequency band. By using different subcarriers in the two slots, a frequency diversity gain can be obtained.

[0035] For clarity, it is assumed hereinafter that one slot consists of 7 OFDM symbols, and thus one subframe including two slots consists of 14 OFDM symbols in total. The number of OFDM symbols included in one subframe or the number

of OFDM symbols included in one slot is for exemplary purposes only, and technical features of the present invention are not limited thereto.

[0036] FIG. 5 shows a structure of an ACK/NACK channel. The ACK/NACK channel is a control channel through which an ACK/NACK signal is transmitted to perform hybrid automatic repeat request (HARQ) of downlink data. The ACK/NACK signal is a transmission and/or reception confirm signal for the downlink data.

[0037] Referring to FIG. 5, among 7 OFDM symbols included in one slot, a reference signal (RS) is carried on three consecutive OFDM symbols in the middle portion of the slot and the ACK/NACK signal is carried on the remaining four OFDM symbols. The RS is carried on three contiguous OFDM symbols located in the middle portion of the slot. The location and the number of symbols used in the RS may vary depending on a control channel. Changes in the location and the number the symbols may result in changes in those symbols used in the ACK/NACK signal.

[0038] When the control signal is transmitted within an assigned band, frequency domain spreading and time domain spreading are simultaneously used to increase the number of multiplexable UEs and the number of control channels. A frequency domain sequence is used as a base sequence to spread the ACK/NACK signal on a frequency domain. A Zadoff-Chu (ZC) sequence is one of constant amplitude zero autocorrelation (CAZAC) sequences and can be used as the frequency domain sequence.

[0039] A k-th element of a ZC sequence having an index of M can be expressed as shown:

MathFigure 1

[Math.1]

$$c(k)=\exp\left\{-\frac{j\pi Mk(k+1)}{N}\right\},\ \text{when } N \text{ is odd number}$$

$$c(k)=\exp\left\{-\frac{j\pi Mk^2}{N}\right\},\ \text{when } N \text{ is even number}$$

where N denotes a length of the ZC sequence. An index M is a natural number equal to or less than N. M and N are relatively prime to each other.

[0040] Control channels can be identified by using base sequences having different cyclic shift values. The number of available cyclic shifts may vary according to channel delay spread.

[0041] After being subjected to frequency domain spreading, the ACK/NACK signal is subjected to IFFT processing and is then spread again in a time domain by using a time domain sequence. The ACK/NACK signal is spread using four orthogonal sequences w , w_1, w_2, and w for four OFDM symbols. The RS is also spread using an orthogonal sequence having a length of 3. This is called orthogonal covering.

[0042] To configure the ACK/NACK channel, the plurality of SC-FDMA symbols in the slot are divided into a first set of SC-FDMA symbols (a SC-FDMA symbol set for the ACK/NACK signal) and a second set of SC-FDMA symbols (a SC-FDMA symbol set for a RS). The ACK/NACK signal is spread with each of first frequency domain sequences which is generated by cyclic shifts of a base sequence, and mapped to each SC-FDMA symbol in the first set. Also, each of second frequency domain sequences which is generated by cyclic shifts of the base sequence is mapped to each SC-FDMA symbol in the second set. The mapped ACK/NACK signal is spread with a first orthogonal sequence which has the length equal to the number of SC-FDMA symbols in the first set. Finally, the ACK/NACK channel is configured by spreading the mapped second frequency domain sequences in the second set with a second orthogonal sequence which has the length equal to the number of SC-FDMA symbols in the second set.

[0043] Now, a method of generating a scheduling request channel for transmitting a scheduling request (SR) will be described.

[0044] The SR is used when a UE request a BS to allocate an uplink radio resource. The SR is a sort of preliminary information exchange for data exchange. In order for the UE to transmit uplink data to the BS, a radio resource needs to be allocated using the SR. When the UE transmits the SR, the BS allocates the radio resource for uplink data transmission and informs the UE of the radio resource allocation. The BS has to only recognize a presence/absence of the SR. Therefore, a positive transmission of the SR can be achieved with the presence of transmission of the SR, and a negative transmission of the SR can be achieved with the absence of transmission of the SR.

[0045] A control channel such as an ACK/NACK channel needs to be considered along with transmission of the SR. If the ACK/NACK channel and the scheduling request channel are separately configured, the UE cannot transmit two channels in order to maintain the single carrier property. Therefore, there is a problem in that the UE cannot simultaneously

transmit the SR and the ACK/NACK signal. This is because transmission is made by selecting one of the scheduling request channel and the ACK/NACK channel in order to maintain the single carrier property. However, it is difficult to clearly distinguish priorities for selecting the SR and other control signals. For example, the ACK/NACK signal has a direct effect on a downlink throughput. In this case, transmission of the ACK/NACK signal may be delayed due to the SR, which may cause deterioration in resource efficiency.

[0046] In addition, even if an additional control channel for simultaneously transmitting the SR and the ACK/NACK signal is defined, limited control channel resources may be wasted as a result. This is because resources for a new control channel needs to be reserved in addition to the scheduling request channel and the ACK/NACK channel.

[0047] Therefore, there is a need for a method whereby the UE can simultaneously transmit the SR and the ACK/NACK signal in an effective manner.

[0048] Hereinafter, a configuration of an effective scheduling request channel for transmitting a SR in an ACK/NACK channel configured using time-frequency domain spreading will be described. To simultaneously transmit the SR and other control signals, the channel has to be configured to satisfy the following requirements.

(1) Compatibility with the ACK/NACK channel (or other control channels) is possible.
(2) The same channel structure is used even when only the SR is transmitted.
(3) Capability of the existing ACK/NACK channel is maintained when only the ACK/NACK signal is transmitted.
(4) Channel capability is maximized when the SR and the ACK/NACK signal is simultaneously transmitted.
(5) The same channel configuration is achieved irrespective of whether the ACK/ NACK signal and the SR are simultaneously transmitted.
(6) Configuration of the ACK/NACK channel and configuration of the scheduling request channel are flexible in an assigned time-frequency resource.
(7) Flexibility of sequence allocation is increased when a dedicated scheduling request channel is configured through sequence allocation.
(8) Transmission of the ACK/NACK signal and the SR is possible when a minimum frequency resource supportable in a narrow band is allocated.
(9) Performance deterioration does not occur when the ACK/NACK signal is detected after detecting the SR.
(10) The same scheduling request detection scheme is used irrespective of a presence/absence of the ACK/NACK signal.
(11) Transmission of other control signals (e.g., the ACK/NACK signal, etc.) is possible along with transmission of the SR. In this case, transmission of the existing control signal is not limited.

[0049] To configure the scheduling request channel by considering the above requirements, configuration using sequence allocation is proposed. In addition, a scheduling request channel using coherent detection or non-coherent detection is proposed. In addition, a scheduling request channel using frequency hopping is proposed.

[0050] Although the ACK/NACK signal will be described hereinafter, the scheduling request channel can also be used for other control signals.

[0051] When using the ACK/NACK channel, in a frequency domain, spreading is performed using a frequency domain sequence. In a time domain, spreading is performed using an orthogonal sequence having a length of 4 for the ACK/NACK signal or an orthogonal sequence having a length of 3 for a reference signal. If one resource block consists of 12 subcarriers, for one resource block, a ZC sequence having a length of 12 can be used in the frequency domain. Supportable UE capacity is determined by the length (i.e., 3) of the reference signal for coherent detection and the number of maximum cyclic shifts. Thus, if four cyclic shifts are possible, control channel capability is 6x3=18.

[0052] To transmit the SR, the scheduling request channel can be configured by reserving a two-dimensional spreading sequence in the ACK/NACK channel. In case of configuring the dedicated scheduling request channel, the SR can be detected using non-coherent detection irrespective of whether the ACK/NACK signal is detected. In case of simultaneously transmitting the SR and the ACK/NACK signal, the BS knows that the SR and the ACK/NACK signal are simultaneously transmitted. Thus, there is no need to detect the SR with respect to all ACK/NACK channels. The BS detects the SR only when the SR and the ACK/NACK signal are simultaneously transmitted.

[0053] A sequence assignment method for configuring the scheduling request channel is as follows.

(1) In a frequency domain sequence assigned to the ACK/NACK channel, one or more orthogonal sequences can be assigned to transmit the SR. For example, one cyclic shift in a base sequence can be assigned to transmit the SR.
(2) One or more time domain sequences assigned to the ACK/NACK channel can be assigned to transmit the SR.
(3) In a time-frequency two-dimensional spreading sequence to be assigned to the ACK/NACK, one or more orthogonal sequences are assigned to transmit the SR.

[0054] Regarding a control channel structure using sequence hopping, the aforementioned three sequence assignment

method can be extended to a spreading hopping pattern defined with respect to one or more symbols.

[0055] According to whether the reference signal is used to detect the SR, there are a scheduling request channel conforming to coherent detection and a scheduling request channel conforming to non-coherent detection. The scheduling request channel can be applied to any control channels using spreading sequences. The following descriptions will be explained by considering the ACK/NACK channel.

[0056] FIG. 6 shows an example of a configuration of a scheduling request channel for coherent detection according to an embodiment of the present invention.

[0057] Referring to FIG. 6, at least one of frequency domain sequences assigned to an ACK/ NACK channel is reserved with a scheduling request resource for transmission of a SR. A ZC sequence may be used as a base sequence for frequency domain sequences. One cyclic shift may be reserved with the scheduling request resource for transmission of the SR. Information on the scheduling request resource may be predetermined between a BS and a UE or may be reported by the BS to the UE.

[0058] For compatibility with the existing ACK/NACK channel structure, the scheduling request channel is configured by allowing the SR to use a time domain sequence having a length of 4 and by allowing a reference signal (RS) for the SR to use a time domain sequence having a length of 3. The reference signal for the SR will be simply referred to as "SR-RS".

[0059] A dedicated SR-RS may be used in the scheduling request channel. In this case, even if a length of a time domain sequence used to transmit the SR is greater than a length of a time domain sequence used to transmit the SR-RS, the number of supportable scheduling request channels is determined by the length of the time domain sequence used for the SR-RS.

[0060] A time-frequency domain sequence used for the ACK/NACK channel may be utilized to configure the scheduling request channel. In this case, channel capability differs depending on assignment of a frequency domain sequence. It is assumed that six orthogonal sequences can be generated for one base sequence through cyclic shifts in the ACK/NACK channel. If at least one cyclic shift is assigned with a scheduling request resource, the number of supportable scheduling request channels is (a length of a time domain sequence used in SR-RS)x(the number of reserved cyclic shifts). Therefore, when one cyclic shift is assigned to transmit the SR, three scheduling request channels can be generated. In this case, the number ACK/NACK channels decreases by 3.

[0061] Table 1 shows the number of scheduling request channels and the number of ACK/ NACK channels according to the number of reserved frequency domain sequences.

Table 1

[Table 1]
[Table]

The number of reserved frequency domain sequence	The number of SR channels with SR-RS	The number of ACK/ NACK channels
0	0	18
1	3	15
2	6	12
...	...	...
6	18	0

[0062] The UE transmits a scheduling request channel through reserved frequency domain spreading and time domain spreading. Upon receiving the scheduling request channel, the BS can detect the SR by using coherent detection or non-coherent detection. Since orthogonality is maintained between the SR and the ACK/NACK signal, the BS can detect the SR and the ACK/NACK signal. The BS can detect the SR by using non-coherent detection and detect the ACK/ NACK signal by using coherent detection.

[0063] FIG. 7 shows an example of a configuration of a scheduling request channel for coherent detection according to another embodiment of the present invention.

[0064] Referring to FIG. 7, at least one of time domain sequences assigned to an ACK/ NACK channel is reserved with a scheduling request resource for transmission of a SR. For compatibility with the existing ACK/NACK channel structure, a time domain sequence having a length of 4 is reserved for the SR, and a time domain sequence having a length of 3 is reserved for a SR-RS. Information on the scheduling request resource may be predetermined between a BS and a UE or may be reported by the BS to the UE.

[0065] The number of supportable scheduling request channels is determined by the number of assigned time domain

sequences and the number of frequency domain sequences. A time-frequency domain sequence used for the ACK/ NACK channel may be utilized to configure the scheduling request channel. In this case, it is assumed that six orthogonal sequences can be generated for one base sequence through cyclic shifts. If one time domain sequence is assigned with a scheduling request resource, the number of supportable scheduling request channels is (the number of available cyclic shifts)x(the number of reserved time domain sequences). Therefore, when one time domain sequence is assigned to the scheduling request resource, six (i.e., 6×1=6) scheduling request channels can be generated. In this case, the number of ACK/NACK channels decreases by 6.

[0066] Table 2 shows the number of scheduling request channels and the number of ACK/ NACK channels according to the number of reserved time domain sequences. Since the time domain sequence having a length of 3 is assigned for the SR-RS, the maximum number of time domain sequences assignable for transmission of the SR is 3.

Table 2

[Table 2]
[Table]

The number of reserved time domain sequence	The number of SR channels with SR-RS	The number of ACK/ NACK channels
0	0	18
1	6	12
2	12	6
3	18	0

[0067] The UE transmits a scheduling request channel through frequency domain spreading and reserved time domain spreading. Upon receiving the scheduling request channel, the BS can detect the SR by using coherent detection or non-coherent detection.

[0068] Even when the SR and the ACK/NACK signal are simultaneously transmitted, orthogonality is maintained between the SR and the ACK/NACK signal. Thus, the BS can detect the SR and the ACK/NACK signal. The BS can detect the SR by using non-coherent detection and detect the ACK/NACK signal by using coherent detection.

[0069] FIG. 8 shows an example of a configuration of a scheduling request channel for coherent detection according to another embodiment of the present invention.

[0070] Referring to FIG. 8, a time domain sequence and a frequency domain sequence, each of which has a different length, are reserved for a SR and a SR-RS with a scheduling request resource. The scheduling request channel uses two-dimensional spreading in a time-frequency domain. Information on the scheduling request resource may be predetermined between a BS and a UE or may be reported by the BS to the UE.

[0071] The number of supportable scheduling request channel is one-to-one mapped to an assigned time-frequency domain sequence. A time-frequency domain sequence used for the ACK/NACK channel may be utilized to configure the scheduling request channel. In this case, it is assumed that six orthogonal sequences can be generated for one base sequence through cyclic shifts. The SR uses a time domain sequence having a length of 4. The SR-RS uses a time domain sequence having a length of 3. Thus, the maximum number of available scheduling request channels is 6×3=18. The scheduling request channel can be generated by assigning one time domain sequence to the SR.

[0072] Table 3 shows the number of scheduling request channels and the number of ACK/ NACK channels according to the number of assigned time-frequency domain sequences.

Table 3

[Table 3]
[Table]

The number of reserved time-frequency domain sequence	The number of SR channels with SR-RS	The number of ACK/ NACK channels
0	0	18
1	1	17
...	...	...
18	18	0

[0073] The UE transmits a scheduling request channel by using two-dimensional spreading. Upon receiving the scheduling request channel, the BS can detect the SR by using coherent detection or non-coherent detection.

[0074] Even when the SR and the ACK/NACK signal are simultaneously transmitted, orthogonality is maintained between the SR and the ACK/NACK signal. Thus, the BS can detect the SR and the ACK/NACK signal. The BS can detect the SR by using non-coherent detection and detect the ACK/NACK signal by using coherent detection.

[0075] FIG. 9 shows an example of transmission of a SR.

[0076] Referring to FIG. 9, a path (1) denotes transmission of the SR. A path (2) denotes transmission of the SR and an ACK/NACK signal. A path (3) denotes transmission of the ACK/NACK signal.

[0077] In the path (1), if only the SR is transmitted on a scheduling request channel, the SR is transmitted on the scheduling request channel assigned with a scheduling request resource. The scheduling request resource can be regarded as a resource for the SR. When considering the path (2), the scheduling request resource can be regarded as a resource for simultaneously transmitting the SR and the ACK/NACK signal. Information on the scheduling request resource may be predetermined between a BS and a UE or may be reported by the BS to the UE.

[0078] SR-related data can be transmitted together with the SR. For example, when coherent detection is used and the SR is defined with 1 bit, if 2-bit transmission is achieved through quadrature phase shift keying (QPSK) modulation, the additional 1 bit can be assigned to the SR-related data. When the SR is detected using non-coherent detection, QPSK-modulated 2-bits can be assigned to the SR-related data.

[0079] In the path (2), the SR and the ACK/NACK signal are simultaneously transmitted. The ACK/NACK signal is transmitted on a scheduling request channel which is configured for a scheduling request resource allocated to transmit the SR. The BS can detect the SR by using non-coherent detection. The BS can detect the ACK/NACK signal by using coherent detection. That is, according to a presence/absence of transmission of the scheduling request channel, the BS can know whether the SR is transmitted. Further, the BS can receive the ACK/NACK signal by detecting information on the scheduling request channel. However, in this case, if the ACK/NACK signal is 1 bit and the QPSK modulation is used, coherent detection can also be used for the SR.

[0080] In the path (3), when only the ACK/NACK signal is transmitted, the ACK/NACK signal is transmitted on an ACK/NACK channel which is configured by an ACK/ NACK resource for the ACK/NACK signal.

[0081] The scheduling request channel using coherent detection can be utilized for additional information transmission by simultaneous transmission with a SR-RS. On the contrary, the scheduling request channel using non-coherent detection can increase channel capability since a reference signal is not required.

[0082] The SR is a signal transmitted when it is required by the UE. Transmission of the ACK/NACK signal is predetermined according to transmission of downlink data. Therefore, one UE may simultaneously transmit the SR and the ACK/NACK signal in the same subframe. In this case, a problem arises in that the scheduling request channel for the SR and the ACK/NACK channel for the ACK/NACK signal cannot be simultaneously transmitted in the same subframe in order to maintain the single carrier property.

[0083] In a case where the SR and the ACK/NACK signal have to be simultaneously transmitted in the same subframe, the UE spreads and transmits modulation symbols for the ACK/NACK signal through the scheduling request channel assigned with the scheduling request resource for transmission of the SR. The scheduling request channel and the ACK/NACK channel have the same structure except for time-frequency sequences assigned thereto. Therefore, when the UE transmits the ACK/NACK signal by using the scheduling request resource, the BS can know the positive transmission of the SR with the presence of the scheduling request channel. Further, the BS can obtain the ACK/NACK signal by using coherent detection through the scheduling request channel for transmitting timing at which the ACK/NACK signal is transmitted.

[0084] Accordingly, existing resources can be utilized without having to reserve additional resources for simultaneously transmitting the SR and the ACK/NACK signal. Therefore, resource efficiency can be enhanced.

[0085] FIG. 10 shows an example of a configuration of a scheduling request channel for non-coherent detection according to an embodiment of the present invention.

[0086] Referring to FIG. 10, at least one of frequency domain sequences (or frequency domain spreading codes) assigned to an ACK/NACK channel is reserved with a scheduling request resource for a SR. A ZC sequence may be used for the frequency domain sequence. One cyclic shift may be reserved to be used for the SR.

[0087] For compatibility with the existing ACK/NACK channel structure, the scheduling request channel is configured by allowing the SR to use a time domain sequence having a length of 4. Unlike coherent detection, the number of supportable scheduling request channels is determined by a length of a time domain sequence used for the SR. Since a time domain sequence having a length of 4 is used for a cyclic shift of one ZC sequence, four scheduling request channels can be generated. If it is assumed that coherent demodulation is used, the number of ACK/NACK channels decreases differently depending on the number of orthogonal spreading sequences for a reference signal and the number of orthogonal spreading sequences for the ACK/NACK signal.

[0088] Even if a frequency or time domain sequence is not reserved to generate a scheduling request channel, the number of time domain sequences for the ACK/NACK signal is basically different from the number of time domain

sequences for the reference signal. Therefore, time domain sequences not used by the ACK/NACK signal can be used as scheduling request resources. Six scheduling request channels can be generated by using six cyclic shifts.

[0089] Table 4 shows the number of scheduling request channels and the number of ACK/ NACK channels according to the number of reserved frequency domain sequences.

Table 4

[Table 4]
[Table]

The number of reserved frequency domain sequence	The number of SR channels without SR-RS	The number of ACK/ NACK channels
0	6	18
1	6	18
2	8	16
3	12	12
...	...	...
6	24	0

[0090] The UE transmits a scheduling request channel through reserved frequency domain spreading and time domain spreading. Upon receiving the scheduling request channel, the BS can detect the SR by using non-coherent detection.

[0091] Even when the SR and the ACK/NACK signal are simultaneously transmitted, the BS can detect the SR by using non-coherent detection. The BS can detect the ACK/ NACK signal by using coherent detection by utilizing a result of channel estimation using the reference signal for the ACK/NACK signal.

[0092] FIG. 11 shows an example of a configuration of a scheduling request channel for non-coherent detection according to another embodiment of the present invention.

[0093] Referring to FIG. 11, at least one of time domain sequences assigned to the ACK/ NACK channel is reserved with a scheduling request resource for a SR. For compatibility with the existing ACK/NACK channel structure, a time domain sequence having a length of 4 is used for the SR.

[0094] If one time domain sequence is assigned with the scheduling request resource, the number of scheduling request channels to be generated is the same as the number of available cyclic shifts of one base sequence. For example, if six cyclic shifts are possible for one base sequence, six scheduling request channels can be generated. In this case, since a redundant time domain sequence can be used among the time domain sequences, the number of ACK/NACK channels does not decrease. If two or more time domain sequences are assigned to the scheduling request channel, the number of ACK/NACK channels decreases by 6.

[0095] Table 5 shows the number of scheduling request channels and the number of ACK/ NACK channels according to the number of reserved time domain sequences.

Table 5

[Table 5]
[Table]

The number of reserved time domain sequence	The number of SR channels without SR-RS	The number of ACK/ NACK channels
0	6	18
1	6	18
2	12	12
3	18	6
4	24	0

[0096] The UE transmits a scheduling request channel through frequency domain spreading and reserved time domain spreading. Upon receiving the scheduling request channel, the BS can detect the SR by using non-coherent detection.

[0097] Even when the SR and the ACK/NACK signal are simultaneously transmitted, the BS can detect the SR by

using non-coherent detection. The BS can detect the ACK/ NACK signal by using coherent detection by utilizing a result of channel estimation using a reference signal for the ACK/NACK signal.

[0098] FIG. 12 shows an example of a configuration of a scheduling request channel for non-coherent detection according to another embodiment of the present invention.

[0099] Referring to FIG. 12, a time-frequency domain sequence is reserved with a scheduling request resource.

[0100] The number of supportable scheduling request channel is one-to-one mapped to an assigned time-frequency domain sequence. A time-frequency domain sequence used for the ACK/NACK channel may be utilized to configure the scheduling request channel. In this case, it is assumed that six orthogonal sequences can be generated for one base sequence through cyclic shifts. If six cyclic shifts and one time domain sequence are assigned with the scheduling request resource, six scheduling request channels can be obtained. In this case, if one of orthogonal sequences for the SR and having a length of 4 is utilized, a total number (i.e., 18) of the existing ACK/NACK channels can be maintained without change.

[0101] Table 6 shows the number of scheduling request channels and the number of ACK/ NACK channels according to the number of assigned time-frequency domain sequences.

Table 6

[Table 6]
[Table]

The number of reserved time-frequency domain sequence	The number of SR channels without SR-RS	The number of ACK/ NACK channels
0~6	6	18
7	7	17
8	8	16
...	...	...
24	24	0

[0102] The UE transmits a scheduling request channel by using two-dimensional spreading. Upon receiving the scheduling request channel, the BS can detect the SR by using coherent detection or non-coherent detection.

[0103] Even when the SR and the ACK/NACK signal are simultaneously transmitted, orthogonality is maintained between the SR and an ACK/NACK signal. Thus, the BS can detect the SR and the ACK/NACK signal. The BS can detect the SR by using non-coherent detection. The BS can detect the ACK/NACK signal by using coherent detection by utilizing a result of channel estimation using a reference signal for the ACK/NACK signal.

[0104] FIG. 13 shows an example of transmission of a SR.

[0105] Referring to FIG. 13, a path (1) denotes transmission of the SR. A path (2) denotes simultaneous transmission of the SR and an ACK/NACK signal. A path (3) denotes transmission of the ACK/NACK signal.

[0106] In the path (1), the SR is transmitted on a scheduling request channel. Unlike coherent detection, it is difficult to transmit additional SR-related information together with the SR. However, the scheduling request channel can be configured without decreasing capability of the existing ACK/NACK channel.

[0107] In the path (2), the SR and the ACK/NACK signal can be simultaneously transmitted. Regarding a reference signal (RS), a RS assigned to the ACK/NACK channel is used. The ACK/NACK signal (e.g., a QPSK symbol) is transmitted on a scheduling request channel assigned to a scheduling request resource allocated for the SR. A BS can detect the SR by using non-coherent detection. The BS can detect the A CK/NACK signal by using coherent detection. In this case, if the ACK/NACK signal is 1 bit and the QPSK modulation is used, coherent detection can also be used for the SR.

[0108] In path (3), when only the ACK/NACK signal is transmitted, the ACK/NACK signal is transmitted on an ACK/NACK channel.

[0109] By allowing the uplink control channel for transmitting only one control signal (e.g., the ACK/NACK signal or the SR) to have the same structure as an uplink control channel for simultaneously transmitting the ACK/NACK signal and the SR, additional channel configurations are not necessary, and resources can be effectively used.

[0110] FIG. 14 shows an example of a configuration of a scheduling request channel according to an embodiment of the present invention. The scheduling request channel has a structure in which resources of a reference signal are not allocated.

[0111] Referring to FIG. 14, in one slot, a time domain sequence having a length of 7 is split to use two time domain sequences having a length of 3 and 4, respectively. The time domain sequence having a length of 3 is used in a portion corresponding to a reference signal of the existing ACK/NACK channel. The time domain sequence having a length of

4 is used in a portion corresponding to an ACK/NACK signal of the existing ACK/ NACK channel.

[0112] In a case where a time domain sequence having a length of 7 is arbitrarily configured when a SR is transmitted, it is difficult for the scheduling request channel to exist within a time-frequency resource which is the same as that of the existing ACK/NACK channel. Further, a frequency domain sequence has to be dedicatedly assigned for the SR, which is burdensome. For example, if a ZC sequence is used as the frequency domain sequence, a dedicated scheduling request channel has to be configured using a specific cyclic shift.

[0113] Accordingly, when the time domain sequence having a length of 7 is split and used, the SR can be modulated with on-off keying. For a detection scheme, both coherent detection and non-coherent detection can be supported.

[0114] FIG. 15 shows an example of transmission of a SR.

[0115] Referring to FIG. 15, in a path (1), the SR is transmitted on a scheduling request channel configured with a scheduling request resource. Both coherent detection and non-coherent detection can be supported in the transmission of the SR. If only the SR is transmitted, the SR is transmitted on the scheduling request channel assigned with the scheduling request resource. The scheduling request resource can be regarded as a resource for the SR. When considering a path (2), the scheduling request resource can be regarded as a resource for simultaneously transmitting the SR and the ACK/NACK signal. Information on the scheduling request resource may be predetermined between a BS and a UE or may be reported by the BS to the UE.

[0116] In the path (2), when the SR and the ACK/NACK signal are simultaneously transmitted in the same subframe, the ACK/NACK signal is transmitted on a scheduling request channel configured with the scheduling request resource. In this case, since a sequence for the SR and having a length of 3 is assigned, a reference signal for coherent detection of the ACK/NACK signal can be used for the sequence assigned to the SR without change. Eventually, the ACK/NACK signal is transmitted by being carried on the scheduling request resource allocated to the SR.

[0117] In a path (3), if only the ACK/NACK signal is transmitted, the ACK/NACK signal is transmitted on the ACK/NACK channel.

[0118] In a case where the SR and the ACK/NACK signal have to be simultaneously transmitted in the same subframe, the UE spreads and transmits modulation symbols for the ACK/NACK signal through an uplink control channel configured with the scheduling request resource for transmission of the SR. The scheduling request channel and the ACK/NACK channel are allocated with different resources but have the same uplink control channel structure. Therefore, when the UE transmits the ACK/NACK signal by using the scheduling request resource, the BS can know the positive transmission of the SR with the presence of the scheduling request channel. Further, the BS can obtain the ACK/NACK signal by using coherent detection with the scheduling request resource for transmitting timing at which the ACK/NACK signal is transmitted. If only the ACK/NACK signal needs to be transmitted, the UE transmits the ACK/NACK signal through the uplink control channel configured with the ACK/ NACK resource for the ACK/NACK signal.

[0119] Accordingly, existing resources can be utilized without having to reserve additional resources for simultaneously transmitting the SR and the ACK/NACK signal. Therefore, resource efficiency can be enhanced.

[0120] Meanwhile, in a case where a dedicated scheduling request channel is transmitted using a dedicated scheduling request resource without consideration of coexistence with the ACK/NACK channel, capability of the scheduling request channel is problematic. For example, if non-coherent detection is used in one resource block (RB) and one subframe, a maximum of 42 scheduling request channels can be generated through two-dimensional spreading. Therefore, if it is assumed that the existing ACK/ NACK channel and the scheduling request channel do not coexist, to transmit the SR through the ACK/NACK channel, there is a need for a method capable of transmitting additional 1-bit information through the existing ACK/NACK channel.

[0121] An additional 1-bit SR can be transmitted through QPSK modulation when the ACK/ NACK signal is 1 bit. The SR can be transmitted by changing a phase or sequence of the ACK/NACK signal carried on a pair of slots.

[0122] FIG. 16 shows an example of transmission of a SR of slot-based hopping. Referring to FIG. 16, when there is no data transmission, an uplink control channel is transmitted using a control region defined at both ends of a slot. In this case, a frequency diversity gain is provided through slot-unit hopping. In case of the existing ACK/NACK channel, the same ACK/NACK signal is transmitted in a slot unit. Thus, the SR can be transmitted by changing a phase or sequence of the ACK/NACK signal carried on two slots.

[0123] In a condition that transmission of the SR is requested, a transmitter may transmit the SR by multiplying a predetermined phase variation or orthogonal sequence or by carrying a specific modulation signal at a portion where the ACK/NACK signal is carried in every slot (i.e., a specific one slot or more slots). The transmitter may transmit the SR by using a differential modulation scheme. A receiver can detect the SR after the ACK/NACK signal is demodulated in a slot unit. Either coherent detection or non-coherent detection can be used to detect the SR.

[0124] FIG. 17 shows an example of a slot structure for transmitting a SR. To carry the SR together with an ACK/NACK signal, the ACK/NACK signal undergoes phase shift, orthogonal spreading sequence and/or differential modulation.

[0125] The present invention can be implemented with hardware, software or combination thereof. In hardware implementation, the present invention can be implemented with one of an application specific integrated circuit (ASIC), a digital signal processor (DSP), a programmable logic device (PLD), a field programmable gate array (FPGA), a processor,

a controller, a microprocessor, other electronic units, and combination thereof, which are designed to perform the aforementioned functions In software implementation, the present invention can be implemented with a module for performing the aforementioned functions. Software is storable in a memory unit and executed by the processor. Various means widely known to those skilled in the art can be used as the memory unit or the processor.

Claims

1. A method of transmitting uplink control signals in a wireless communication system using at least one subframe comprising two slots, each slot comprising a plurality of symbols, the method comprising:

   assigning an uplink control channel for a scheduling request resource for transmitting a scheduling request, the scheduling request being used to request a radio resource for uplink transmission;
   assigning an uplink control channel for an ACK/NACK resource for transmitting an ACK/NACK signal for a hybrid automatic repeat request HARQ of downlink data; and
   wherein, for transmitting both the ACK/NACK signal and a positive scheduling request in same subframe, the method comprises
   generating a modulation symbol by modulating the ACK/NACK signal; and
   transmitting the modulation symbol on the uplink control channel which is assigned for the scheduling request resource.

2. The method according to claim 1, wherein for transmitting a negative scheduling request and the ACK/NACK signal, the method comprises generating a modulation symbol by modulating the ACK/NACK signal and transmitting the modulation symbol on the uplink control channel assigned for the ACK/NACK resource.

3. The method of any one of claims 1 and 2, wherein information on the scheduling request resource is transmitted from a base station.

4. The method of any one of claims I to 3, wherein the scheduling request is transmitted on the uplink control channel which is configured by the scheduling request resource when only the scheduling request is transmitted in the same subframe and no ACK/NACK signal is transmitted.

5. The method of any one of claims 1 to 4, wherein the symbols of said subframe are single carrier-frequency division multiple access symbols SC-FDMA and the uplink control channel is configured by dividing the plurality of SC-FDMA symbols in each slot into a first set of SCFDMA symbols and a second set of SC-FDMA symbols; the method comprising for the SC-FDMA symbols in each slot:

   spreading a control signal with each of a plurality of first frequency domain sequences, wherein the control signal corresponds to the scheduling request or the ACK/NACK signal;
   mapping a corresponding one of a plurality of frequency domain sequences to each SC-FDMA symbol in the first set of SC-FDMA symbols, thereby generating a first set of mapped frequency domain sequences;
   mapping a corresponding one of a plurality of frequency domain sequences to each SC-FDMA symbol in the second set of SC-FDMA symbols, thereby generating a second set of mapped frequency domain sequences;
   spreading the first set of mapped frequency domain sequences with a first orthogonal sequence, the first orthogonal sequence having a length equal to the number of SC-FDMA symbols in the first set of SC-FDMA symbols; and
   spreading the second set of mapped frequency domain sequences associated with each of the SC-FDMA symbols in the second set of SF-FDMA symbols with a second orthogonal sequence, the second orthogonal sequence having a length equal to the number of SC-FDMA symbols in the second set of SC-FDMA symbols.

6. The method of claim 5, wherein the scheduling request resource and the ACK/NACK resource use different cyclic shifts of the base sequence.

7. The method of any one of claims 5 and 6, wherein the scheduling request resource and the ACK/NACK resource use different orthogonal sequences.

8. The method of any one of claims 5 to 7, wherein the first orthogonal sequence and the second orthogonal sequence are time domain sequences whose elements correspond to SC-FDMA symbols.

9. The method of any one of claims 5 to 8, wherein each of the length of the first frequency domain sequence and the length of the second frequency domain sequence equals to the number of subcarriers in one SC-FDMA symbol on the uplink control channel.

10. The method of any one of claim 5 to 9, wherein the number of SC-FDMA symbols in the first set is larger than that of SC-FDMA symbols in the second set.

11. The method of claim 10, wherein the SC-FDMA symbols in the second set are consecutive.

12. The method of any one of claims 1 to 11, wherein the two slots in the subframe uses different subcarriers.

13. Transmitter (100) for uplink control signals in a wireless communication system using at least one subframe comprising two slots, each slot comprising a plurality of symbols, the transmitter comprising a processor (110) configured for:

assigning an uplink control channel for a scheduling request resource for transmitting a scheduling request, the scheduling request being used to request a radio resource for uplink transmission;
assigning an uplink control channel for an ACK/NACK resource for transmitting an ACK/NACK signal for a hybrid automatic repeat request HARQ of downlink data; and
wherein, for transmitting both the ACK/NACK signal and a positive scheduling request in same subframe, the processor is configured for
generating a modulation symbol by modulating the ACK/NACK signal; and
transmitting the modulation symbol on the uplink control channel which is assigned for the scheduling request resource.

14. Transmitter according to claim 13, wherein the processor is further configured for carrying out the method as claim in any one of claims 2 to 12.

15. Mobile terminal (10) configured for being used in a wireless communication system using a subframe comprising two slots, a slot comprising a plurality of symbols wherein the mobile terminal comprises a transmitter according to any one of claims 13 or 14.

Patentansprüche

1. Verfahren zur Übertragung von Aufwärtssteuersignalen in einer drahtlosen Kommunikationsanordnung, die mindestens einen Subframe verwendet, der zwei Schlitze umfasst, wobei jeder Schlitz mehrere Symbole umfasst, wobei das Verfahren umfasst:

Zuordnen eines Aufwärtssteuerkanals zu einer Terminanfrageressource zum Übertragen einer Terminanfrage, wobei die Terminanfrage zum Anfordern einer Funkressource für eine Aufwärtsübertragung verwendet wird;
Zuordnen eines Aufwärtssteuerkanals zu einer ACK/NACK-Ressource zur Übertragung eines ACK/NACK-Signals für eine hybride automatische Wiederholungsanfrage HARQ von Abwärtsdaten; und
wobei zum Übertragen sowohl des ACK/NACK-Signals wie auch einer positiven Terminanfrage im selben Subframe das Verfahren Folgendes umfasst:

Erzeugen eines Modulationssymbols durch Modulieren des ACK/NACK-Signals; und
Übertragen des Modulationssymbols auf dem Aufwärtssteuerkanal, der der Terminanfrageressource zugeordnet ist.

2. Verfahren nach Anspruch 1, wobei zum Übertragen einer negativen Terminanfrage und des ACK/NACK-Signals das Verfahren das Erzeugen eines Modulationssymbols durch Modulieren des ACK/NACK-Signals und das Übertragen des Modulationssymbols auf einem Aufwärtssteuerkanal, der der ACK/NACK-Ressource zugeordnet ist, umfasst.

3. Verfahren nach einem der Ansprüche 1 und 2, wobei Informationen über die Terminanfrageressource von einer Basisstation übertragen werden.

4. Verfahren nach Anspruch 1 bis 3, wobei die Terminanfrage auf dem Aufwärtssteuerkanal übertragen wird, der durch die Terminanfrageressource konfiguriert ist, wenn nur die Terminanfrage in demselben Subframe übertragen wird und kein ACK/NACK-Signal übertragen wird.

5. Verfahren nach einem der Ansprüche 1 bis 4, wobei die Symbole des Subframes Einzelträger-Frequenzmultiplex-, SC-FDMA, Symbole sind und der Aufwärtssteuerkanal durch Unterteilen der mehreren SC-FDMA-Symbole in jedem Schlitz in einen ersten Satz von SC-FDMA-Symbolen und einen zweiten Satz von SC-FDMA-Symbolen konfiguriert ist; wobei das Verfahren für die SC-FDMA-Symbole in jedem Schlitz Folgendes umfasst:

Streuen eines Steuersignals mit jeder von mehreren ersten Frequenzdomänesequenzen, wobei das Steuersignal der Terminanfrage oder dem ACK/NACK-Signal entspricht;
Abbilden einer entsprechenden von mehreren Frequenzdomänesequenzen auf jedes SC-FDMA-Symbol im ersten Satz von SC-FDMA-Symbolen, wodurch ein erster Satz von abgebildeten Frequenzdomänesequenzen erhalten wird;
Abbilden einer entsprechenden von mehreren Frequenzdomänesequenzen auf jedes SC-FDMA-Symbol im zweiten Satz von SC-FDMA-Symbolen, wodurch ein zweiter Satz von abgebildeten Frequenzdomänesequenzen erhalten wird;
Streuen des ersten Satzes von abgebildeten Frequenzdomänesequenzen mit einer ersten orthogonalen Sequenz, wobei die erste orthogonale Sequenz eine Länge gleich der Anzahl von SC-FDMA-Symbolen im ersten Satz von SC-FDMA-Symbolen hat; und
Streuen des zweiten Satzes von abgebildeten Frequenzdomänesequenzen, die jedem der SC-FDMA-Symbole im zweiten Satz von SC-FDMA-Symbolen zugeordnet sind, mit einer zweiten orthogonalen Sequenz, wobei die zweite orthogonale Sequenz eine Länge gleich der Anzahl von SC-FDMA-Symbolen im zweiten Satz von SC-FDMA-Symbolen hat.

6. Verfahren nach Anspruch 5, wobei die Terminanfrageressource und die ACK/NACK-Ressource verschiedene zyklische Verschiebungen der Grundsequenz verwenden.

7. Verfahren nach einem der Ansprüche 5 und 6, wobei die Terminanfrageressource und die ACK/NACK-Ressource verschiedene orthogonale Sequenzen verwenden.

8. Verfahren nach einem der Ansprüche 5 bis 7, wobei die erste orthogonale Sequenz und die zweite orthogonale Sequenz Zeitdomänesequenzen sind, deren Elemente SC-FDMA-Symbolen entsprechen.

9. Verfahren nach einem der Ansprüche 5 bis 8, wobei sowohl die Länge der ersten Frequenzdomänesequenz wie auch die Länge der zweiten Frequenzdomänesequenz der Zahl von Subträgern in einem SC-FDMA-Symbol auf dem Aufwärtssteuerkanal entsprechen.

10. Verfahren nach einem der Ansprüche 5 bis 9, wobei die Anzahl von SC-FDMA-Symbolen im ersten Satz größer ist als jene von SC-FDMA-Symbolen im zweiten Satz.

11. Verfahren nach Anspruch 10, wobei die SC-FDMA-Symbole im zweiten Satz konsekutiv sind.

12. Verfahren nach einem der Ansprüche 1 bis 11, wobei die zwei Schlitze im Subframe verschiedene Subträger verwenden.

13. Sender (100) für Aufwärtssteuersignals in einer drahtlosen Kommunikationsanordnung, die mindestens einen Subframe verwendet, der zwei Schlitze umfasst, wobei jeder Schlitz mehrere Symbole umfasst, wobei der Sender einen Prozessor (110) umfasst, der konfiguriert ist zum:

Zuordnen eines Aufwärtssteuerkanals zu einer Terminanfrageressource zum Übertragen einer Terminanfrage, wobei die Terminanfrage zum Anfordern einer Funkressource für eine Aufwärtsübertragung verwendet wird;
Zuordnen eines Aufwärtssteuerkanals zu einer ACK/NACK-Ressource zur Übertragung eines ACK/NACK-Signals für eine hybride automatische Wiederholungsanfrage HARQ von Abwärtsdaten; und
wobei zum Übertragen sowohl des ACK/NACK-Signals wie auch einer positiven Terminanfrage im selben Subframe der Prozessor konfiguriert ist zum:

Erzeugen eines Modulationssymbols durch Modulieren des ACK/NACK-Signals; und

Übertragen des Modulationssymbols auf dem Aufwärtssteuerkanal, der der Terminanfrageressource zugeordnet ist.

14. Sender nach Anspruch 13, wobei der Prozessor des Weiteren zum Ausführen des Verfahrens nach einem der Ansprüche 2 bis 12 konfiguriert ist.

15. Mobiles Endgerät (10), das zur Verwendung einer drahtlosen Kommunikationsanordnung konfiguriert ist, die mindestens einen Subframe verwendet, der zwei Schlitze umfasst, wobei jeder Schlitz mehrere Symbole umfasst, wobei das mobile Endgerät einen Sender nach einem der Ansprüche 13 oder 14 umfasst.

Revendications

1. Procédé d'émission de signaux de contrôle sur la voie montante dans un système de communication sans fil utilisant au moins une sous-trame comprenant deux intervalles, chaque intervalle comprenant une pluralité de symboles, le procédé comprenant :

   allouer un canal de contrôle sur la voie montante pour une ressource de requête d'ordonnancement pour émettre une requête d'ordonnancement, la requête d'ordonnancement étant utilisée pour requérir une ressource radio pour une transmission sur la voie montante ;
   allouer un canal de contrôle sur la voie montante pour une ressource ACK/NACK pour émettre un signal ACK/NACK pour une requête de répétition automatique hybride, HARQ, de données de la voie descendante ; et
   dans lequel, pour l'émission du signal ACK/NACK et d'une requête d'ordonnancement positive dans la même sous-trame, le procédé comprend générer un symbole de modulation en modulant le signal ACK/NACK ; et
   émettre le symbole de modulation sur le canal de contrôle sur la voie montante alloué pour la ressource de requête d'ordonnancement.

2. Procédé selon la revendication 1, dans lequel, pour l'émission d'une requête d'ordonnancement négative et du signal ACK/NACK, le procédé comprend la génération d'un symbole de modulation en modulant le signal ACK/NACK et l'émission du symbole de modulation sur le canal de contrôle sur la voie montante alloué pour la ressource ACK/NACK.

3. Procédé selon l'une quelconque des revendications 1 et 2, dans lequel des informations sur la ressource de requête d'ordonnancement sont émises par une station de base.

4. Procédé selon l'une quelconque des revendications 1 à 3, dans lequel la requête d'ordonnancement est émise sur le canal de contrôle sur la voie montante configuré par la ressource de requête d'ordonnancement lorsqu'uniquement la requête d'ordonnancement est émise dans la même sous-trame et aucun signal ACK/NACK n'est émis.

5. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel les symboles de ladite sous-trame sont des symboles d'accès multiple par répartition en fréquence à porteuse unique SC-FDMA et le canal de contrôle sur la voie montante est configuré en divisant la pluralité de symboles SC-FDMA dans chaque intervalle en un premier ensemble de symboles SC-FDMA et un deuxième ensemble de symboles SC-FDMA; le procédé comprenant pour les symboles SC-FDMA dans chaque intervalle :

   étaler un signal de contrôle avec chacune d'une pluralité de premières séquences du domaine fréquentiel, dans lequel le signal de contrôle correspond à la requête d'ordonnancement ou au signal ACK/NACK ;
   associer l'une correspondante d'une pluralité de séquences du domaine fréquentiel à chaque symbole SC-FDMA dans le premier ensemble de symboles SC-FDMA,
   générant de ce fait un premier ensemble de séquences du domaine fréquentiel en correspondance ;
   associer l'une correspondante d'une pluralité de séquences du domaine fréquentiel à chaque symbole SC-FDMA dans le deuxième ensemble de symboles SC-FDMA,
   générant de ce fait un deuxième ensemble de séquences du domaine fréquentiel en correspondance ;
   étaler le premier ensemble de séquences du domaine fréquentiel en correspondance avec une première séquence orthogonale, la première séquence orthogonale ayant une longueur égale au nombre de symboles SC-FDMA dans le premier ensemble de symboles SC-FDMA ; et
   étaler le deuxième ensemble de séquences du domaine fréquentiel en correspondance associées à chacun des symboles SC-FDMA dans le deuxième ensemble de symboles SC-FDMA avec une deuxième séquence

orthogonale, la deuxième séquence orthogonale ayant une longueur égale au nombre de symboles SC-FDMA dans le deuxième ensemble de symboles SC-FDMA.

6. Procédé selon la revendication 5, dans lequel la ressource de requête d'ordonnancement et la ressource ACK/NACK utilisent différents décalages cycliques de la séquence de base.

7. Procédé selon l'une quelconque des revendications 5 et 6, dans lequel la ressource de requête d'ordonnancement et la ressource ACK/NACK utilisent différentes séquences orthogonales.

8. Procédé selon l'une quelconque des revendications 5 à 7, dans lequel la première séquence orthogonale et la deuxième séquence orthogonale sont des séquences du domaine temporel dont des éléments correspondent à des symboles SC-FDMA.

9. Procédé selon l'une quelconque des revendications 5 à 8, dans lequel chacune de la longueur de la première séquence du domaine fréquentiel et de la longueur de la deuxième séquence du domaine fréquentiel est égale au nombre de sous-porteuses dans un symbole SC-FDMA sur le canal de contrôle sur la voie montante.

10. Procédé selon l'une quelconque des revendications 5 à 9, dans lequel le nombre de symboles SC-FDMA dans le premier ensemble est supérieur au nombre de symboles SC-FDMA dans le deuxième ensemble.

11. Procédé selon la revendication 10, dans lequel les symboles SC-FDMA dans le deuxième ensemble sont consécutifs.

12. Procédé selon l'une quelconque des revendications 1 à 11, dans lequel les deux intervalles dans la sous-trame utilisent des sous-porteuses différentes.

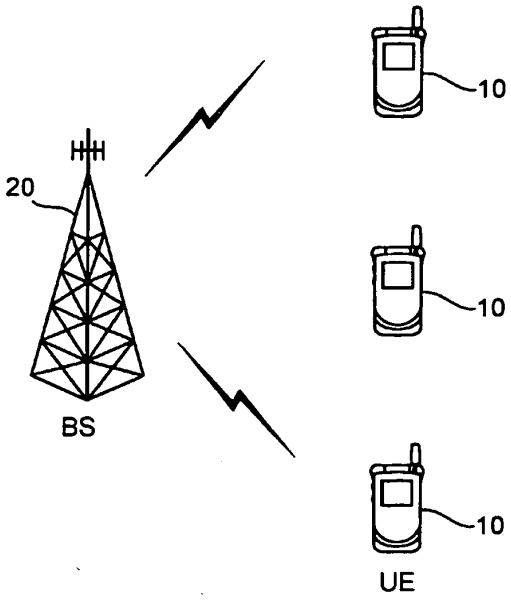
13. Emetteur (100) pour des signaux de contrôle de la voie montante dans un système de communication sans fil utilisant au moins une sous-trame comprenant deux intervalles, chaque intervalle comprenant une pluralité de symboles, l'émetteur comprenant un processeur (110) configuré pour :

allouer un canal de contrôle sur la voie montante pour une ressource de requête d'ordonnancement pour émettre une requête d'ordonnancement, la requête d'ordonnancement étant utilisée pour requérir une ressource radio pour une transmission sur la voie montante ;
allouer un canal de contrôle sur la voie montante pour une ressource ACK/NACK pour émettre un signal ACK/NACK pour une requête de répétition automatique hybride HARQ de données de la voie descendante ; et
dans lequel, pour l'émission du signal ACK/NACK et d'une requête d'ordonnancement positive dans la même sous-trame, le processeur est configuré pour
générer un symbole de modulation en modulant le signal ACK/NACK ; et
émettre le symbole de modulation sur le canal de contrôle sur la voie montante alloué pour la ressource de requête d'ordonnancement.

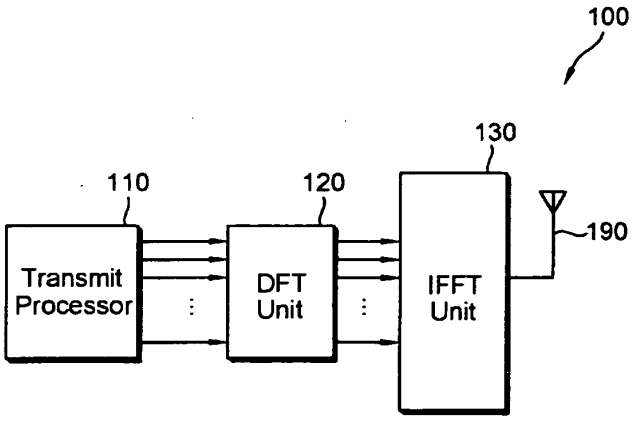
14. Emetteur selon la revendication 13, dans lequel le processeur est en outre configuré pour la mise en oeuvre du procédé selon l'une quelconque des revendications 2 à 12.

15. Terminal mobile (10) configuré pour être utilisé dans un système de communication sans fil utilisant une sous-trame comprenant deux intervalles, un intervalle comprenant une pluralité de symboles, dans lequel le terminal mobile comprend un émetteur selon l'une quelconque des revendications 13 ou 14.

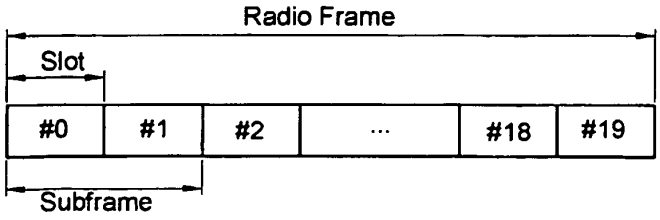
[Fig. 1]



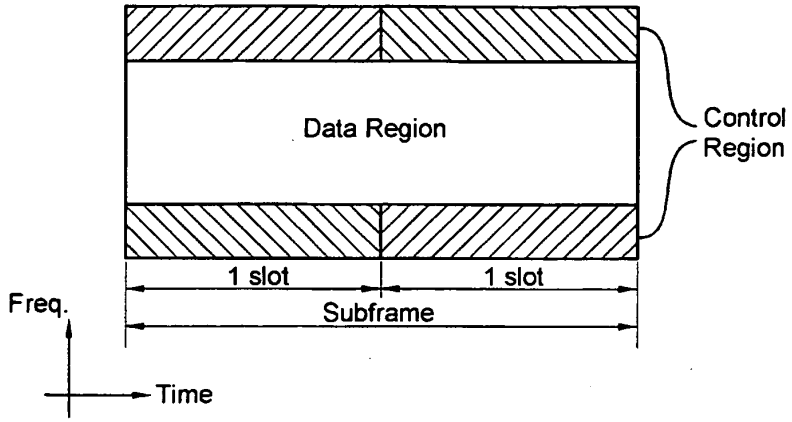
[Fig. 2]



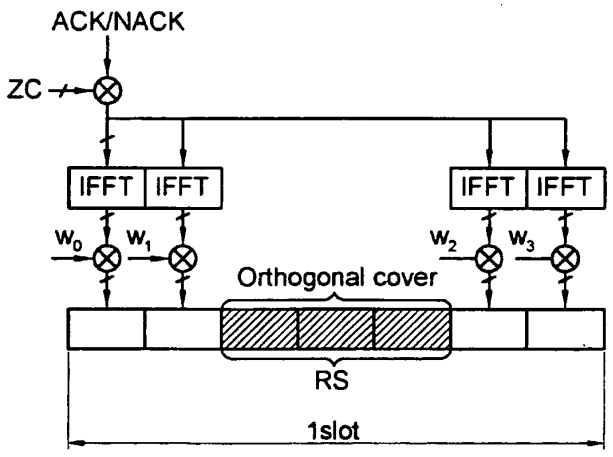
[Fig. 3]



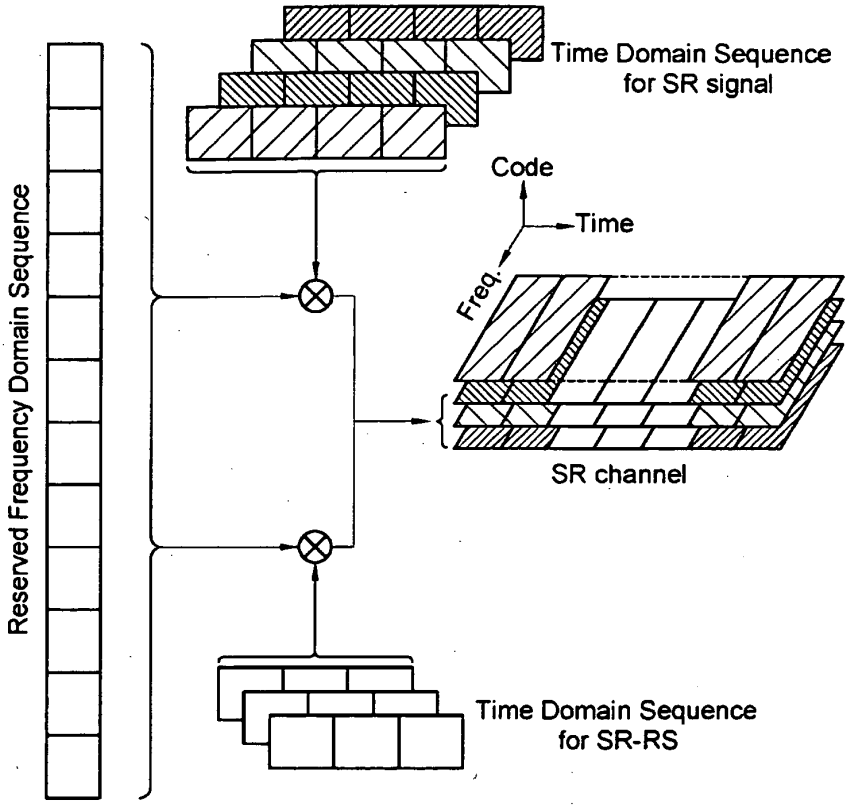
[Fig. 4]


Data Region
Control Region
1 slot
1 slot
Subframe
Freq.
Time

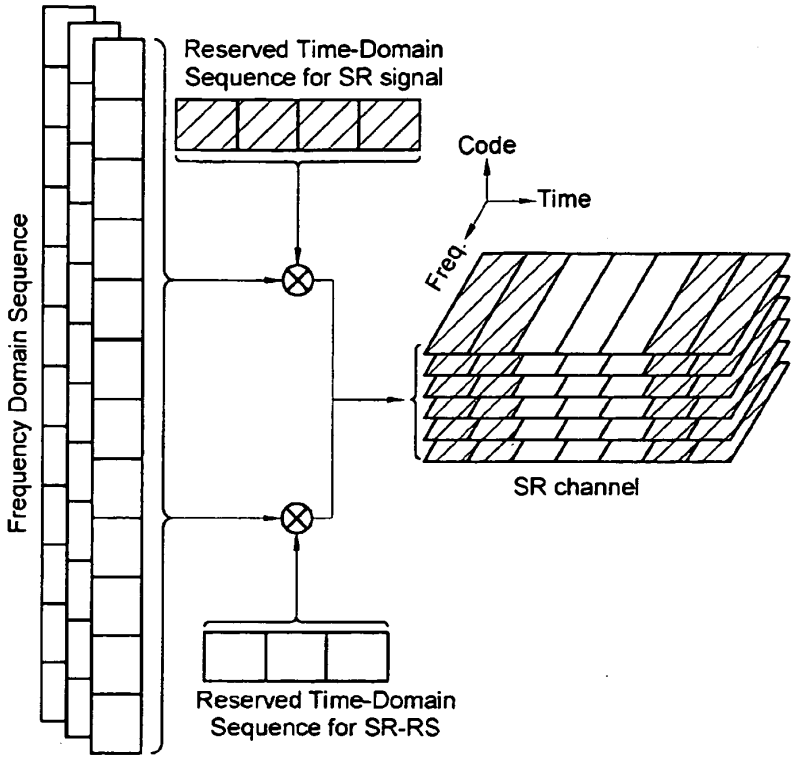
[Fig. 5]


ACK/NACK
ZC
IFFT
IFFT
IFFT
IFFT
w_0
w_1
w_2
w_3
Orthogonal cover
RS
1slot

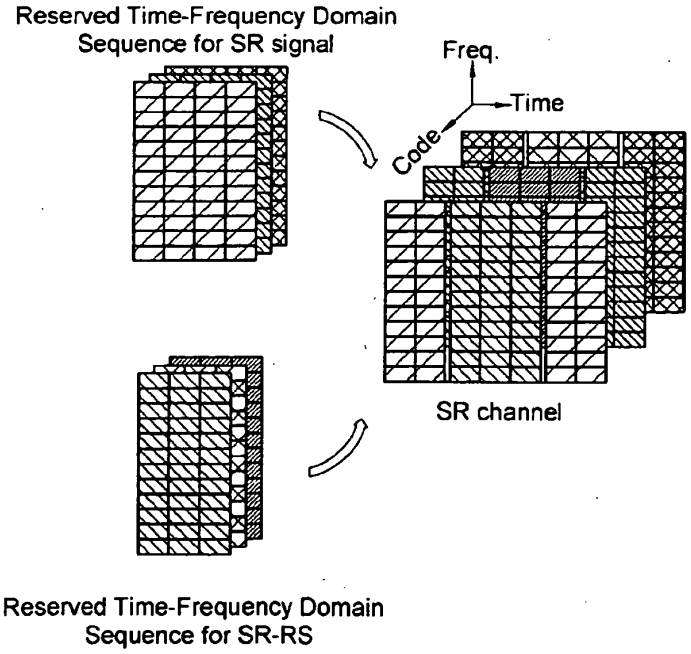
[Fig. 6]


Time Domain Sequence
for SR signal
Code
Time
Freq.
SR channel
Reserved Frequency Domain Sequence
Time Domain Sequence
for SR-RS

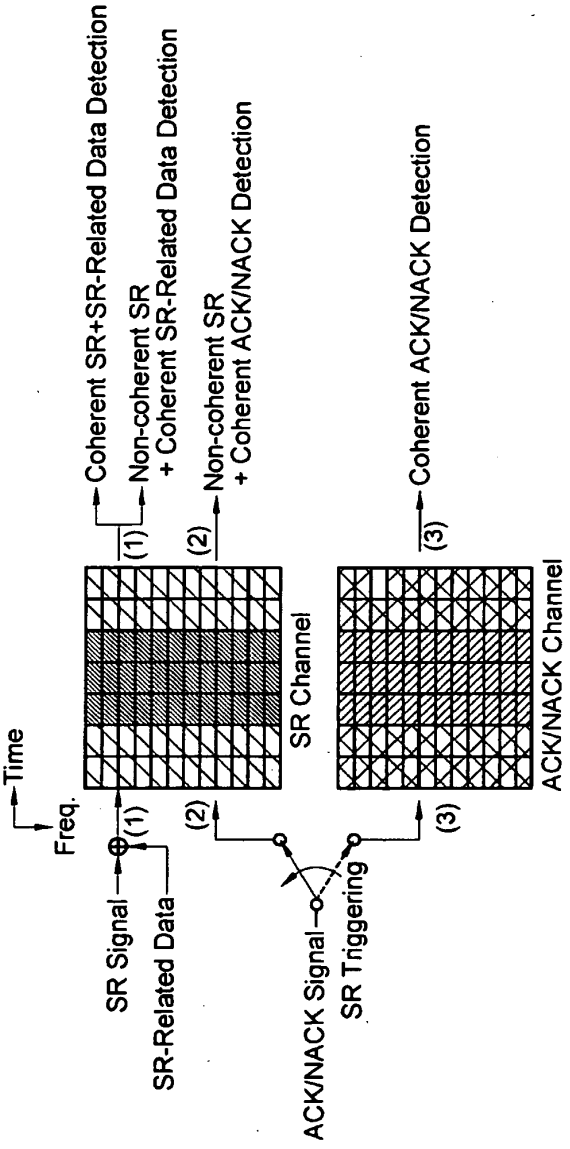
[Fig. 7]


Reserved Time-Domain Sequence for SR signal
Code
Time
Freq.
Frequency Domain Sequence
SR channel
Reserved Time-Domain Sequence for SR-RS

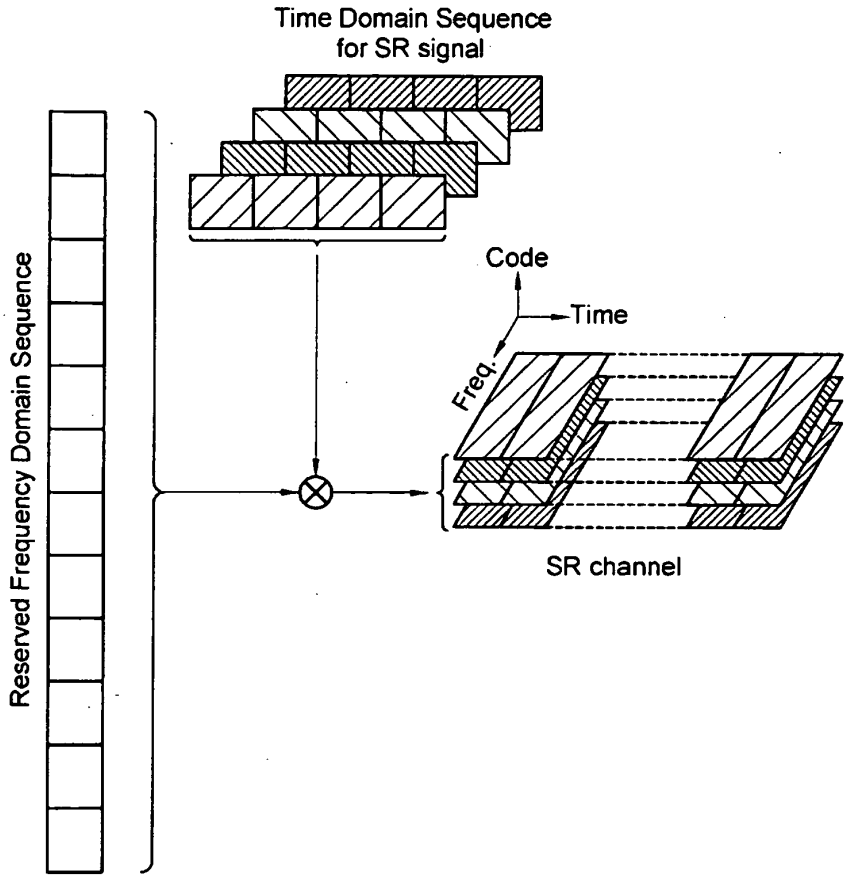
[Fig. 8]


Reserved Time-Frequency Domain Sequence for SR signal
Freq.
Time
Code
SR channel
Reserved Time-Frequency Domain Sequence for SR-RS

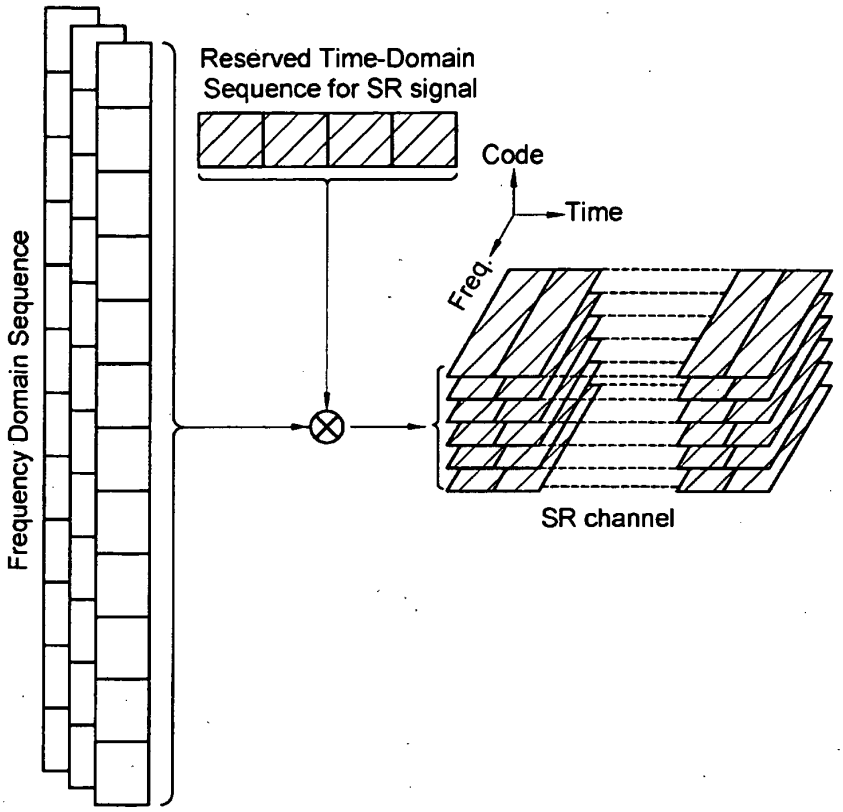
[Fig. 9]


Coherent SR+SR-Related Data Detection
Non-coherent SR
+ Coherent SR-Related Data Detection
Non-coherent SR
+ Coherent ACK/NACK Detection
Coherent ACK/NACK Detection
(1)
(2)
(3)
SR Channel
ACK/NACK Channel
Time
Freq.
SR Signal
SR-Related Data
ACK/NACK Signal
SR Triggering

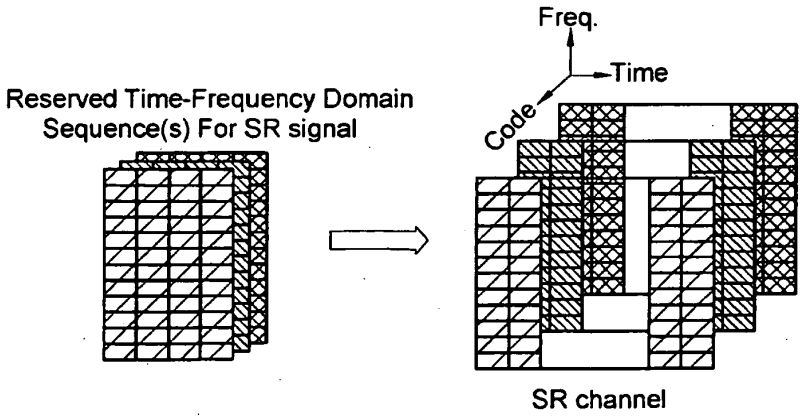
[Fig. 10]


Time Domain Sequence
for SR signal
Code
Time
Freq.
Reserved Frequency Domain Sequence
SR channel

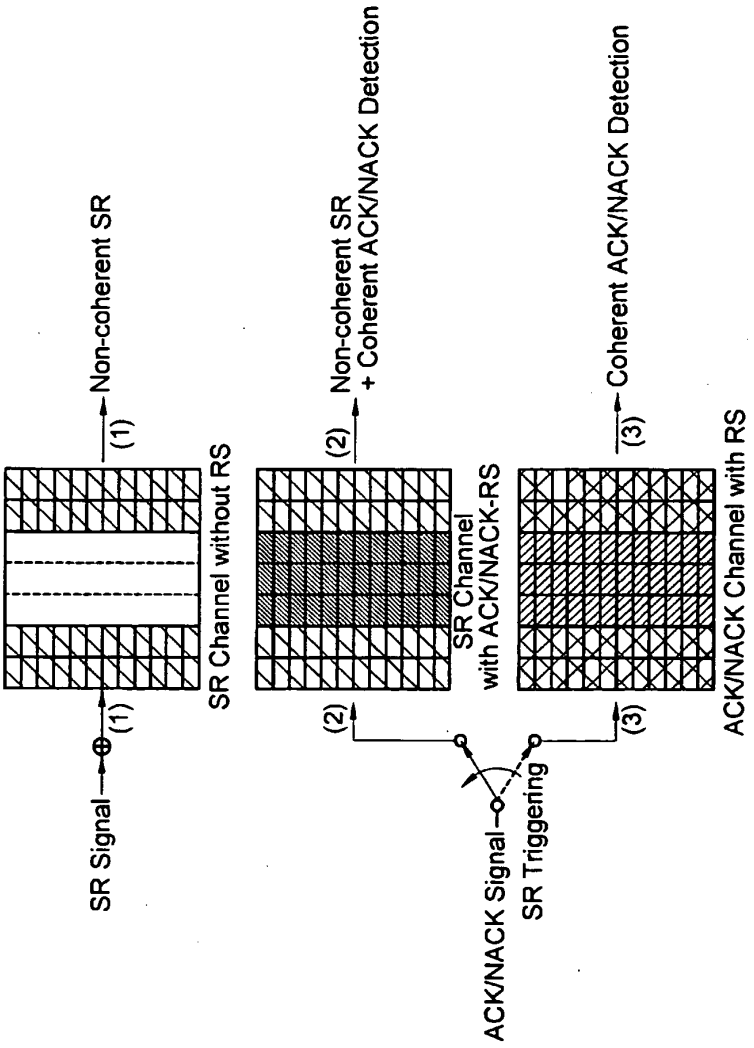
[Fig. 11]


Reserved Time-Domain
Sequence for SR signal
Code
Time
Freq.
Frequency Domain Sequence
SR channel

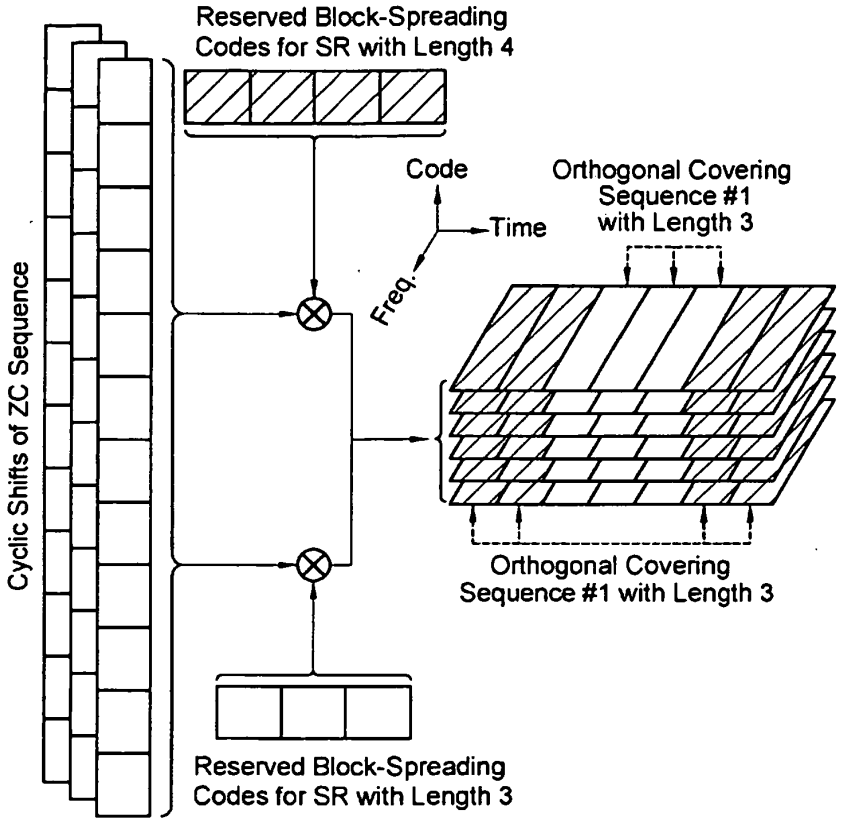
[Fig. 12]


Freq.
Time
Code
Reserved Time-Frequency Domain
Sequence(s) For SR signal
SR channel

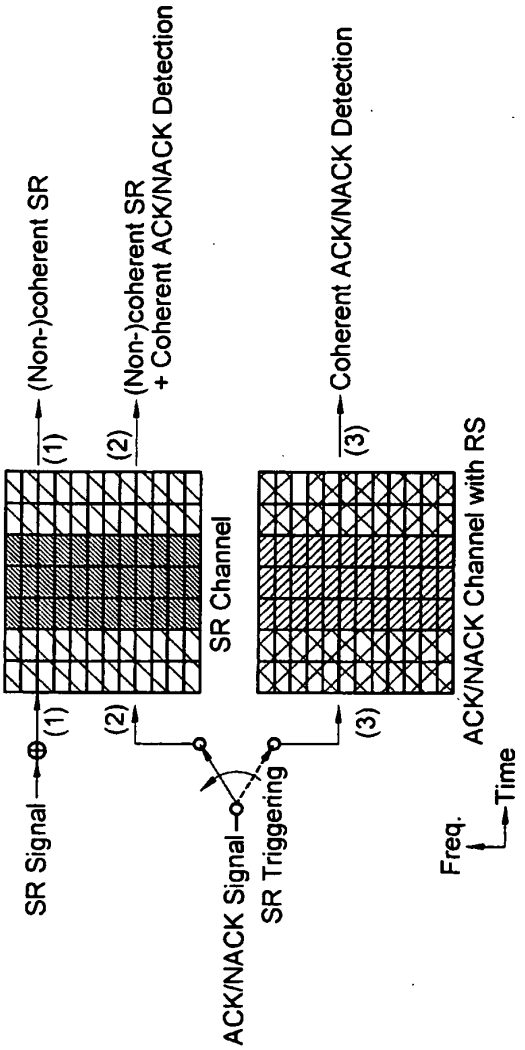
[Fig. 13]


Non-coherent SR
(1)
SR Channel without RS
Non-coherent SR
+ Coherent ACK/NACK Detection
(2)
SR Channel
with ACK/NACK-RS
Coherent ACK/NACK Detection
(3)
ACK/NACK Channel with RS
(1)
SR Signal
(2)
(3)
ACK/NACK Signal
SR Triggering

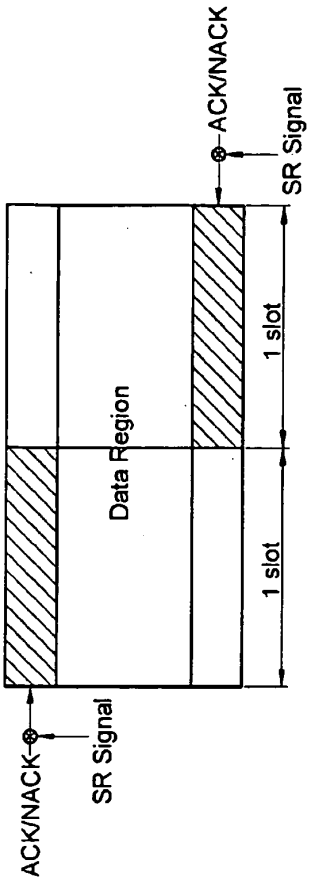
[Fig. 14]


Reserved Block-Spreading
Codes for SR with Length 4
Code
Time
Freq.
Orthogonal Covering
Sequence #1
with Length 3
Cyclic Shifts of ZC Sequence
Orthogonal Covering
Sequence #1 with Length 3
Reserved Block-Spreading
Codes for SR with Length 3

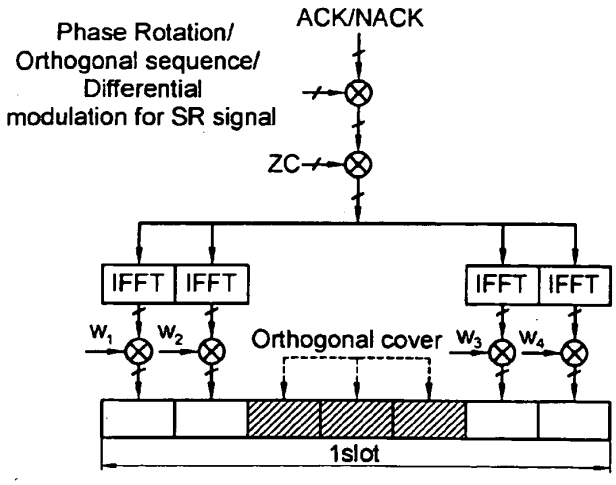
[Fig. 15]


(Non-)coherent SR
(Non-)coherent SR
+ Coherent ACK/NACK Detection
Coherent ACK/NACK Detection
(1)
(2)
(3)
SR Channel
ACK/NACK Channel with RS
SR Signal
ACK/NACK Signal
SR Triggering
Freq.
Time

[Fig. 16]


ACK/NACK
SR Signal
1 slot
Data Region
1 slot
ACK/NACK
SR Signal

[Fig. 17]


Phase Rotation/
Orthogonal sequence/
Differential
modulation for SR signal
ACK/NACK
ZC
IFFT
IFFT
IFFT
IFFT
W1
W2
Orthogonal cover
W3
W4
1slot

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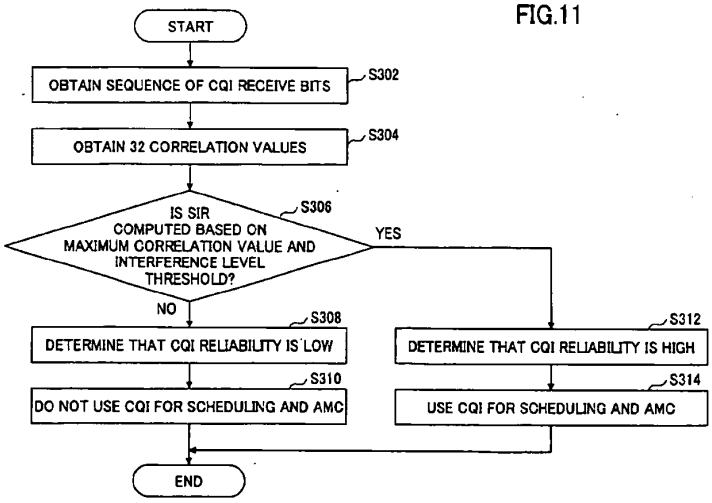
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(54) BASE STATION DEVICE AND COMMUNICATION CONTROL METHOD

(57) A base station apparatus for communicating to a mobile station over an uplink shared channel includes a transmit instruction unit configured to assign an uplink shared channel to the mobile station and instruct the mobile station to conduct transmissions over the assigned uplink shared channel; a measurement unit configured to measure a radio quality of the assigned uplink shared channel; and a determination unit configured to determine based on the radio quality whether the mobile station has transmitted data over the assigned uplink shared channel. In addition, a communication control method at a base station apparatus for communicating to a mobile station over an uplink shared channel includes assigning an uplink shared channel to the mobile station and instructing the mobile station to conduct transmissions over the assigned uplink shared channel; measuring a radio quality of the uplink shared channel assigned to the mobile station; and determining based on the radio quality whether the mobile station has transmitted data over the assigned uplink shared channel.

FIG.11



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Description

TECHNICAL FIELD

[0001] The present invention relates to base station apparatuses and communication control methods to which OFDM (Orthogonal Frequency Division Multiplexing) is applied in downlinks.

BACKGROUND ART

[0002] A communication scheme serving as a successor of W-CDMA and HSDPA, that is, a LTE (Long Term Evolution) system has been and is being discussed by a W-CDMA standardization organization 3GPP. In the LTE system, an OFDM scheme and a SC-FDMA (Single-Carrier Frequency Division Multiple Access) scheme are being investigated as downlink and uplink radio access schemes, respectively. See 3GPP TR 25.814 (V7.0.0), "Physical Layer Aspects for Evolved UTRA", June 2006, for example.

[0003] In the OFDM scheme, a frequency band is segmented into multiple smaller frequency bands (subcarriers), and data is carried and transmitted over the individual subcarriers. According to the OFDM scheme, the subcarriers are densely arranged on the frequency band in such a manner that the subcarriers are partially overlapped with each other without mutual interference, resulting in fast transmission and highly efficient utilization of the frequency band.

[0004] In the SC-FDMA scheme, a frequency band is segmented, and different frequency bands are used among multiple terminals for transmission, resulting in reduced interference among the terminals. According to the SC-FDMA scheme, variations in transmit power are reduced, resulting in lower power consumption for the terminals and wider coverage.

[0005] The above-mentioned LTE system uses shared channels in uplinks and downlinks. For example, in uplink, a base station apparatus selects mobile stations to communicate to the base station apparatus using the shared channel for each subframe (each 1 ms) and uses downlink control channels to instruct the selected mobile stations to communicate over the shared channel in certain subframes. The mobile stations transmit the shared channels in accordance with the downlink control channels. The base station apparatus receives and decodes the shared channels transmitted from the mobile stations. The above-mentioned selection of mobile stations to communicate over the shared channels is called as scheduling.

[0006] Also, AMC (Adaptive Modulation and Coding) is applied to the LTE system, and thus different transmission formats for the shared channels are used for different subframes. The transmission formats may include assignment information of resource blocks, which corresponds to frequency resources, modulation schemes, payload sizes, HARQ related information such as redundancy version parameters and process numbers, and/or MIMO related information such as reference signal sequences for MIMO application, for example.

[0007] In the LTE, identification information of the mobile stations communicating over the shared channels in the subframes and the transmission formats of the shared channels are transmitted over physical downlink control channels (PDCCHs). The PDCCH may be also referred to as DL L1/L2 control channels.

[0008] In a MAC layer of the LTE, HARQ (Hybrid Automatic Repeat reQeust) is applied in both uplinks and downlinks. For example, the mobile stations transmit acknowledgement information in uplinks based on CRC check results of DL-SCH. The base station apparatus controls retransmissions depending on the acknowledgement information. The acknowledgement information is represented as either of a positive response (ACK) indicating that transmitted signals have been successfully received or a negative response (NACK) indicating that the transmitted signals have not been successfully received. Also, the base station apparatus transmits acknowledgement information in downlinks based on CRC check results of UL-SCH. The mobile station controls retransmission depending on the acknowledgement information. The acknowledgement information is represented as either of a positive response (ACK) indicating that transmitted signals have been successfully received or a negative response (NACK) indicating that the transmitted signals have not been successfully received.

DISCLOSURE OF INVENTION

[PROBLEM TO BE SOLVED BY THE INVENTION]

[0009] In the above-mentioned scheduling and HARQ operations, if PDCCHs for transmitting the identification information of mobile stations communicating over uplink shared channels and transmission formats for the shared channels are erroneously decoded at a mobile station, the mobile station may not transmit the uplink shared channels. On the other hand, the base station apparatus reserves the uplink shared channels for that mobile station, resulting in inefficient utilization of resources.

[0010] Also, if PDCCHs for transmitting the identification information of mobile stations communicating over downlink

shared channels and transmission formats for the shared channels are erroneously decoded at a mobile station, the mobile station fails to receive the downlink shared channels and accordingly does not transmit acknowledgement information for those downlink shared channels. In this case, the base station apparatus has to determine whether the mobile station has actually transmitted the acknowledgement information. The acknowledgement information does not include an error check function such as CRC. Thus, if the determination is not made at the base station apparatus, the acknowledgement information would be determined to be either ACK or NACK, and particularly the determination that the acknowledgement information is ACK may be problematic.

[0011] Thus, the present invention addresses the above-mentioned problem, and one object of the present invention is to provide a base station apparatus and a communication control method that can perform scheduling and HARQ operations properly in uplinks and downlinks of LTE systems.

[MEANS FOR SOLVING THE PROBLEM]

[0012] In order to the above-mentioned problem, one aspect of the present invention relates to a base station apparatus for communicating to a mobile station over an uplink shared channel, including: a transmit instruction unit configured to assign an uplink shared channel to the mobile station and instruct the mobile station to conduct transmissions over the assigned uplink shared channel; a measurement unit configured to measure a radio quality of the assigned uplink shared channel; and a determination unit configured to determine based on the radio quality whether the mobile station has transmitted data over the assigned uplink shared channel.

[0013] A further one aspect of the present invention relates to a communication control method at a base station apparatus for communicating to a mobile station over an uplink shared channel, the method including: assigning an uplink shared channel to the mobile station and instructing the mobile station to conduct transmissions over the assigned uplink shared channel; measuring a radio quality of the uplink shared channel assigned to the mobile station; and determining based on the radio quality whether the mobile station has transmitted data over the assigned uplink shared channel.

[0014] A still further one aspect of the present invention relates to a communication control method at a base station apparatus for communicating to a mobile station over uplink and downlink shared channels, the method including: determining based on a radio quality of an uplink shared channel assigned to the mobile station whether the mobile station has transmitted data over the uplink shared channel; and if it is determined in the determining step that the mobile station has not transmitted data over the uplink shared channel, receiving downlink radio quality information or acknowledgement information to a downlink shared channel, which are mapped into an uplink control channel.

[ADVANTAGE OF THE INVENTION]

[0015] According to the embodiments of the present invention, it is possible to provide a base station apparatus and a communication control method that can perform scheduling and HARQ operations properly in uplinks and downlinks of LTE systems.

BRIEF DESCRIPTION OF DRAWINGS

[0016]

FIG. 1 is a block diagram illustrating a radio communication system according to one embodiment of the present invention;

FIG. 2 is a schematic diagram illustrating a relationship between PUCCHs and PUSCHs according to one embodiment of the present invention;

FIG. 3 is a schematic diagram illustrating an arrangement of a slot and a subframe according to one embodiment of the present invention;

FIG. 4 is a partial block diagram illustrating a base station apparatus according to one embodiment of the present invention;

FIG. 5 is a first schematic diagram illustrating a temporal relationship between operations at a base station apparatus and a mobile station according to one embodiment of the present invention;

FIG. 6 is a second schematic diagram illustrating a temporal relationship between operations at the base station apparatus and the mobile station according to one embodiment of the present invention;

FIG. 7 is a third schematic diagram illustrating a temporal relationship between operations at the base station apparatus and the mobile station according to one embodiment of the present invention;

FIG. 8A is a partial block diagram illustrating a baseband signal processing unit in the base station apparatus according to one embodiment of the present invention;

FIG. 8B is a partial block diagram illustrating the layer 1 processing unit in the base station apparatus according to one embodiment of the present invention;
FIG. 8C is a partial block diagram illustrating the layer 1 processing unit in the base station apparatus according to one embodiment of the present invention;
FIG. 8D is a partial block diagram illustrating the layer 1 processing unit in the base station apparatus according to one embodiment of the present invention;
FIG. 9 is a flowchart illustrating a transmission determination method according to one embodiment of the present invention;
FIG. 10 is a flowchart illustrating an acknowledgement determination method according to one embodiment of the present invention;
FIG. 11 is a flowchart illustrating a CQI reliability determination method according to one embodiment of the present invention;
FIG. 12 is a flowchart illustrating an acknowledgement information reception method according to one embodiment of the present invention;
FIG. 13 illustrates exemplary segmentation of resources in PUCCH; and
FIG. 14 is a flowchart illustrating a CQI reception method according to one embodiment of the present invention.

LIST OF REFERENCE SYMBOLS

[0017]

200: base station apparatus
202: transmit and receive antenna
204: amplification unit
206: transmitting and receiving unit
208: baseband signal processing unit
210: call processing unit
212: channel interface
2081: layer 1 processing unit
2082: MAC processing unit
2083: RLC processing unit

BEST MODE FOR CARRYING OUT THE INVENTION

[0018] Best modes for carrying out the present invention are described below in conjunction with embodiments with reference to the accompanying drawings.

[0019] Throughout all the drawings for illustrating the embodiments, elements and components having the same function are referred to as the same reference numerals and are not repeatedly described.

[Description of radio communication system and communication channels]

[0020] A radio communication system where a base station apparatus according to one embodiment of the present invention is used is described with reference to FIG. 1.

[0021] A radio communication system 1000 may be an Evolved UTRA and UTRAN (also referred to as Long Term Evolution or Super 3G) applied system and includes a base station apparatus eNB (eNode B) 200 and multiple mobile station apparatuses or user equipment (UE) 100_n (100_1, 100_2, 100_3, ..., 100_n where n is a positive integer). The base station apparatus 200 is connected to an upper station such as an access gateway apparatus 300, which is connected to a core network 400. In this embodiment, the mobile station apparatuses 100_n communicate to the base station apparatus 200 within a cell 50 in accordance with the Evolved UTRA and UTRAN.

[0022] Hereinafter, unless specifically stated otherwise, it is assumed that the mobile stations 100_n have the same arrangement, function and state.

[0023] In the radio communication system 1000, the OFDM and the SC-FDMA are used as radio access schemes in downlinks and uplinks, respectively. As mentioned above, the OFDM is a scheme where a frequency band is segmented into smaller frequency bands (subcarriers) and data is transferred over the individual subcarriers. The SC-FDMA is a scheme where a frequency band is segmented and segmented different frequency bands are used among multiple terminals for transmission, resulting in reduction in interference among the terminals.

[0024] Communication channels in the Evolved UTRA and UTRAN are described below.

[0025] For downlinks, a PDSCH (Physical Downlink Shared Channel) shared among the mobile station apparatuses

100_n and a PDCCH (Physical Downlink Control Channel) for LTE are used. In the downlinks, the LTE PDCCH is used to transmit information on users which PDSCH is transmitted to and transport formats of the PDSCH, information on users which transmits PUSCH (Physical Uplink Shared Channel) and transport formats, acknowledgement information for the PUSCH or others. Also, user data is transmitted in PDSCH. The user data is transmitted in a DL-SCH (Downlink-Share Channel) as a transport channel.

[0026] The above-mentioned information on users which PDSCH is transmitted and transport formats of the PDSCH may be referred to as downlink scheduling information, downlink scheduling grant or downlink assignment information. Also, the above-mentioned information on users which transmits PUSCH and transport formats of the PUSCH may be referred to as uplink scheduling grant.

[0027] For uplinks, the PUSCH (Physical Uplink Shared Channel) shared among the mobile station apparatuses 100_n and a LTE control channel are used. As illustrated in FIG. 2, the control channel includes two types of channels, a channel time-multiplexed with the PUSCH and a channel frequency-multiplexed with the PUSCH. The frequency-multiplexed channel is referred to as a PUCCH (Physical Uplink Control Channel). The time-multiplexed channel may be mapped into the top of a subframe as illustrated in FIG. 2 or into any other position within the subframe. For example, the time-multiplexed channel may be mapped into a SC-FDMA symbol near a SC-FDMA symbol into which a demodulation reference signal is mapped.

[0028] In the uplinks, the LTE PUCCH is used to transmit downlink quality information (CQI: Channel Quality Indicator) used for scheduling of the PDSCH and AMC (Adaptive Modulation and Coding) and acknowledgement information for the PDSCH (HARQ ACK information). Also, the PUSCH is used to transmit user data. The user data is transmitted in a UL-SCH (Uplink-Shared Channel) as a transport channel.

[0029] For uplink transmissions, seven SC-FDMA symbols are used per slot. A single subframe consists of two slots. Thus, the single subframe consists of 14 SC-FDMA symbols as illustrated in FIG. 3. A demodulation reference signal (demodulation RS) for data demodulation is mapped into two of the 14 SC-FDMA symbols. Also, a sounding reference signal (sounding RS) used to determine a transmission format for the PUSCH, such as scheduling, uplink AMC and TPC, is transmitted in one of the 14 SC-FDMA symbols other than the two SC-FDMA symbols assigned for the demodulation RS. However, the sounding RS does not have to be mapped into all subframes. In the SC-FDMA symbols for transmitting the sounding RS, sounding RSs from multiple mobile stations are multiplexed in accordance with CDM (Code Division Multiplexing). For example, the demodulation RSs may be mapped into the fourth and eleventh SC-FDMA symbols within one subframe. Also, the sounding RS may be mapped into the first SC-FDMA symbol within one subframe, for example.

[0030] Note that in addition to the above-mentioned CDM, block spread multiplexing may be applied.

[0031] As illustrated in FIG. 3, a data modulation reference signal together with data is transmitted in uplink transmissions. Thus, it can be determined whether a data transmission is occurring by only checking the demodulation reference signal.

[Arrangement of base station apparatus]

[0032] The base station apparatus 200 according to one embodiment of the present invention is described with reference to FIG. 4.

[0033] In this embodiment, the base station apparatus 200 includes a transmit and receive antenna 202, an amplification unit 204, a transmitting and receiving unit 206, a baseband signal processing unit 208, a call processing unit 210 and a channel interface 212.

[0034] User data transmitted from the base station apparatus 200 to the mobile station 100_n in downlinks is supplied to the baseband signal processing unit 208 from an upper station of the base station apparatus 200, such as the access gateway apparatus 300, via the channel interface 212.

[0035] The baseband signal processing unit 208 performs transmission operations in a PDCP layer, transmission operations in a RLC layer such as segmentation and concatenation of the user data and RLC (Radio Link Control) retransmission control, MAC (Medium Access Control) retransmission control such as HARQ (Hybrid Automatic Repeat reQuest) transmission operations, scheduling, transmission format selection, and/or channel decoding, IFFT (Inverse Fast Fourier Transform) and forwards the resulting data to the transmitting and receiving unit 206. Also, The baseband signal processing unit 208 performs transmission operations such as channel coding and IFFT on signals in the PDCCH serving as a downlink control channel and forwards the resulting signal to the transmitting and receiving unit 206.

[0036] The transmitting and receiving unit 206 performs frequency conversion for converting base band signals supplied from the baseband signal processing unit 208 into a radio frequency band, which is subsequently amplified at the amplification unit 204 and transmitted via the transmit and receive antenna 202.

[0037] On the other hand, for data transmitted from the mobile station 100_n to the base station apparatus 200 in uplinks, a radio frequency signal received at the transmit and receive antenna 202 is amplified at the amplification unit 204 and frequency-converted into a baseband signal at the transmitting and receiving unit 206. Then, the baseband

signal is supplied to the baseband signal processing unit 208.

[0038] The baseband signal processing unit 208 performs a FFT operation, an IDFT operation, error correction decoding, a reception operation for MAC retransmission control, a reception operation at the RLC layer and/or a reception operation at the PDCP layer on user data in the supplied baseband signal and supplies the resulting signal to the access gateway apparatus 300 via the channel interface 212.

[0039] As will be described with reference to FIG. 5, the baseband signal processing unit 208 evaluates power of the uplink shared channel and determines whether the mobile station has actually transmitted the uplink shared channel. Uplink resource management is performed based on the determination.

[0040] FIG. 5 illustrates the above-mentioned operations of the mobile station 100_n and the base station apparatus 220 from the temporal viewpoint. As illustrated in FIG. 5A, for example, at step 1002, the base station apparatus 200 informs the mobile station 100_n in subframe #i of an ID for a user communicating over the PUSCH in subframe #i+3 and/or transport format information for the user data, that is, the uplink scheduling grant. At step 1004, the mobile station 100_n receives a PDCCH in subframe #i. At step 1006, if the ID for the user communicating over the PUSCH in subframe #i+3 within the PDCCH matches the ID of the mobile station 100_n, the mobile station 100_n transmits a PUSCH in subframe #i+3 based on the transport format information in the PDCCH, that is, the uplink scheduling grant. At step 1008, the base station apparatus 200 receives the PUSCH in the subframe #i+3 from the mobile station which the base station apparatus 200 informs that the mobile station should communicate over the PUSCH at timing 1002.

[0041] As illustrated in FIG. 5B, if the mobile station 100_n fails to receive the PDCCH (1012) from the base station apparatus 200 successfully at step 1014, the mobile station 100_n does not transmit the PUSCH in subframe #i+3 at step 1016. As a result, at step 1018, the base station apparatus 200 would fail to receive the PUSCH in subframe #i+3 from the mobile station 100_n. Thus, the base station apparatus 200 could make power determination for the uplink shared channel by checking the data demodulation reference signal at steps 1008 and 1018.

[0042] In the above-mentioned example, the power determination is made for the PUSCH corresponding to the uplink scheduling grant, which is the ID for the user communicating over the PUSCH and/or the transport format information for the user data. The uplink scheduling grant is transmitted to the mobile station 100_n in subframe #i. In other embodiments, the same power determination can be applied to a PUSCH (UL-SCH) retransmitted in response to a NACK being transmitted as acknowledgement information to the PUSCH (UL-SCH). Exemplary operations of the mobile station 100_n and the base station apparatus 200 in this case are described with reference to FIG. 6.

[0043] As illustrated FIG. 6A, for example, the base station apparatus 200 informs the mobile station 100_n in a PDCCH in subframe #i of an ID for a user communicating over a PUSCH in subframe #i+3 and/or transport format information for the user data, that is, uplink scheduling grant at step 1202. At step 1204, the mobile station 100_n receives the PDCCH in subframe #i. At step 1206, if the ID for the user communicating over the PUSCH in subframe #i+3 matches the ID of the mobile station 100_n, the mobile station 100_n transmits a PUSCH in subframe #i+3 based on the transport format information within the PDCCH, that is, uplink scheduling grant. At step 1208, the base station apparatus 200 receives the PUSCH in subframe #i+3 from the mobile station which the base station apparatus 200 informs that the mobile station should communicate over the PUSCH in subframe #i+3, and determines that the decoding has been unsuccessful, that is, determines that the CRC check result is NG. In this case, at step 1210, the base station apparatus 200 transmits NACK as acknowledgement information to the PUSCH (UL-SCH as a transport channel) to the mobile station 100_n. Since the mobile station 100_n receives the NACK at step 1212, the mobile station 100_n transmits a PUSCH at a predefined timing, that is, in subframe #i+9 at step 1214. At step 1216, the base station apparatus 200 receives the PUSCH from the mobile station 100_n to which it transmitted the NACK.

[0044] As illustrated in FIG. 6B, for example, the base station apparatus 200 informs the mobile station 100_n in a PDCCH in subframe #i of an ID for a user communicating over a PUSCH in #i+3 subframe and/or transport format information for the user data, that is, uplink scheduling grant at step 1222. At step 1224, the mobile station 100_n receives the PDCCH in subframe #i. At step 1226, if the ID for the user communicating over the PUSCH in subframe #i+3 matches the ID of the mobile station 100_n, the mobile station 100_n transmits the PUSCH in subframe #i+3 based on the transport format information in the PDCCH, that is, the uplink scheduling grant. At step 1228, the base station apparatus 200 receives the PUSCH in subframe #i+3 from the mobile station 100_n which the base station apparatus 200 informs that the mobile station 100_n should communicate over the PUSCH and determines that the decoding has been unsuccessful, that is, determines that the CRC check result is NG. In this case, at step 1230, the base station apparatus 200 transmits a NACK as acknowledgement information (UL-SCH as a transport channel) to the mobile station 100_n. If the mobile station 100_n erroneously determines the NACK as ACK at step 1232, the mobile station 100_n does not transmit the PUSCH in subframe #i+9 at step 1234. As a result, the base station apparatus 200 would not also receive the PUSCH in subframe #i+9 from the mobile station 100_n at step 1236. Thus, the base station apparatus 200 could conduct power determination (power detection) of the uplink shared channel by checking the data demodulation reference signal at steps 1216 and 1236.

[0045] In addition, as will be illustrated with reference to FIG. 7, the baseband signal processing unit 208 makes the power determination for a predefined portion of the received signal and determines whether the mobile station 100_n has

actually transmitted acknowledgement information. A transmission operation of MAC retransmission control is performed based on the determination. An exemplary case where the PUSCH is not transmitted from the mobile station 100_n in a subframe and acknowledgement information is transmitted is described below. In this case, the acknowledgement information is transmitted in a PUCCH being a control channel frequency-multiplexed with the PUSCH.

[0046] FIG. 7 illustrates the above-mentioned operations of the mobile station 100_n and the base station apparatus 200 from a temporal viewpoint. As illustrated in FIG. 7A, for example, the base station apparatus 200 informs the mobile station 100_n over a PDCCH in subframe #i of an ID for a user communicating over a PDSCH in subframe #i and/or transport format information for the user data, that is downlink scheduling information at step 1102. At step 1102, the base station apparatus 200 also transmits a PDSCH corresponding to the downlink scheduling information to the mobile station 100_n in subframe #i. At step 1104, the mobile station 100_n receives the PDCCH in subframe #i. At step 1104, if the ID for the user communicating over the PDSCH in subframe #i within the PDCCH matches the ID of the mobile station 100_n, the mobile station 100_n receives the PDSCH based on the transport format information in the PDCCH, that is, downlink scheduling information. At step 1106, the mobile station 100_n transmits acknowledgement information over an uplink control channel PUCCH in subframe #i+3 based on the CRC check result at reception of the PDSCH at step 1104. At step 1108, the base station apparatus 200 receives the acknowledgement information from the mobile station 100_n which the base station apparatus 200 informs at step 1102 that the mobile station 100_n should communicate over the PDSCH in subframe #i.

[0047] As illustrated in FIG. 7B, if the mobile station 100_n fails to receive the PDCCH transmitted (1112) from the base station apparatus 200 at step 1114, the mobile station 100_n does not receive the PDSCH and thus does not transmit acknowledgement information based on the CRC check result at reception of the PDSCH in subframe #i+3 at step 1116. Accordingly, the base station apparatus 200 also would not receive the PUCCH in subframe #i+3 from the mobile station 100_n at step 1118. As a result, the base station apparatus 200 can make a SIR determination for the acknowledgement information by checking the data demodulation reference signal at steps 1108 and 1118. In other words, the base station apparatus can determine whether the mobile station 100_n has actually transmitted the acknowledgement information. Furthermore, the base station apparatus 200 can determine whether the mobile station 100_n has received downlink scheduling information.

[0048] The call processing unit 210 performs call operations such as communication channel setting or release, management of states of the radio base station 200 and/or radio resources.

[0049] An exemplary arrangement of the baseband signal processing unit 208 is described with reference to FIG. 8A.

[0050] As illustrated in FIG. 8A, the baseband signal processing unit 208 includes a layer 1 processing unit 2081, a MAC processing unit 2082 and a RLC processing unit 2083.

[0051] The layer 1 processing unit 2081, the MAC processing unit 2082 in the baseband signal processing unit 208, and the call processing unit 210 are coupled to each other.

[0052] The layer 1 processing unit 2081 performs channel coding and IFFT operations on shared channels transmitted in downlinks, reception operations, such as FFT and IDFT operations on shared channels transmitted in uplinks and channel decoding.

[0053] The layer 1 processing unit 2081 receives from the MAC processing unit 2082 an ID for a user communicating over a PDSCH and/or transport format information for the user data, that is, downlink scheduling information, and an ID for a user communicating over a PUSCH and/or transport format information for the user data, that is, uplink scheduling grant. Also, the layer 1 processing unit 2081 performs transmission operations such as channel coding and IFFT on the ID for the user communicating over the PDSCH and/or the transport format information for the user data, that is, the downlink scheduling information, and the ID for the user communicating over the PUSCH and/or the transport format information for the user data, that is, the uplink scheduling grant. The ID for the user communicating over the PDSCH and/or the transport format information for the user data, that is, the downlink scheduling information, and the ID for the user communicating over the PUSCH and/or the transport format information for the user data, that is, the uplink scheduling grant, are mapped into a PDCCH being a downlink control channel.

[0054] Also, the layer 1 processing unit 2081 demodulates and decodes acknowledgement information and CQI mapped into transmitted uplink control channels. If the layer 1 processing unit 2081 receives the acknowledgement information or the CQI for a mobile station that does not transmit user data in the subframe when the acknowledge information or the CQI is transmitted in uplinks, the layer 1 processing unit 2081 receives the acknowledgement information or the CQI mapped into PUCCHs placed at both ends of a system frequency band. Then, the layer 1 processing unit 2081 transmits the received acknowledgement information or CQI to the MAC processing unit 2082. The acknowledgement information consists of either of ACK, NACK or DTX, and the notation "DTX" means that the mobile station 100_n has not actually transmitted the acknowledgement information. A DTX determination method, that is, a determination method of determining whether the mobile station 100_n has actually transmitted the acknowledgement information is described below. The CQI is transmitted after performing reliability determination of the CQI as described below. In other words, only CQIs with higher reliability are transmitted to the MAC processing unit 2082 while CQIs with lower reliability are not transmitted to the MAC processing unit 2082.

[0055] As described with reference to FIG. 5 or FIG. 6, if the mobile station 100_n has not properly received the PDCCH into which the ID for the user communicating over the PUSCH or the transport format information for the user data is mapped or if the mobile station 100_n has erroneously determined NACK transmitted as the acknowledgement information to the uplink shared channel as ACK, the mobile station 100_n does not transmit the uplink shared channel. In this embodiment, the base station apparatus 200 determines whether the mobile station 100_n has actually transmitted the uplink shared channel through reception operations such as FFT or IDFT operations on the transmitted uplink shared channel and channel decoding.

[0056] The layer 1 processing unit 2081 determines whether the mobile station 100_n has actually transmitted the uplink shared channel in a subframe to be used by the mobile station 100_n to transmit the uplink shared channel. For example, the layer 1 processing unit 2081 measures a SIR of a data demodulation reference signal in the PUSCH to be transmitted, and if the SIR is higher than a predefined threshold, the layer 1 processing unit 2081 may determine that the mobile station 100_n has actually transmitted the uplink shared channel. On the other hand, if the SIR is lower than or equal to the predefined threshold, the layer 1 processing unit 2081 may determine that the mobile station 100_n has not actually transmitted the uplink shared channel. In general, it may be determined based on comparison between quality of received signals and a threshold whether the PUSCH has been transmitted. Then, the layer 1 processing unit 2081 transmits results of power determination for the PUSCH to the MAC processing unit 2082.

[0057] The quality of received signals may be any value as long as it is a measure indicative of the quality of received signals such as the above-mentioned SIR and a reception level.

[0058] Also, if the layer 1 processing unit 2081 determines in the power determination for the PUSCH that the mobile station 100_n has not actually transmitted the uplink shared channel, the layer 1 processing unit 2081 may transmit an ACK being positive acknowledgement to the mobile station 100_n as the acknowledgement information to the uplink shared channel. Some effects of transmitting the ACK to the mobile station 100_n are described below. If the UL-SCH power determination is erroneous, that is, if the mobile station 100_n has actually transmitted the PUSCH (UL-SCH) but the base station apparatus 200 erroneously determines that the mobile station 100_n has not transmitted it, the mobile station 100_n continues retransmission. On the other hand, the base station apparatus 200 may sometimes assign resource blocks used by the mobile station 100_n for the retransmissions to a new transmission by another mobile station (for example, mobile station 100_m ($m \neq n$)). In this case, the retransmission by the mobile station 100_n may conflict with the new transmission by the mobile station 100_m, which may significantly degrade characteristics of both the retransmission by the mobile station 100_n and the new transmission by the mobile station 100_m. As mentioned above, in the case where the positive acknowledgement ACK is transmitted as the acknowledgement information to the PUSCH (UL-SCH) for which it is determined that the mobile station 100_n has not actually transmitted the uplink shared channel, , the mobile station 100_n could be caused to stop the retransmission even if the mobile station 100_n has actually transmitted the PUSCH (UL-SCH), which may prevent the above-mentioned collision.

[0059] In the above-mentioned embodiment, the layer 1 processing unit 2081 makes the power determination based on the SIR of the data demodulation reference signal in the PUSCH to be transmitted. In other embodiments, in addition to the SIR of the data demodulation reference signal in the PUSCH to be transmitted, the power determination may be made based on the SIR of a data signal in the PUSCH to be transmitted. It is possible to improve accuracy of the power determination by using the SIRs of both the reference signal and the data signal.

[0060] Alternatively, the power determination may be made based on only the SIR of the data signal in the PUSCH to be transmitted rather than the SIR of the data demodulation reference signal in the PUSCH to be transmitted.

[0061] The threshold may be set based on transmit power of the mobile station 100_n. The transmit power of the mobile station 100_n may be transmitted to the mobile station 100_n as one information item in the uplink scheduling grant in the PDCCH, for example. Alternatively, the transmit power of the mobile station 100_n may be transmitted to the mobile station 100_n in association with payload size (data size) being one information item in the uplink scheduling grant. The association of the transmit power with the payload size means that correspondence between the transmit power and the payload size is predefined between the mobile station 100_n and the base station apparatus 200. More specifically, a greater threshold may be set if the transmit power is higher while a smaller threshold may be set if the transmit power is lower.

[0062] Alternatively, the threshold may be set based on power difference between the uplink shared channel and the sounding reference signal. More specifically, a greater threshold may be set if the power difference between the uplink shared channel and the sounding reference signal is larger while a smaller threshold may be set if the power difference between the uplink shared channel and the sounding reference signal is smaller.

[0063] Alternatively, the threshold may be set based on the modulation scheme for the uplink shared channel, for example. More specifically, a greater threshold may be set if the modulation scheme is 16QAM while a smaller threshold may be set if the modulation scheme is QPSK.

[0064] Alternatively, the threshold may be set based on MCS (Modulation and Scheme) level for the uplink shared channel. More specifically, a greater threshold may be set if the MCS level is higher while a smaller threshold may be set if the MCS level is lower. The MCS level may be defined based on at least one of a modulation scheme, a data size,

transmit power, a required SIR and the amount of frequency resources.

[0065] Alternatively, the threshold may be set based on the amount of frequency resources for the PUSCH to be transmitted, that is, a transmit bandwidth or the number of resource blocks. More specifically, a greater threshold may be set if the amount of frequency resources is larger while a smaller threshold may be set if the amount of frequency resources is smaller. In this embodiment, information regarding the frequency resources for the PUSCH to be transmitted, that is, information regarding the resource blocks, may be transmitted to a mobile station in a form of frequency resource assignment information or resource block assignment information being one information item in uplink scheduling grant within a PDCCH, for example. For a larger amount of frequency resources, power determination can be made with higher accuracy. On the other hand, if the power determination is false, the involved impact would be significant, and thus the power determination must be performed more rigorously. In contrast, for a smaller amount of frequency resources, the power determination cannot be made with insufficient accuracy. On the other hand, if the power determination is false, the involved impact would be insignificant, and thus the power determination must be performed less rigorously than the case of the larger amount of frequency resources. In order to satisfy such requirements, it may be advantageous to set the threshold for the power determination based on the amount of frequency resources for the PUSCH, that is, the transmit bandwidth or the number of resource blocks.

[0066] An exemplary arrangement of the layer 1 processing unit 2081 is described in detail with reference to FIG. 8B. The layer 1 processing unit 2081 includes a CP removal unit 208102, a FFT unit 208104, a subcarrier demapping unit 208106, a demultiplexer (DEMUX) unit 208108, a channel estimation unit 208109, frequency equalization units 208110A-208110C, IDFT units 208112A-208112C, a PUSCH (UL-SCH) decoding unit 208114A, a PUCCH (ACK/NACK) decoding unit 208114B, a PUCCH (CQI) decoding unit 208114C, a signal power estimation unit 208116A, an interference power estimation unit 208118A, a SIR computation unit 208120A, a PUSCH power determination unit 208122A and a threshold setting unit 208124A.

[0067] The CP removal unit 208102 removes an attached CP portion from an uplink baseband signal incoming from the transmitting and receiving unit 206 at a predefined timing and supplies the resulting signal to the FFT unit 208104.

[0068] The FFT unit 208104 converts the whole system bandwidth from temporal domain signals into frequency domain signals through Fast Fourier Transform and supplies the converted signals to the subcarrier demapping unit 208106.

[0069] The subcarrier demapping unit 208106 restores demapped subcarriers into a multiplexed signal, and the demultiplexer 208108 segments the multiplexed signal into certain blocks. Signals for uplink shared channels are supplied to the frequency equalization unit 208110A. Acknowledgement information mapped into PUCCHs is supplied to the frequency equalization unit 208110B. CQIs mapped into PUCCHs are supplied to the frequency equalization unit 208110C. Demodulation reference signals in the PUCCHs or the uplink shared channels are supplied to the channel estimation unit 208109.

[0070] The frequency equalization unit 208110A performs reception operations in accordance with channel compensation (restore phases turned in transmission into original transmit states) using channel estimation values from the channel estimation unit 208109. The resulting signals for uplink shared channels are decoded at the IDFT unit 208112A and the PUSCH (UL-SCH) decoding unit 208114A.

[0071] Signals subjected to IDFT processing at the IDFT unit 208112A are supplied to the signal power estimation unit 208116A and the interference power estimation unit 208118A.

[0072] The frequency equalization unit 208110B performs reception operations in accordance with channel compensation (restore phases turned in transmission into original transmit states) using channel estimation values from the channel estimation unit 208109. The resulting signals for acknowledgement information mapped into control channels are decoded at the IDFT unit 208112B and the PUCCH (ACK/NACK) decoding unit 208114B.

[0073] The frequency equalization unit 208110C performs reception operations in accordance with channel compensation (restore phases turned in transmission into original transmit states) using channel estimation values from the channel estimation unit 208109. The resulting signals for the CQIs mapped into control channels are decoded at the IDTF unit 208112C and the PUCCH (ACK/NACK) decoding unit 208114C.

[0074] The channel estimation unit 208109 derives the channel estimation values from uplink demodulation reference signals generated at the demultiplexer 208108. The channel estimation values are supplied to the frequency equalization units 208110A-208110C.

[0075] The signal power estimation unit 208116A derives a signal power level of the IDFT processed uplink shared channel supplied from the IDFT unit 208112A and supplies the derived signal power level to the SIR computation unit 208120A.

[0076] The interference power estimation unit 208116A derives an interference power level of a frequency band for transmitting the IDFT processed uplink shared channel supplied from the IDFT unit 208112A and supplies the derived interference power level to the SIR computation unit 208120A.

[0077] The SIR computation unit 208120A derives a SIR based on the signal power level received from the signal power estimation unit 208116A and the interference power level received from the interference power estimation unit 208118A and supplies the derived SIR to the PUSCH power determination unit 208122A.

[0078] The PUSCH power determination unit 208122A determines whether a mobile station has actually transmitted the uplink shared channel PUSCH based on comparison between the SIR supplied from the SIR computation unit 208120A and a threshold supplied from the threshold setting unit 208124A. In other words, the PUSCH power determination unit 208122A makes the determination as to whether the mobile station 100_n has actually transmitted the uplink shared channel as described above in conjunction with the layer 1 processing unit 2081 and performs operations for (1) UL-SCH power determination method as described below. The PUSCH power determination unit 208122A transmits to the MAC processing unit 2082 the determination result as to whether the mobile station has actually transmitted the uplink shared channel PUSCH.

[0079] Also, if the PUSCH power determination unit 208122A determines that the mobile station 100_n has not actually transmitted the uplink shared channel, the PUSCH power determination unit 208122A may determine that positive response ACK should be transmitted to the mobile station 100_n as acknowledgement information to the uplink shared channel. In this case, for example, the determination result that the positive response ACK should be transmitted to the mobile station 100_n is transmitted to the MAC processing unit 2082, which may perform transmission operations on the positive response ACK as a part of HARQ operations. Alternatively, the determination result that the positive response ACK should be transmitted to the mobile station 100_n is transmitted from the PUSCH power determination unit 208122A to a transmission operation executing part in the layer 1 processing unit 2081, which may perform transmission operations on the positive response ACK.

[0080] The threshold setting unit 208124A sets a threshold used for the determination at the PUSCH power determination unit 208122A and transmits the threshold to the PUSCH power determination unit 208122A.

[0081] In this embodiment, the threshold setting unit 208124A may set the threshold based on transmit power for use in the mobile station, as mentioned above. Alternatively, the threshold setting unit 208124A may set the threshold based on a modulation scheme for the uplink shared channel, as mentioned above. Alternatively, the threshold setting unit 208124A may set the threshold based on the MCS level for the uplink shared channel, as mentioned above. Alternatively, the threshold setting unit 208124A may set the threshold based on the amount of frequency resources for the uplink shared channel, as mentioned above. Alternatively, the threshold setting unit 208124A may set the threshold based on power difference between the uplink shared channel and a sounding reference signal, as mentioned above.

[0082] In this manner, the layer 1 processing unit 2081 in the base station apparatus 200 determines whether a mobile station has actually transmitted the PUSCH through the power determination for the PUSCH. The determination as to whether a mobile station has actually transmitted the PUSCH makes it possible to determine whether the mobile station has successfully received uplink scheduling grant within a PDCCH or acknowledgement information to the PUSCH within the PDCCH, as illustrated in FIGS. 5 and 6.

[0083] Also as illustrated with reference to FIG. 7, if a mobile station failed to receive an ID for a user communicating over a downlink shared channel and/or transport format information for the user data, that is, a PDCCH into which the downlink scheduling information is mapped, the mobile station does not receive the PDSCH and thus does not transmit the acknowledgement information at a predefined timing. In this embodiment, the layer 1 processing unit 2081 determines whether a mobile station has actually transmitted the acknowledgement information. Also in this embodiment, it is assumed that the PUSCH is not transmitted from a mobile station at a subframe and the acknowledgement information is transmitted instead. In other words, the case where the acknowledgement information is transmitted over a control channel PUCCH frequency-multiplexed with the PUSCH is described below.

[0084] The layer 1 processing unit 2081 determines whether the mobile station 100_n has actually transmitted the acknowledgement information in a subframe to transmit the acknowledgement information in a PUCCH. For example, the layer 1 processing unit 2081 measures a SIR for a data demodulation reference signal in the PUCCH into which the acknowledgement information may be mapped. If the SIR is higher than a predefined threshold, the layer 1 processing unit 2081 may determine that the mobile station 100_n has actually transmitted the acknowledgement information. On the other hand, if the SIR is lower than the predefined threshold, the layer 1 processing unit 2081 may determine that the mobile station 100_n has not actually transmitted the acknowledgement information. In general, the determination may be made through comparison between quality of a received signal and the threshold. For the quality of a received signal, any measure such as the above-mentioned SIR or receive level may be used as long as it indicates the quality of the received signal. Then, the layer 1 processing unit 2081 transmits a result of power determination on the acknowledgement information to the MAC processing unit 2082. Note that the determination as to whether the mobile station 100_n has actually transmitted the acknowledgement information is applicable even in any of the cases where only the acknowledgement information is transmitted, the acknowledgement information and CQI are multiplexed with each other and transmitted, and other control information items such as a scheduling request and a release request are multiplexed with each other and transmitted. In these cases, different thresholds may be set. Also, even if a joint coding scheme to encode the acknowledgement information and the CQI together is applied to multiplex the acknowledgement information with the CQI or even if a separate coding scheme to encode the acknowledgement information and the CQI separately is applied to multiplex the acknowledgement information with the CQI, the above-mentioned determination as to whether the mobile station 100_n has actually transmitted the acknowledgement information is still applicable.

[0085] In the case where only the acknowledgement information is transmitted, for example, the acknowledgement information may be transmitted in any of resources A illustrated in FIG. 13. Also in the case where the acknowledgment information and the CQI are multiplexed with each other and transmitted, for example, they may be transmitted in any of resources B illustrated in FIG. 13. Multiple resources are multiplexed in FIG. 13, but any of multiplexing schemes such as CDM, block spreading multiplexing, frequency multiplexing, time multiplexing or any combination thereof may be applied. In addition, the CDM may include Walsh CDM and CAZAC sequence CDM, for example.

[0086] For example, a threshold used for the power determination in the case of transmission of the multiplexed acknowledgement and the CQI may be set to be greater than that in the case of transmission of only the acknowledgement information. More specifically, in the case of transmission of the multiplexed acknowledgement information and CQI, if a mobile station has failed to successfully receive a PDCCH transmitted (1112) by the base station apparatus 200 (1114), the mobile station would transmit only the CQI. In this case, the layer 1 processing unit 2081 has to determine a difference between the power in the transmission of only the CQI and the power in the transmission of the multiplexed acknowledgement information and CQI. To this end, a greater threshold would be set than that for the power determination in the transmission of only the acknowledgement information.

[0087] In this embodiment, the layer 1 processing unit 2081 makes the power determination based on the SIR for the data demodulation reference signal in the PUCCH to be transmitted. In other embodiments, in addition to the SIR for the data demodulation reference signal in the PUCCH to be transmitted, the layer 1 processing unit 2081 may make the power determination based on the acknowledgement information to be transmitted or the SIR of a signal sequence of the multiplexed acknowledgement information and the CQI if the CQI is multiplexed. By using both the SIR of the reference signal and the SIR of the signal sequence of the acknowledgement information and the CQI, the accuracy of the power determination can be improved.

[0088] Alternatively, the power determination may be made based on the acknowledgement information to be transmitted or only the SIR for the signal sequence of the multiplexed acknowledgement information and CQI if the CQI is multiplexed rather than the SIR for the data demodulation reference signal in the PUCCH to be transmitted.

[0089] An exemplary arrangement of the layer 1 processing unit 2081 is described in detail with reference to FIG. 8C. The layer 1 processing unit 2081 includes a CP removal unit 208102, a FFT unit 208104, a subcarrier demapping unit 208106, a demultiplexer (DEMUX) unit 208108, a channel estimation unit 208109, frequency equalization units 208110A-208110C, IDFT units 208112A-208112C, a PUSCH (UL-SCH) decoding unit 208114A, a PUCCH (ACK/NACK) decoding unit 208114B, a PUCCH (CQI) decoding unit 208114C, a signal power estimation unit 208116B, an interference power estimation unit 208118B, a SIR computation unit 208120B, a PUCCH power determination unit 208126B and a threshold setting unit 208124B.

[0090] The components other than the IDFT unit 208112B, the signal power estimation unit 208116B, the interference power estimation unit 208118B, the SIR computation unit 208120B, the PUCCH power determination unit 208126B and the threshold setting unit 208124B are the same as those in FIG. 8B and thus are not repeatedly described.

[0091] The IDFT unit 208112B performs IDFT on signals subjected to reception operations through channel compensation at the frequency equalization unit 208110B and supplies the resulting signals to the PUCCH (ACK/NACK) decoding unit 208114B. Also, the IDFT unit 208112B supplies the IDFT processed signals to the signal power estimation unit 208116B and the interference power estimation unit 208118B.

[0092] The signal power estimation unit 208116B derives a signal power level of the IDFT processed uplink control channel received from the IDFT unit 208112B and supplies the derived signal power level to the SIR computation unit 208120B.

[0093] The interference power estimation unit 208116B derives an interference power level after the IDFT processing of a frequency band for transmitting the uplink control channel received from the IDFT unit 208112B and supplies the derived interference power level to the SIR computation unit 208120B.

[0094] The SIR computation unit 208120B derives a SIR based on the signal power level supplied from the signal power estimation unit 208116B and the interference power level supplied from the interference power estimation unit 208118B and supplies the derived SIR to the PUCCH power determination unit 208126B.

[0095] The PUCCH power determination unit 208126B determines whether a mobile station has actually transmitted acknowledgement information over a PUCCH based on comparison between the SIR supplied from the SIR computation unit 208120B and a threshold supplied from the threshold setting unit 208124B. In other words, the PUCCH power determination unit 208126B determines whether the mobile station 100_n has actually transmitted the acknowledgement information as described in conjunction with the layer 1 processing unit 2081 and (2) performs reception operations of HARQ ACK. The PUCCH power determination unit 208126B transmits the determination result to the MAC processing unit 2082.

[0096] The threshold setting unit 208124B sets a threshold used for the determination at the PUCCH power determination unit 208126B and transmits the threshold to the PUCCH power determination unit 208126B.

[0097] The operations as described with reference to FIG. 8C may be applied to the case of transmission of only the acknowledgement information over the PUCCH or to the case of transmission of the multiplexed acknowledgement

information downlink radio quality information CQI.

[0098] In this manner, the layer 1 processing unit 2081 in the base station apparatus 200 determines whether a mobile station has actually transmitted the acknowledgement information through the power determination for the acknowledgement information to the downlink shared channel in the PUCCH. The determination as to whether the mobile station has actually transmitted the acknowledgement information makes it possible to determine whether the mobile station has successfully received downlink scheduling information within the PDCCH, as illustrated in FIG. 7.

[0099] Also, the layer 1 processing unit 2081 performs reception operations on the CQI mapped into the PUCCH placed at both ends of the system band if the CQI is received for a mobile station that does not receive user data in uplinks in a subframe. At this time, the layer 1 processing unit 2081 may determine reliability of the CQI. In other words, the layer 1 processing unit 2081 measures a SIR of a sequence of received bits for the CQI in a PUCCH into which the CQI is mapped. If the SIR is higher than a predefined threshold, the layer 1 processing unit 2081 determines that the received CQI reliability is high, and on the other hand, if the SIR is lower than or equal to the predefined threshold, the layer 1 processing unit 2081 determines that the received CQI reliability is low. In general, the received CQI reliability may be determined depending on comparison between quality of received signals and a threshold. The quality of received signals may be any measure such as the SIR and a receive level as long as the measure indicates quality of the received signals. In this embodiment, the SIR of the sequence of received bits for the CQI may be for a bit sequence with the maximum correlation value, that is, a bit sequence with the maximum likelihood within the CQI bit sequence. Alternatively, the layer 1 processing unit 2081 may measure the SIR for a data demodulation reference signal in the PUCCH into which the CQI is mapped. Alternatively, the layer 1 processing unit 2081 may measure both the SIR for the data demodulation reference signal in the PUCCH into which the CQI is mapped and the SIR for the sequence of received bits for the CQI in the PUCCH into which the CQI is mapped. In this embodiment, as a result of the determination of the CQI reliability, the layer 1 processing unit 2081 may transmit only the CQI with high reliability to the MAC processing unit 2082 and does not transmit the CQI with insufficient reliability to the MAC processing unit 2082. In this case, the CQI with insufficient reliability would not be used in scheduling and AMC.

[0100] When the reliability is determined, the layer 1 processing unit 2081 may determine whether a mobile station has actually transmitted the CQI. If the layer 1 processing unit 2081 determines that the mobile station has not actually transmitted the CQI, the layer 1 processing unit 2081 may determine that an uplink of the mobile station is out of synchronization.

[0101] An exemplary arrangement of the layer 1 processing unit 2081 is described in detail with reference to FIG. 8D. The layer 1 processing unit 2081 includes a CP removal unit 208102, a FFT unit 208104, a subcarrier demapping unit 208106, a demultiplexer (DEMUX) unit 208108, a channel estimation unit 208109, frequency equalization units 208110A-208110C, IDFT units 208112A-208112C, a PUSCH (UL-SCH) decoding unit 208114A, a PUCCH (ACK/NACK) decoding unit 208114B, a PUCCH (CQI) decoding unit 208114C, a signal power estimation unit 208116C, an interference power estimation unit 208118C, a SIR computation unit 208120C, a PUCCH power determination unit 208126C and a threshold setting unit 208124C.

[0102] The components other than the IDFT unit 208112C, the signal power estimation unit 208116C, the interference power estimation unit 208118C, the SIR computation unit 208120C, the PUCCH power determination unit 208126C and the threshold setting unit 208124C are the same as those in FIG. 8B and thus are not repeatedly described.

[0103] The IDFT unit 208112C performs IDFT on signals subjected to reception operations through channel compensation at the frequency equalization unit 208110C and supplies the resulting signals to the PUCCH (ACK/NACK) decoding unit 208114C. Also, the IDFT unit 208112C supplies the IDFT processed signals to the signal power estimation unit 208116C and the interference power estimation unit 208118C.

[0104] The signal power estimation unit 208116C derives a signal power level of the IDFT processed uplink control channel received from the IDFT unit 208112C and supplies the derived signal power level to the SIR computation unit 208120C.

[0105] The interference power estimation unit 208118B derives an interference power level for the IDFT processed signals of a frequency band for transmitting the uplink control channel received from the IDFT unit 208112C and supplies the derived interference power level to the SIR computation unit 208120C.

[0106] The SIR computation unit 208120C derives a SIR based on the signal power level supplied from the signal power estimation unit 208116C and the interference power level supplied from the interference power estimation unit 208118C and supplies the derived SIR to the PUCCH power determination unit 208126C.

[0107] The PUCCH power determination unit 208126C determines reliability of radio quality information CQI for downlinks transmitted from a mobile station based on comparison between the SIR supplied from the SIR computation unit 208120C and a threshold supplied from the threshold setting unit 208124C. In other words, the PUCCH power determination unit 208126C determines the CQI reliability as described in conjunction with the layer 1 processing unit 2081 and (3) performs CQI reliability determination as describe below. The PUCCH power determination unit 208126C transmits the determination result of the CQI reliability to the MAC processing unit 2082 pending.

[0108] The threshold setting unit 208124C sets a threshold used for the determination at the PUCCH power determi-

nation unit 208126C and transmits the threshold to the PUCCH power determination unit 208126C.

[0109] The MAC processing unit 2082 receives reception results of the acknowledgement information and the CQI mapped into uplink control channels.

[0110] The MAC processing unit 2082 performs MAC retransmission control on downlink user data such as HARQ transmission operations, scheduling operations, selection operations of transmission formats and frequency resource assignment operations. The scheduling operation may mean selection of a mobile station that receives user data over a downlink shared channel in a subframe. The selection operation of transmission formats may mean determination of a modulation scheme, a coding rate and a data size for user data received at the mobile station selected in the scheduling operation. The determination of a modulation scheme, a coding rate and a data size may be made based on a CQI transmitted from the mobile station in uplinks, for example. In addition, the frequency resource assignment operation may mean to determine a resource block to be used for user data received at the mobile station selected in the scheduling operation. The resource block determination may be made based on the CQI transmitted from the mobile station in uplinks, for example. The MAC processing unit 2082 transmits to the layer 1 processing unit 2081 an ID for a user communicating over a PDSCH and/or transport format information for user data, that is, downlink scheduling information, which are determined in the scheduling operation, the transmission format selection operation and the frequency resource assignment operation.

[0111] The MAC processing unit 2082 performs reception operations for the MAC retransmission control over uplink user data, scheduling operations, transmission format selection operations, frequency resource assignment operations and/or others. The scheduling operation may mean selection of a mobile station to transmit user data over a shared channel in a certain subframe. The transmission format selection operation means to determine a modulation scheme, a coding rate and a data size for user data transmitted from the mobile station selected in the scheduling operation. The determination of a modulation scheme, a coding rate and a data size may be made based on a SIR, receive power and/or path loss for a sounding reference signal transmitted from the mobile station in uplinks, for example. The frequency resource assignment operation means to determine a resource block used to transmit user data from the mobile station selected in the scheduling operation. The resource block determination may be made based on the SIR for the sounding reference signal transmitted from the mobile station in uplinks, for example. Then, the MAC processing unit 2082 transmits to the layer 1 processing unit 2081 an ID for a user communicating over a PUSCH and/or transport format information for the user data, that is, uplink scheduling grant, as determined in the scheduling operation, the transport format selection operation and the frequency resource assignment operation.

[0112] The MAC processing unit 2082 receives results of the power determination for uplink shared channels from the layer 1 processing unit 2081. If it is determined in the power determination that the mobile station 100_n has not actually transmitted the uplink shared channel, the MAC processing unit 2082 determines that the mobile station 100_n failed to receive the previously transmitted corresponding PDCCH or that the mobile station 100_n failed to receive the previously transmitted corresponding acknowledgement information to the uplink shared channel, the MAC processing unit 2082 releases a retransmission resource assigned to the uplink shared channel. In this embodiment, the releasing of a resource means that the resource is reassigned to an uplink shared channel for another mobile station or to another uplink shared channel newly transmitted from the current mobile station. According to Evolved UTRA and UTRAN, synchronous HARQ is used in uplinks. Thus, the uplink shared channel is transmitted from the mobile station to the base station apparatus 200 at a predefined timing until it is successfully received or until the number of retransmissions reaches a maximum number of transmissions. On the other hand, if it is determined that the mobile station 100_n has not actually transmitted the uplink shared channel, all retransmission resources in subframes to be retransmitted in future are released for the uplink shared channel.

[0113] The MAC processing unit 2082 receives results of power determination for acknowledgement information mapped into PUCCHs that are frequency-multiplexed with PUSCHs and transmitted from the layer 1 processing unit 2081. Then, if it is determined as a result of the power determination that the mobile station 100_n has not actually transmitted the acknowledgement information, the MAC processing unit 2082 determines that the previously transmitted corresponding downlink shared channel has not been successfully received and retransmits information mapped into the previously transmitted corresponding downlink shared channel. For example, the MAC processing unit 2082 determines that the mobile station 100_n failed to receive not the shared channel but downlink scheduling information in a PDCCH attached thereto and then assumes the information mapped into the downlink shared channel as the previous transmission would be invalid. In other words, if the previous transmission corresponds to the first transmission, the current transmission may be also performed as the first transmission. Also, if the previous transmission corresponds to the second transmission, the current transmission may be also performed as the second transmission.

[0114] Also in the case where the power determination is negative (NACK) for the acknowledgement information transmitted in a PUCCH where the acknowledgement information is multiplexed with the CQI, the MAC processing unit 2082 may determine that the corresponding downlink transmission is invalid and transmit information mapped into the downlink shared channel. In other words, if the previous transmission corresponds to the first transmission, the current transmission may be also performed as the first transmission. Also, if the previous transmission corresponds to the

second transmission, the current transmission may be also performed as the second transmission.

[0115] Some reasons why the above-mentioned operations should be performed in the case where the power determination is negative (NACK) for the acknowledgement information transmitted in the PUCCH is described in detail below. For example, signals for the acknowledgement information may be embedded in demodulation reference signals in the PUCCH for transmitting the CQI as the multiplexing scheme of the acknowledgement information and the CQI. In this case, it may appear to the base station apparatus that the acknowledgement information is always transmitted independently of whether the mobile station has or has not actually transmitted the acknowledgement information. Thus, the base station apparatus cannot determine whether the mobile station has not received the shared channel or downlink scheduling information successfully. For this reason, the corresponding downlink transmission is determined to be invalid in consideration of unsuccessful reception of downlink scheduling information at the mobile station, and retransmission of the information mapped into downlink shared channels makes it possible to reduce occurrence frequency of events where the mobile station fails to receive the first transmission.

[0116] In the case where the power determination is negative (NACK) for the acknowledgement information transmitted in a PUCCH where the acknowledgement information is multiplexed with the CQI, the MAC processing unit 2082 does not always retransmit information mapped into the downlink shared channel as the corresponding downlink transmission being invalid. For the first reception of the NACK, the MAC processing unit 2082 may retransmit the information mapped into the downlink shared channel as the corresponding transmission being invalid. For the next reception of the NACK, the MAC processing unit 2082 may retransmit the information mapped into the downlink shared channel as the corresponding downlink transmission being valid. The fact that the corresponding downlink transmission is valid means that downlink scheduling information is successfully received at a mobile station and signals for the corresponding shared channel is received at the mobile station. For the determination of validity of the corresponding downlink transmission in the NACK reception, only the first NACK may be determined to be invalid and subsequent NACKs may be determined to be valid. Alternatively, odd numbered NACKs may be determined to be invalid while even numbered NACKS may be determined to be valid.

[0117] In addition, if a CQI with lower reliability is not transmitted in accordance with CQI reliability determination, the MAC processing unit 2082 may use the previous CQI as the CQI to be transmitted at the current timing.

[0118] The RLC processing unit 2083 performs transmission operations in a RLC layer on downlink packet data such as segmentation and concatenation and transmission operations for RLC retransmission control and/or reception operations in the RLC layer on uplink data such as segmentation and concatenation and reception operations for the RLC retransmission control. Also, the RLC processing unit 2083 may further perform operations in a PDCP layer.

[Procedure for uplink reception method]

[0119] Next, an exemplary uplink reception method at a base station apparatus is described below. Specifically, three types of uplink reception methods as presented below are described: UL-SCH power determination method (uplink shared channel power determination method), HARQ ACK reception method (Acknowledgement information reception method), and CQI reliability determination method.

(1) UL-SCH power determination method

[0120] A transmission determination method (UL-SCH power determination method) according to one embodiment of the present invention is described with reference to FIG. 9.

[0121] In the UL-SCH power determination method, after UL scheduling grant (an ID for a user communicating over a PUSCH and transport format information) is transmitted to the mobile station over a PDCCH, power determination is made as to whether the mobile station actually transmits the PUSCH (UL-SCH). In the initial transmission, it is detected whether a detection error of the UL scheduling grant in the PDCCH causes the PUSCH (UL-SCH) not to be transmitted from the mobile station. In retransmissions, it is detected whether erroneous detection of the acknowledgement information NACK to the UL-SCH in the PDCCH as ACK causes the PUSCH (UL-SCH) not to be transmitted from the mobile station UE.

[0122] A SIR_{data} is derived from a receive power level $DRSP_{data}$ and an interference wave level $Interference_{data}$ computed based on DM RS (demodulation reference signal) transmitted from the mobile station,

$$SIR_{data}=DRSP_{data}/Interference_{data},$$

where the suffix "data" means that the mobile station makes computation on a frequency band in which the PUSCH (UL-SCH) is transmitted.

[0123] An exemplary method of computing the interference wave level $Interference_{data}$ is described in detail below.

[0124] The interference wave level may be an instantaneous interference wave level in a relevant subframe or an interference wave level averaged over a longer time period such as 200 ms or 100 ms.

[0125] The interference wave level may be computed by averaging variances of demodulation reference signals transmitted from all mobile stations or by averaging variances of demodulation reference signals transmitted from the relevant mobile station. Alternatively, the interference wave level may be computed by averaging variances of sounding reference signals transmitted from all mobile stations or by averaging variances of sounding reference signals transmitted from the relevant mobile station.

[0126] Alternatively, the interference wave level may be determined by subtracting the receive power level of the demodulation reference signal from a total uplink receive power level including thermal noise. Also in this case, the interference wave level may be derived from signals transmitted from only the relevant mobile station or by averaging signals transmitted from all mobile stations.

[0127] The frequency band to compute the interference wave level may be an exact frequency band in which the PUSCH is transmitted or a frequency band near the frequency band in which the PUSCH is transmitted. Also, the interference wave level during application of hopping is determined as an actual average value of the interference wave levels computed in two frequency bands where the hopping is applied.

[0128] Then, the power determination is made based on a DTX threshold Th_{data} and a determination as follows,

```
          if (SIRdata<(Thdata+Δdata)) ·(S102 in FIG. 9)
               "PUSCH (UL-SCH) has not been
transmitted" (S106 in FIG. 9),
          else
               "PUSCH (UL-SCH) has been transmitted"
(S104 in FIG. 9),
```

where Δ_{data} is a transmit power related value for a mobile station, for example, a power difference (power offset) between the sounding reference signal and the PUSCH. The power determination can be made based on the transmit power of the mobile station through the Δ_{data}.

[0129] The DTX threshold Th_{data} may be set based on the amount of frequency resources in which the PUSCH is transmitted, that is, the transmit bandwidth or the number of resource blocks. Information on frequency resources in which the PUSCH is transmitted, that is, information on the resource blocks, is transmitted to a mobile station as frequency resource assignment information or resource block assignment information being one information item in the uplink scheduling grant in a PDCCH. For a larger amount of frequency resources, the power determination is achieved with high accuracy but has to be strictly made due to greater significance caused by the erroneous power determination. On the other hand, for a smaller amount of frequency resources, the power determination cannot be achieved with high accuracy but does not have to be strictly made due to less significance caused by the erroneous power determination compared to the larger amount of frequency resources. In order to satisfy the requirement, it is advantageous to determine the DTX threshold Th_{data} based on the amount of frequency resources for the PUSCH, that is, the transmit bandwidth or the number of resource blocks.

[0130] If it is determined in the UL-SCH power determination that the PUSCH (UL-SCH) has not been transmitted, the process where non-transmission of the PUSCH (UL-SCH) from the relevant mobile station has been detected is released (S108 in FIG. 9). The term "releasing of process" herein means that it is determined that the mobile station does not transmit the PUSCH (UL-SCH) in that process. In other words, the mobile station determines that it has no data to be retransmitted.

[0131] In addition, retransmission resources to be assigned to the PUSCH are released at the same time. The term "releasing of resources" herein means that these resources are assigned to uplink shared channels for other mobile stations or that the resources are assigned to uplink shared channels to be newly transmitted for the relevant mobile station. Also, since synchronous HARQ is used in uplinks in accordance with the Evolved UTRA and UTRAN, uplink shared channels are transmitted from the relevant mobile station to a base station apparatus at predefined timings until the uplink shared channels are successfully received or until the maximum number of retransmission is reached. If it is determined that the mobile station 100_n has not actually transmitted the uplink shared channels, retransmission resources are released in all subsequent subframes to be retransmitted for the uplink shared channels.

[0132] Furthermore, at the same time (S108 in FIG. 9), the base station apparatus may transmit a positive response ACK to the relevant mobile station as acknowledgement information to the PUSCH (UL-SCH) determined as not being transmitted in the UL-SCH power determination. Some effects of the transmission of the ACK to the mobile station is described below. If a determination error occurs in the UL-SCH power determination, that is, if the mobile station has actually transmitted the PUSCH (UL-SCH) but the base station apparatus has determined that the PUSCH has not been transmitted, the mobile station continues on retransmissions, and on the other hand, the base station apparatus may

assign resource blocks for the retransmissions from the mobile station to new transmissions for other mobile stations. In this case, the retransmissions from the mobile station conflict with the new transmissions from the other mobile stations, and thus both characteristics of the retransmissions from the mobile station and the new transmissions from the other mobile stations may be significantly degraded. As stated above, if the positive response ACK is transmitted as the acknowledgement information to the PUSCH (UL-SCH) determined as not being transmitted, the mobile station stops the retransmission regardless of the actual transmissions of the PUSCH (UL-SCH), and thus the above-mentioned conflict may not occur.

(2) HARQ ACK reception method

[0133] An acknowledgement information determination method (HARQ ACK reception method) according to one embodiment of the present invention is described with reference to FIG. 10.

[0134] A HARQ-ACK for the DL-SCH (acknowledgement information for a downlink shared channel) is mapped into a PUCCH frequency-multiplexed with a PUSCH as illustrated in FIG. 2. A determination of three values is made for the HARQ-ACK for the DL-SCH (acknowledgement information for downlink shared channels) in accordance with methods as presented below.

(2-1) Case of transmission of only ACK

[0135] A SIR_{ACK} is derived from a receive power level $DRSP_{ACK}$ for a demodulation reference signal in a relevant subframe and an interference wave level $Interference_{ACK}$ computed based on DM RS (demodulation reference signal) transmitted from the relevant mobile station,

$$SIR_{ACK1}=DRSP_{ACK}/Interference_{ACK},$$

where the suffix "ACK1" means that the SIR, the receive level for the demodulation reference signal and the interference wave level are derived for a signal to transmit acknowledgement information to a downlink shared channel from the mobile station.

[0136] An exemplary method of computing the interference wave level $Interference_{ACK}$ is described in detail below.

[0137] The interference wave level may be an instantaneous interference wave level in the relevant subframe or an interference wave level averaged over a longer time period such as 200 ms or 100 ms.

[0138] The interference wave level may be computed by averaging variances of demodulation reference signals transmitted from all mobile stations or by averaging variances of demodulation reference signals transmitted from the relevant mobile station.

[0139] Alternatively, the interference wave level may be determined by subtracting the receive power level of the demodulation reference signal from a total uplink receive power level including thermal noise. Also in this case, the interference wave level may be derived from signals transmitted from only the relevant mobile station or by averaging signals transmitted from all mobile stations.

[0140] The frequency band to compute the interference wave level may be an exact frequency band in which a PUCCH is transmitted or a frequency band near the frequency band in which the PUCCH is transmitted. Also, the interference wave level during application of hopping is determined as an actual average value of the interference wave levels computed in two frequency bands where the hopping is applied.

[0141] Then, the three values (ACK/NACK/DTX) determination is made based on a DTX threshold Th_{DTX_ACK1} and a determination as follows,

```
if (SIRACK1<ThDTX_ACK1) (S202 in FIG. 10)
     "DTX has been transmitted" (S206 in FIG.
10),
else
     "ACK or NACK has been transmitted" (S204
in FIG. 10),
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where the determination of ACK/NACK is made from signs of a signal sequence of the HARQ-ACK for a downlink (acknowledgement information of a downlink shared channel).

[0142] If it is determined that the DTX has been transmitted, the base station apparatus retransmits a downlink shared channel (S208 in FIG. 10). For example, the base station apparatus may determine that the mobile station 100_n fails to receive not a shared channel but downlink scheduling information in the accompanying PDCCH. In this case, the base

station apparatus may determine the previous transmission to be invalid and retransmit information mapped into a downlink shared channel. In other words, if the previous transmission is the first one, the current transmission is processed as the first transmission. If the previous transmission is the second one, the current transmission may be also handled as the second one.

(2-2) Case where ACK is multiplexed with CQI, scheduling request and/or release request

[0143] A $SIR_{ACK+CQI}$ is derived from a receive power level $DRSP_{ACK+CQI}$ for a demodulation reference signal in a relevant subframe and an interference wave level $Interference_{CQI}$ computed based on DM RS (demodulation reference signal) transmitted from the relevant mobile station,

$$SIR_{ACK+CQI}=DRSP_{ACK+CQI}/Interference_{CQI},$$

where the suffixes "ACK+CQI" and "CQI" mean that the SIR, the receive level for the demodulation reference signal and the interference wave level are derived for a signal transmitted from the mobile station where acknowledgement information is multiplexed with the CQI.

[0144] An exemplary method of computing the interference wave level $Interference_{CQI}$ is described in detail below.

[0145] The interference wave level may be an instantaneous interference wave level in the relevant subframe or an interference wave level averaged over a longer time period such as 200 ms or 100 ms.

[0146] The interference wave level may be computed by averaging variances of demodulation reference signals transmitted from all mobile stations or by averaging variances of demodulation reference signals transmitted from the relevant mobile station.

[0147] Alternatively, the interference wave level may be determined by subtracting the receive power level of the demodulation reference signal from a total uplink receive power level including thermal noise. Also in this case, the interference wave level may be derived from signals transmitted from only the relevant mobile station or by averaging signals transmitted from all mobile stations.

[0148] The frequency band to compute the interference wave level may be an exact frequency band in which a PUCCH is transmitted or a frequency band near the frequency band in which the PUCCH is transmitted. Also, the interference wave level during application of hopping is determined as an actual average value of the interference wave levels computed in two frequency bands where the hopping is applied.

[0149] Then, the three values (ACK/NACK/DTX) determination is made based on a DTX threshold $Th_{DTX_ACK+CQI}$ and a determination as follows,

```
if (SIRACK+CQI<ThDTX_ACK+CQI) (S202 in FIG. 10)
     "DTX has been transmitted" (S206 in FIG.
10),
else
     "ACK or NACK has been transmitted" (S204
in FIG. 10),
```

where the determination of ACK/NACK is made from signs of a signal sequence of the HARQ-ACK for a downlink (acknowledgement information of a downlink shared channel).

[0150] In addition to the above-mentioned transmission together with the multiplexed CQI, the HARQ-ACK for DL-SCH (acknowledgement information to a downlink shared channel) may be transmitted in such a manner that it is multiplexed with the CQI and scheduling request or in such a manner that it is multiplexed with the CQI and release request. In any of the manners, the DTX threshold $Th_{DTX_ACK+CQI+SR}$ and $TH_{DTX_ACK+CQI+RR}$ may be used for the determination.

[0151] If it is determined that the DTX has been transmitted, the base station apparatus retransmits a downlink shared channel (S208 in FIG. 10). For example, the base station apparatus may determine that the mobile station 100_n fails to receive not a shared channel but downlink scheduling information in the accompanying PDCCH. In this case, the base station apparatus may determine the previous transmission to be invalid and retransmit information mapped into a downlink shared channel. In other words, if the previous transmission is the first one, the current transmission is processed as the first transmission. If the previous transmission is the second one, the current transmission may be also handled as the second one.

[0152] The above-mentioned HARQ ACK reception method in the case where the ACK is multiplexed with the CQI may be applied to the case where the ACK and the CQI are encoded together (Joint Coding applied case) or to the case

where the ACK and the CQI are separately encoded (Separate Coding applied case).

[0153] Alternatively, the base station apparatus may be configured not to perform the above-mentioned ACK/NACK/DTX determination (three values determination) in the case where the ACK is multiplexed with the CQI. For example, a signal for the above-mentioned acknowledgement information may be embedded in a demodulation reference signal in a PUCCH to transmit the CQI as a method of multiplexing the acknowledgement information with the CQI. In this case, it appears to the base station apparatus that the acknowledgement information is always transmitted independently of whether the mobile station actually transmits the acknowledgement information. Thus, the base station apparatus would not perform the above-mentioned ACK/NACK/DTX determination (three values determination) in the case where the ACK is multiplexed with the CQI.

(3) CQI reliability determination method

[0154] The CQI reliability determination method is performed in accordance with three steps as presented below.

[0155] The CQI reliability determination is made under the case where the CQI is mapped into a PUCCH frequency-multiplexed with a PUSCH as illustrated in FIG. 2.

Step 1:

[0156] Obtain a received bit sequence z[n] (n is a bit index) for the CQI. It is assumed that the number of bits for the CQI transmitted in one subframe is equal to N. The number N depends on the presence of other information elements (acknowledgement information, scheduling request and release request) multiplexed with the CQI (S302 in FIG. 11).

Step 2:

[0157] Obtain 32 different correlation values in accordance with a formula as presented below (S304 in FIG. 11), where it is assumed that the number of information bits for the CQI transmitted in one subframe is equal to 5.

[0158] The number of information bits for the CQI may be any other value. For example, the number of information bits for the CQI may be equal to four.

$$z_{corr}(i) = \frac{1}{N} \cdot \sum_{n=1}^{N} z[n] \cdot S[n]$$

, where s[n] represents CQI code word bits, and i represents a CQI index.

Step 3:

[0159] Perform power determination based on the SIR_{CQI} for the maximum $z_{corr}(i)$ (referred to as $MAX[z_{corr}(i)]$ hereinafter) and a formula as presented below (S306 in FIG. 11),

```
          if (SIRCQI<ThCQI) "No_Code_Word_Detected"
(S308 in FIG. 11)
          else "Code_Word_Detected" (S312 in FIG. 11),
```

where it is assumed that

[0160] $SIR_{CQI}=\{MAX[z_{corr}(i)]\}^2/Interference_{CQI}$. The parameter $Interference_{CQI}$ is the same as $Interference_{CQI}$ under the above-mentioned case (2-2) where the ACK is multiplexed with the CQI, scheduling request and release request.

[0161] If it is determined that "No_Code_Word_Detected" holds, it is determined that the reliability of the CQI is extremely low, and the less reliable CQI is not used in the scheduling and AMC operations (S310 in FIG. 11). On the other hand, if it is determined that "Code_Word_Detected" holds, it is determined the CQI is highly reliable, and the reliable CQI is used in the scheduling and AMC operations (S314 in FIG. 11).

[0162] In the above-mentioned embodiment, the SIR for the received bit sequence for the CQI in the PUCCH into which the CQI is mapped is used, but the SIR for a data demodulation reference signal in the PUCCH into which the CQI is mapped may be used.

[Procedure for acknowledgement information reception method for downlink shared channels]

[0163] An exemplary reception method of acknowledgement information to downlink shared channels at a base station apparatus is described with reference to FIGS. 12 and 13. The acknowledgement information to downlink shared channels is transmitted in uplinks.

[0164] It is assumed below that if the acknowledgement information to downlink shared channels and CQI are mapped into a PUCCH at both ends of a system band, resources are divided into resources into which only the acknowledgement information to downlink shared channels is mapped (referred to as resource A hereinafter) and resources where the CQI or the CQI and the acknowledgement information to downlink shared channels are multiplexed (referred to as resource B hereinafter). In other words, if a mobile station does not transmit uplink shared channels, the mobile station uses resources A to transmit only the acknowledgement information to downlink shared channels and uses resources B to transmit the CQI or the multiplexed CQI and acknowledgement information to downlink shared channels. In the transmissions of the CQI, if scheduling request or release request are multiplexed and transmitted in addition to the ACK, resources B are used.

[0165] In exemplary resource assignment illustrated in FIG. 13, if a subframe is assumed to be for a mobile station to transmit the acknowledgement information, resource #2 in resources A is defined as a resource assigned to the mobile station for the acknowledgement information. For example, the resource may have one-to-one correspondence to a resource number for a downlink shared channel corresponding to the acknowledgement information or a resource number for a downlink control channel (DL scheduling information) corresponding to the acknowledgement information. Resource #n+3 in resources B is defined as a resource assigned to the mobile station for the CQI if a relevant subframe is assumed to be for the mobile station to transmit the CQI. The resource numbers n and m are any natural numbers.

[0166] The resources may be frequency resources, code resources or a combination of the frequency resources and the code resources. Alternatively, the resources may be multiplexed in accordance with block spreading, temporal resources or a combination of the frequency resources and the code resources. In other words, the resources are defined depending on multiplexing methods for multiplexing the acknowledgement information to downlink shared channels and the CQI in PUCCHs. If the multiplexing method relates to CDMA, the resources consist of code resources. If the multiplexing method relates to FDMA, the resources consist of frequency resources. If the multiplexing method relates to a combination of CDMA and FDMA, the resources consist of a combination of the code resources and the frequency resources. Also, Walsh code multiplexing, CAZAC sequence code multiplexing and/or others may be applied in the CDMA.

[0167] The acknowledgement information to downlink shared channels may be time-multiplexed with uplink shared channels or mapped into PUCCHs at both ends of a system band. Furthermore, in the case where the acknowledgement information to downlink shared channels is mapped into PUCCHs at both ends of the system band, the acknowledgement information may be multiplexed with the CQI (the above-mentioned case (2-2)) or may not be multiplexed with the CQI (the above-mentioned case (2-1). An exemplary procedure at a base station apparatus of determining these cases and receiving the acknowledgement information is described below.

[0168] At step S401, the base station apparatus determines whether an uplink shared channel is to be received in a relevant subframe. Specifically, the base station apparatus determines to receive the uplink shared channel if the base station apparatus has transmitted scheduling grant to a mobile station and does not determine to receive the uplink shared channel otherwise. More specifically, in FIG. 5, subframe #i+3 corresponds to a subframe where the uplink shared channel is to be received, and subframes other than subframe #i+3 correspond to subframes where the uplink shared channel is not to be received. In another example, in FIG. 6, subframes #i+3 and #i+9 correspond to subframes where the uplink shared channel is to be received, and subframes other than subframes #i+3 and #i+9 correspond to subframes where the uplink shared channel is not to be received. Even in the case where the UL scheduling grant has not been transmitted to the mobile station, as illustrated in subframe #i+9 in FIG. 9, if NACK has been transmitted as the acknowledgement information to uplink shared channels, a subframe at the corresponding retransmission timing would be a subframe where the uplink shared channel is to be received. In other words, if the uplink scheduling grant was transmitted in a subframe preceding a relevant subframe by a predefined number of subframes over a PDCCH or if NACK was transmitted as the acknowledgement information to uplink shared channels in a subframe preceding the relevant subframe by a predefined number of subframes over a PDCCH, the relevant subframe would be a subframe where the uplink shared channel is to be received.

[0169] If the uplink shared channel is to be received at the relevant subframe (S401: YES), at step S403, the base station apparatus determines whether the mobile station 100_n has actually transmitted the uplink shared channel. If the base station apparatus determines that the mobile station 100_n has actually transmitted the uplink shared channel (S403: YES), at step S405, the base station apparatus decodes the uplink shared channel. At step S407, the base station apparatus determines whether to receive acknowledgement information to downlink shared channels in the relevant subframe. If the base station apparatus is to receive the acknowledgement information (S407: YES), at step S409, the base station apparatus receives the acknowledgement information time-multiplexed with the uplink shared channel. If the base station apparatus is not to receive the acknowledgement information (S407: NO), the base station apparatus

does not receive the acknowledgement information.

[0170] On the other hand, if the base station apparatus is not to receive the uplink shared channel in the relevant subframe (S401: NO) or if the base station apparatus does not determine that the mobile station 100_n has actually transmitted the uplink shared channel (S403: NO), the base station apparatus checks the PUCCH mapped into both ends of the system band. To this end, at step S411, the base station apparatus determines whether to receive the acknowledgement information to downlink shared channel in the relevant subframe. More specifically, in FIG. 7, subframe #i+3 corresponds to a subframe where the acknowledgement information to downlink shared channels is to be received, and subframes other than subframe #i+3 correspond to subframes where the acknowledgement information to downlink shared channels is not to be received. In other words, if the downlink scheduling information was transmitted in a subframe preceding the relevant subframe by a predefined number of subframes over a PDCCH, the relevant subframe would be a subframe where the acknowledgement information to downlink shared channels is to be received.

[0171] If the base station apparatus is not to receive the acknowledgement information (S411: NO), the base station apparatus does not receive the acknowledgement information. On the other hand, if the base station apparatus is to receive the acknowledgement information (S411: YES), at step S413, the base station apparatus determines whether to receive the CQI in the relevant subframe. If the base station apparatus is to receive the CQI (S413: YES), at step S415, the base station apparatus receives the acknowledgement information multiplexed with the CQI mapped into resources B (resource #n+3) in accordance with the above-mentioned case (2-2) where ACK is multiplexed with the CQI, scheduling request or release request. On the other hand, if the base station apparatus is not receive the CQI (S413: NO), at step S417, the base station apparatus receives the acknowledgement information mapped into resources A (resource #2) in accordance with the above-mentioned case (2-1) where only ACK is transmitted.

[Procedure for uplink CQI reception method]

[0172] An exemplary method for receiving uplink CQI at a base station apparatus is described with reference to FIG. 14.

[0173] A CQI may be time-multiplexed with uplink shared channels or mapped into a PUCCH at both ends of a system band. Furthermore, in the case where the CQI is mapped into the PUCCH at both ends of the system band, the CQI may be multiplexed with acknowledgement information or may not be multiplexed with the acknowledgement information. The base station apparatus may determine these cases and receive the CQI as follows.

[0174] At step S501, the base station apparatus determines whether to receive an uplink shared channel in a relevant subframe. Specifically, if the base station apparatus transmits scheduling grant to a mobile station, the base station apparatus determines that it is to receive the uplink shared channel. On the other hand, if the base station apparatus has not transmitted the scheduling grant to the mobile station, the base station apparatus determines that it is not to receive the uplink shared channel. More specifically, in FIG. 5, subframe #i+3 corresponds to a subframe where the uplink shared channel is to be received, and subframes other than subframe #i+3 correspond to subframes where the uplink shared channel is not to be received. Alternatively, in FIG. 6, subframes #i+3 and #i+9 correspond to subframes where the uplink shared channel is to be received, and subframes other than subframes #i+3 and #i+9 correspond to subframes where the uplink shared channel is not to be received. Even in the case where UL scheduling grant has not been transmitted to the mobile station, as illustrated in subframe #i+9 in FIG. 9, if NACK has been transmitted as acknowledgement information to the uplink shared channel, a subframe corresponding to its retransmission timing would be to be received in the uplink shared channel. In other words, if the uplink scheduling grant was transmitted in a subframe preceding the relevant subframe by a predefined number of subframes or if NACK was transmitted as the acknowledgement information to the uplink shared channel in a subframe preceding the relevant subframe by a predefined number of subframes over a PDCCH, the relevant subframe would be to be received in the uplink shared channel.

[0175] If the base station apparatus is to receive the uplink shared channel in the relevant subframe (S501: YES), at step S503, the base station apparatus determines whether the mobile station 100_n has actually transmitted the uplink shared channel in accordance with FIG. 9. If the base station apparatus determines that the mobile station 100_n has actually transmitted the uplink shared channel (S503: YES), at step S505, the base station apparatus decodes the uplink shared channel. Then, at step S507, the base station apparatus determines whether to receive a CQI in the relevant subframe. If the base station apparatus is to receive the CQI (S507: YES), at step S509, the base station apparatus receives the CQI time-multiplexed with the uplink shared channel. In other embodiments, at step S509, the base station apparatus may determine the reliability of the CQI in accordance with FIG. 11. If the base station apparatus is not to receive the CQI (S507: NO), the base station apparatus does not receive the CQI.

[0176] On the other hand, if the base station apparatus is not to receive the uplink shared channel in the relevant subframe (S501: NO) or if the base station apparatus does not determine that the mobile station 100_n has actually transmitted the uplink shared channel (S503: NO), the base station apparatus checks a PUCCH mapped into both ends of a system band. To this end, at step S511, the base station apparatus determines whether to receive a CQI in the relevant subframe. If the base station apparatus is not to receive the CQI (S511: NO), the base station apparatus does not receive the CQI. On the other hand, if the base station apparatus is to receive the CQI (S511: YES), at step S513,

the base station apparatus determines whether to receive acknowledgement information to a downlink shared channel in the relevant subframe. More specifically, in FIG. 7, subframe #i+3 corresponds to a subframe where the acknowledgement information to the downlink shared channel is to be received, and subframes other than subframe #i+3 correspond to subframes where the acknowledgement information to the downlink shared channel is not to be received. In other words, if downlink scheduling information was transmitted in a subframe preceding the relevant subframe by a predefined number of subframes over a PDCCH, the relevant subframe would be a subframe for receiving the acknowledgement information to the downlink shared channel.

[0177] If the base station apparatus is not to receive the acknowledgement information (S513: NO), at step S519, the base station apparatus receives the CQI mapped into resources B (resource #n+3) in the PUCCH. On the other hand, if the base station apparatus is to receive the acknowledgement information (S513: YES), at step S515, the base station apparatus determines whether a mobile station has actually transmitted the acknowledgement information in resources B (resource #n+3) in accordance with the above-mentioned case (2-2) where the ACK is multiplexed with the CQI, scheduling request or release request. If the base station apparatus determines that the mobile station has actually transmitted the acknowledgement information (S515: YES), at step S517, the base station apparatus receives the CQI multiplexed with the acknowledgement information in resources B (resource #n+3) in the PUCCH. If the base station apparatus determines that the mobile station has not transmitted the acknowledgement information (S515: NO), at step S519, the base station apparatus receives the CQI mapped into resources B (resource #n+3) in the PUCCH.

[0178] In this embodiment, at step S515, the base station apparatus determines that the mobile station has actually transmitted the acknowledgement information in resources B (resource #n+3). In other embodiments, at step S515, the base station apparatus may always determine that the mobile station has actually transmitted the acknowledgement information. For example, a signal for the acknowledgement information may be embedded in a demodulation reference signal in the PUCCH for transmitting the CQI in order to multiplex the acknowledgement information with the CQI. In this case, it appears to the base station apparatus that the acknowledgement information is always transmitted independently of whether the mobile station has actually transmitted the acknowledgement information. Thus, at step S515, the base station apparatus would always determine that the mobile station has actually transmitted the acknowledgement information.

[0179] In this manner, according to the embodiments of the present invention, the base station apparatus can be achieved for appropriate scheduling and HARQ operations in uplinks and downlinks in LTE.

[0180] In the above-mentioned embodiments, it has been assumed that RRT (Round Trip Time) for HARQ in uplinks and downlinks is equal to 6, but the present invention is not limited to the RRT value. For example, apparatuses and operations according to embodiments of the present invention may be applied to RTT equal to 8 in uplink and downlink HARQ.

[0181] Although the present invention has been described by way of the above specific embodiments, the present invention is not limited to them. Various alternative embodiments, implementations and operations will be conceived by those skilled in the art from this disclosure.

[0182] In other words, it is understood that the present invention encompasses other embodiments not disclosed herein. Thus, the scope of the present invention can only be defined via accompanying claims.

[0183] For convenience, the present invention has been described with reference to the distinct embodiments, but separation of the embodiments is not essential to the present invention and two or more of the embodiments may be used together as needed. Some specific numerals have been used to facilitate understanding of the present invention, but unless otherwise noted, these numerals are simply illustrative and any other appropriate values may be used.

[0184] The present invention has been described with reference to the specific embodiments of the present invention, but the embodiments are simply illustrative and variations, modifications, alterations and substitutions could be contrived by those skilled in the art. For convenience of explanation, apparatuses according to the embodiments of the present invention have been described with reference to functional block diagrams, but these apparatuses may be implemented in hardware, software or combinations thereof. The present invention is not limited to the above embodiments, and variations, modifications, alterations and substitutions can be made by those skilled in the art without deviating from the spirit of the present invention.

[0185] This international patent application is based on Japanese Priority Applications No. 2007-052112 filed on March 1, 2007 and No. 2007-121301 filed on May 1, 2007, the entire contents of which are hereby incorporated by reference.

Claims

1. A base station apparatus for communicating to a mobile station over an uplink shared channel, comprising:

   a transmit instruction unit configured to assign an uplink shared channel to the mobile station and instruct the mobile station to conduct transmissions over the assigned uplink shared channel;

a measurement unit configured to measure a radio quality of the assigned uplink shared channel; and
a determination unit configured to determine based on the radio quality whether the mobile station has transmitted data over the assigned uplink shared channel.

2. The base station apparatus as claimed in claim 1, wherein the transmit instruction unit is configured to instruct the mobile station to conduct transmissions over the assigned uplink shared channel by transmitting an uplink scheduling grant or negative response (NACK) as acknowledgement information.

3. The base station apparatus as claimed in claim 1, wherein the radio quality includes at least one of a ratio between a receive power level for a data demodulation reference signal in the uplink shared channel and an interference power level and a ratio between a receive power level for a data signal in the uplink shared channel and an interference power level.

4. The base station apparatus as claimed in claim 1, wherein if the radio quality is lower than or equal to a predefined threshold, the determination unit is configured to determine that the mobile station has not transmitted data over the assigned uplink shared channel.

5. The base station apparatus as claimed in claim 4, wherein the threshold is determined based on at least one of a power difference between the uplink shared channel and a sounding reference signal, an amount of frequency resources for the uplink shared channel, a MCS level for the uplink shared channel, a modulation scheme for the uplink shared channel and a transmit power level for the uplink shared channel.

6. The base station apparatus as claimed in claim 5, wherein the threshold is increased if the power difference is greater, and the threshold is decreased if the power difference is smaller.

7. The base station apparatus as claimed in claim 5, wherein the threshold is increased if the amount of frequency resources for the uplink shared channel is larger, and the threshold is decreased if the amount of frequency resources for the uplink shared channel is smaller.

8. The base station apparatus as claimed in claim 1, further comprising:

an ACK transmission unit configured to transmit a positive response (ACK) for acknowledgement information to the mobile station if it is determined that the mobile station has not transmitted data over the uplink shared channel.

9. The base station apparatus as claimed in claim 1, further comprising:

a resource management unit configured to release a retransmission resource for the uplink shared channel assigned to the mobile station if it is determined that the mobile station has not transmitted data over the uplink shared channel.

10. A communication control method at a base station apparatus for communicating to a mobile station over an uplink shared channel, the method comprising:

assigning an uplink shared channel to the mobile station and instructing the mobile station to conduct transmissions over the assigned uplink shared channel;
measuring a radio quality of the uplink shared channel assigned to the mobile station; and
determining based on the radio quality whether the mobile station has transmitted data over the assigned uplink shared channel.

11. A communication control method at a base station apparatus for communicating to a mobile station over uplink and downlink shared channels, the method comprising:

determining based on a radio quality of an uplink shared channel assigned to the mobile station whether the mobile station has transmitted data over the uplink shared channel; and
if it is determined in the determining step that the mobile station has not transmitted data over the uplink shared channel, receiving downlink radio quality information or acknowledgement information to a downlink shared channel, which are mapped into an uplink control channel.

12. The communication control method as claimed in claim 11, wherein the uplink control channel comprises a channel frequency-multiplexed with the uplink shared channel.

FIG.1

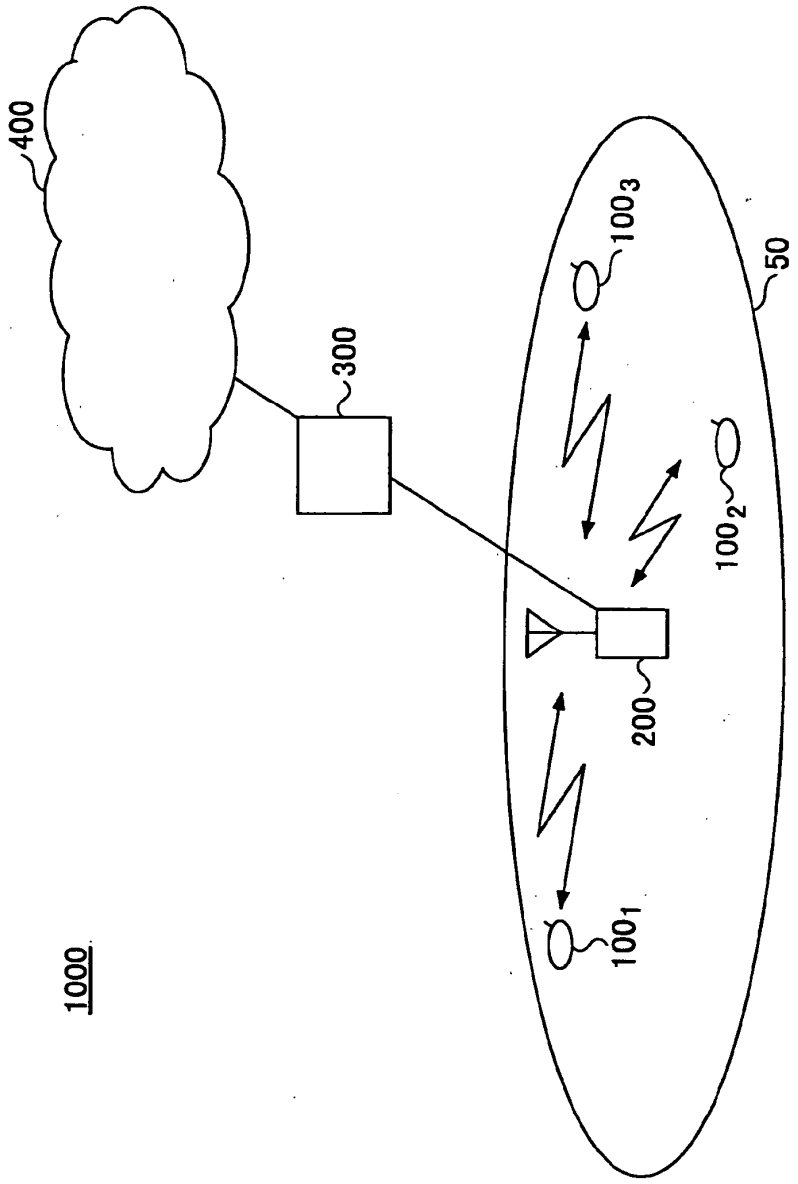


FIG.2

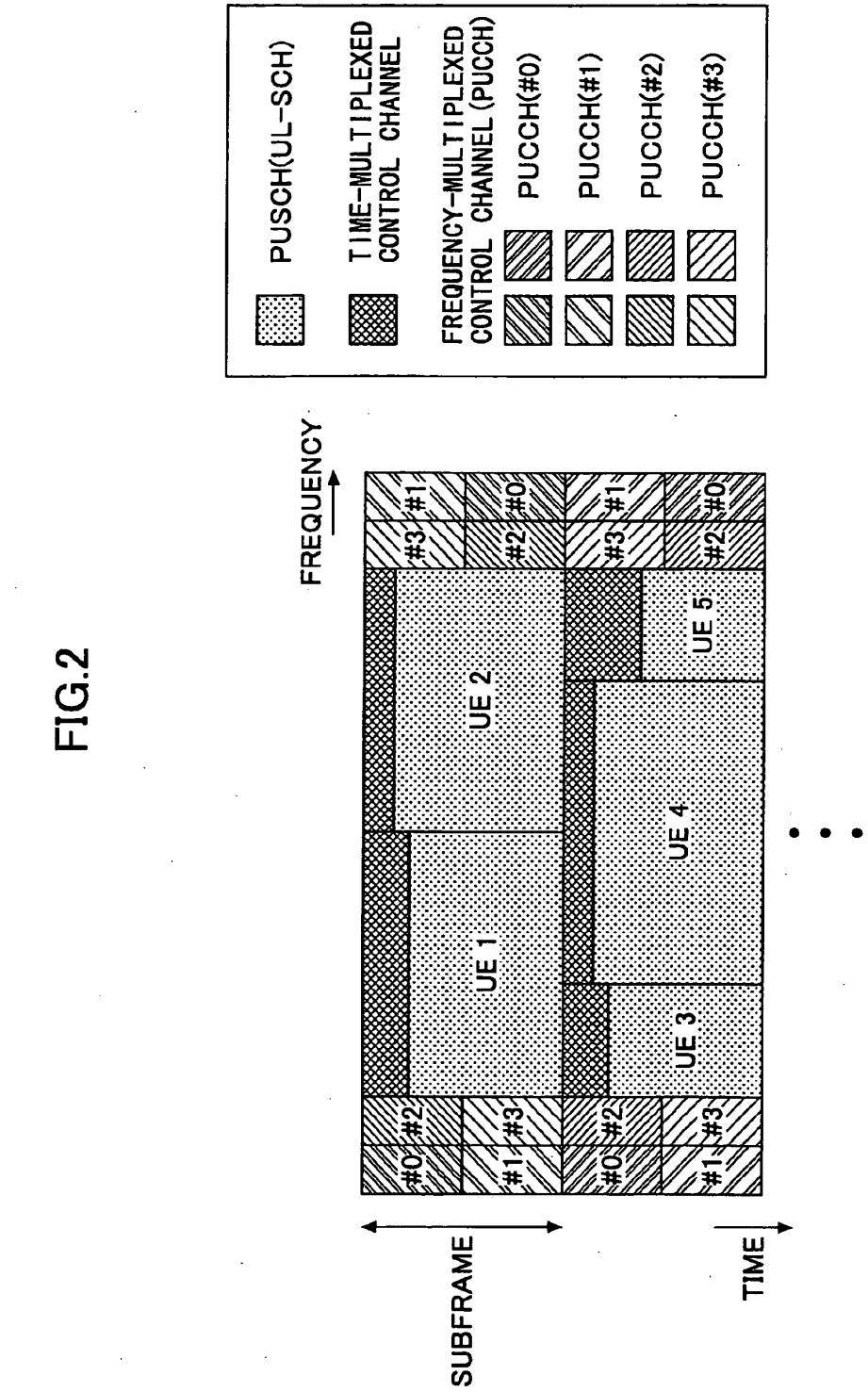

PUSCH(UL-SCH)
TIME-MULTIPLEXED CONTROL CHANNEL
FREQUENCY-MULTIPLEXED CONTROL CHANNEL (PUCCH)
PUCCH(#0)
PUCCH(#1)
PUCCH(#2)
PUCCH(#3)
FREQUENCY
SUBFRAME
TIME
UE 1
UE 2
UE 3
UE 4
UE 5
#0
#1
#2
#3

FIG.3

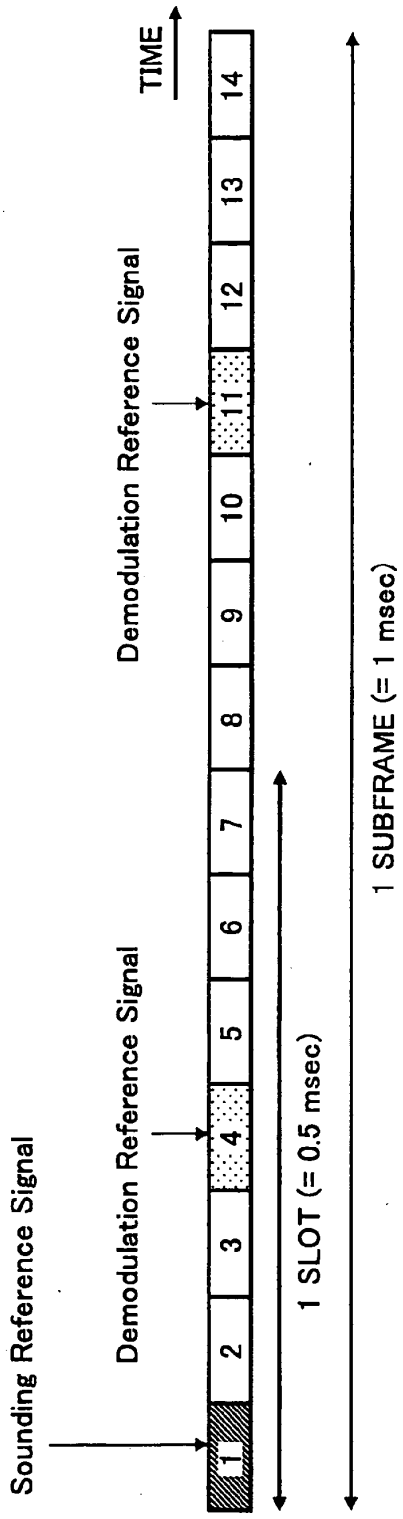
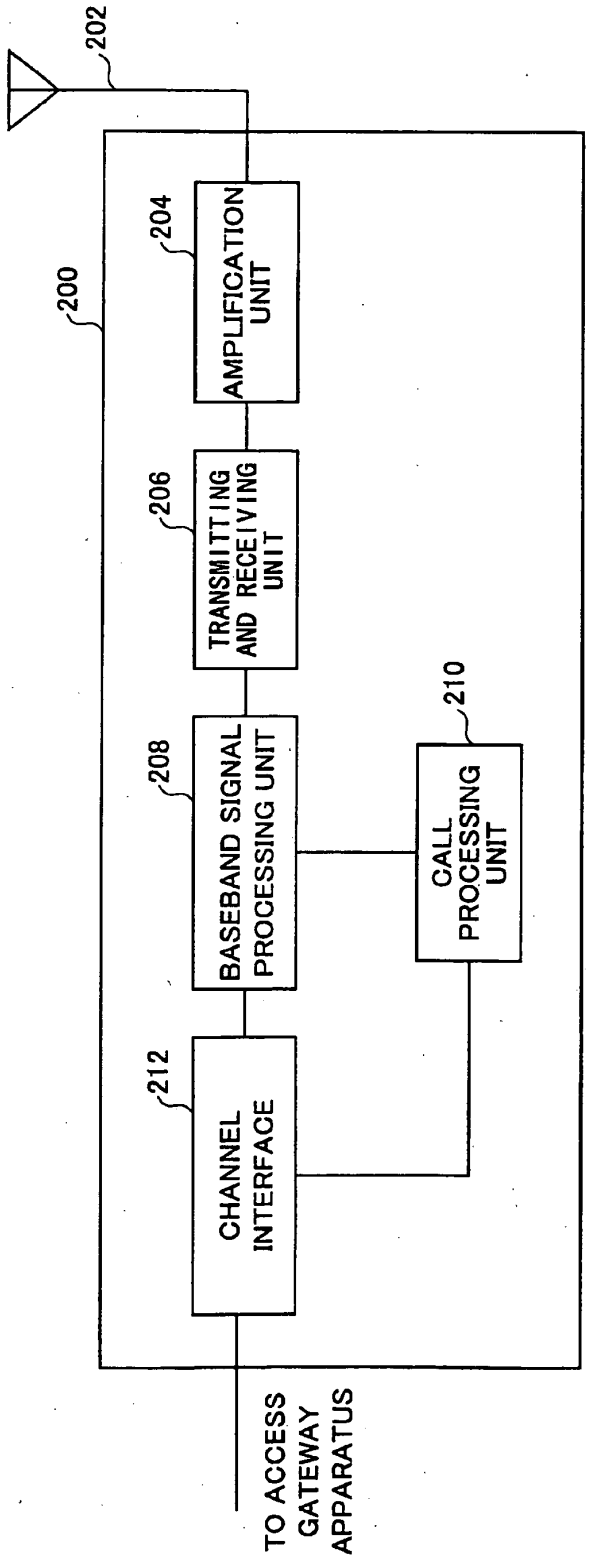

TIME
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Sounding Reference Signal
Demodulation Reference Signal
Demodulation Reference Signal
1 SLOT (= 0.5 msec)
1 SUBFRAME (= 1 msec)

FIG.4


202
200
204
AMPLIFICATION UNIT
206
TRANSMITTING AND RECEIVING UNIT
208
BASEBAND SIGNAL PROCESSING UNIT
210
CALL PROCESSING UNIT
212
CHANNEL INTERFACE
TO ACCESS GATEWAY APPARATUS

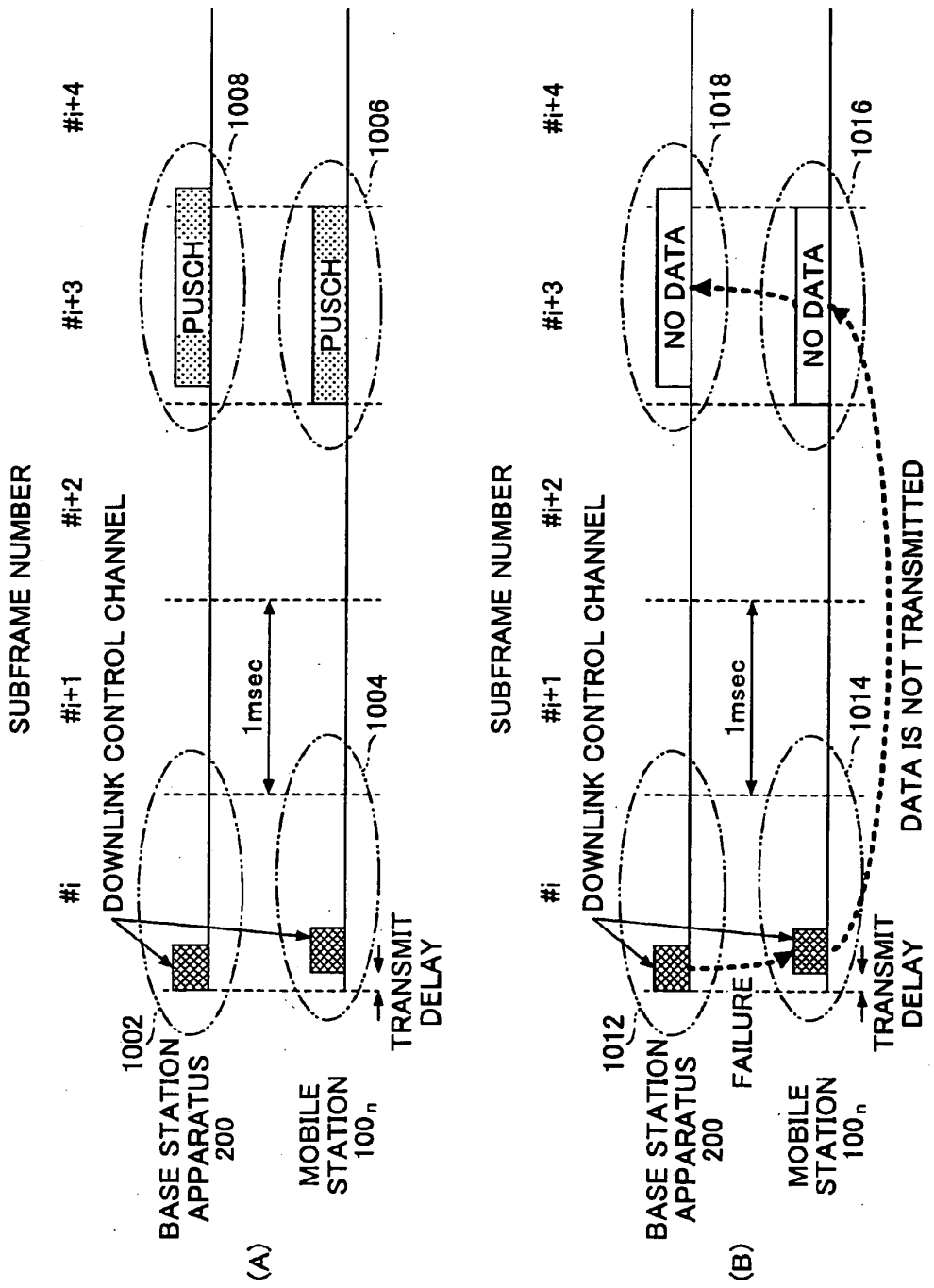
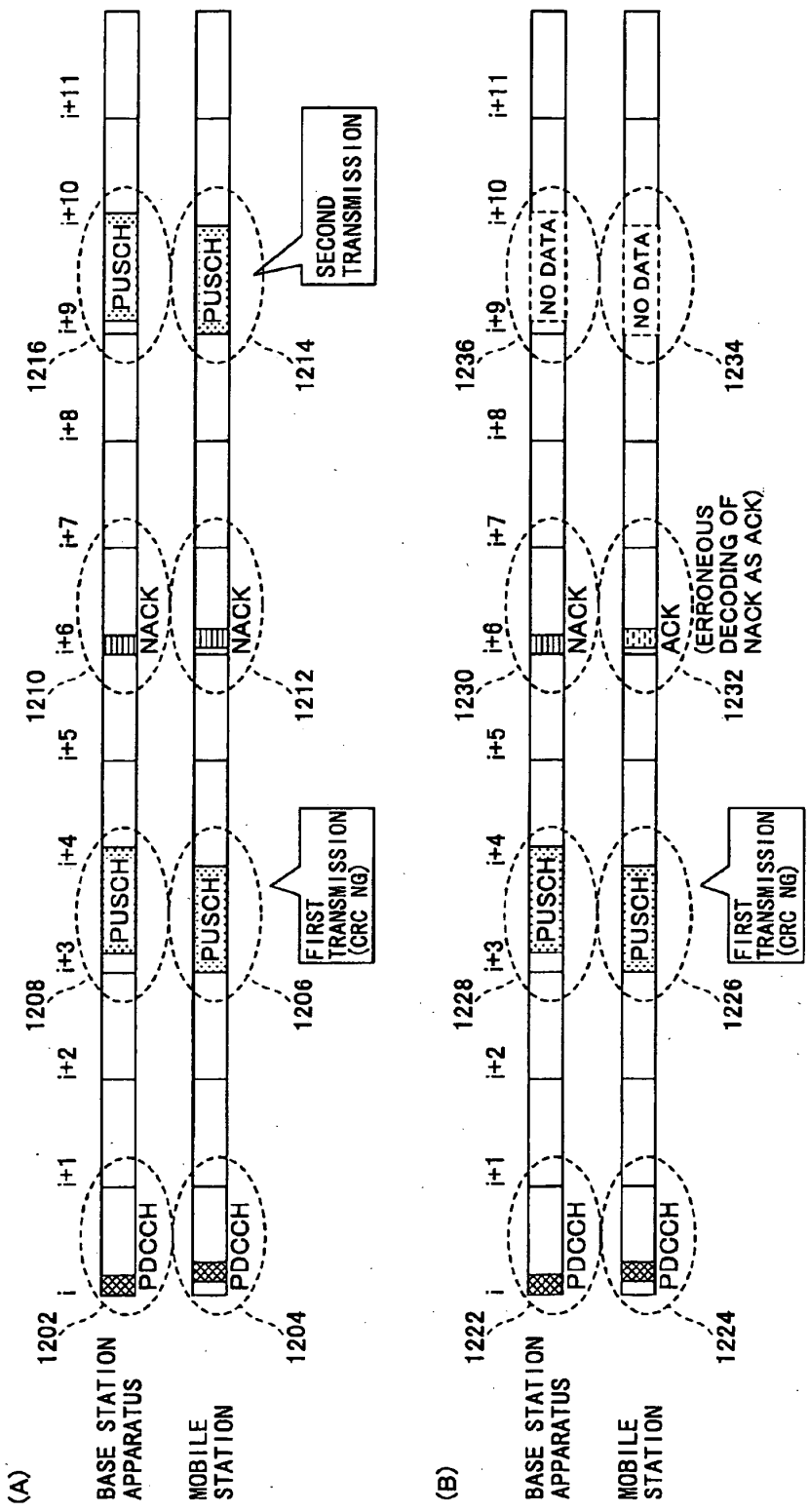

SUBFRAME NUMBER
#i
#i+1
#i+2
#i+3
#i+4
DOWNLINK CONTROL CHANNEL
1msec
PUSCH
1008
PUSCH
1006
1004
1002
TRANSMIT DELAY
BASE STATION APPARATUS 200
MOBILE STATION 100n
(A)
SUBFRAME NUMBER
#i
#i+1
#i+2
#i+3
#i+4
DOWNLINK CONTROL CHANNEL
1msec
NO DATA
1018
NO DATA
1016
1014
1012
FAILURE
TRANSMIT DELAY
DATA IS NOT TRANSMITTED
BASE STATION APPARATUS 200
MOBILE STATION 100n
(B)

FIG.5

FIG.6


(A)
BASE STATION APPARATUS
MOBILE STATION
i
i+1
i+2
i+3
i+4
i+5
i+6
i+7
i+8
i+9
i+10
i+11
PDCCH
PUSCH
NACK
1202
1204
1206
1208
1210
1212
1214
1216
FIRST TRANSMISSION (CRC NG)
SECOND TRANSMISSION
(B)
BASE STATION APPARATUS
MOBILE STATION
PDCCH
PUSCH
NACK
ACK
NO DATA
1222
1224
1226
1228
1230
1232
1234
1236
FIRST TRANSMISSION (CRC NG)
(ERRONEOUS DECODING OF NACK AS ACK)

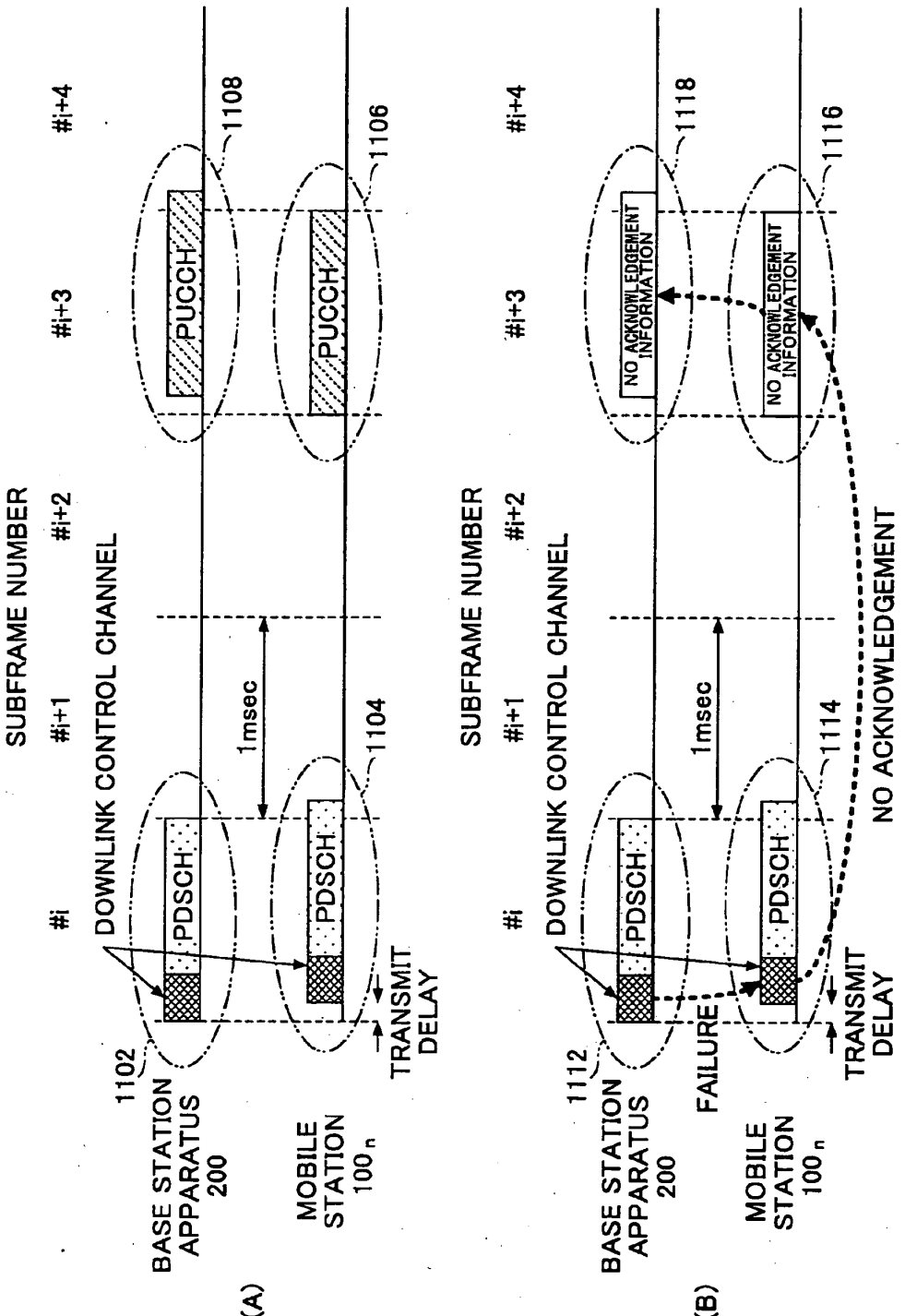
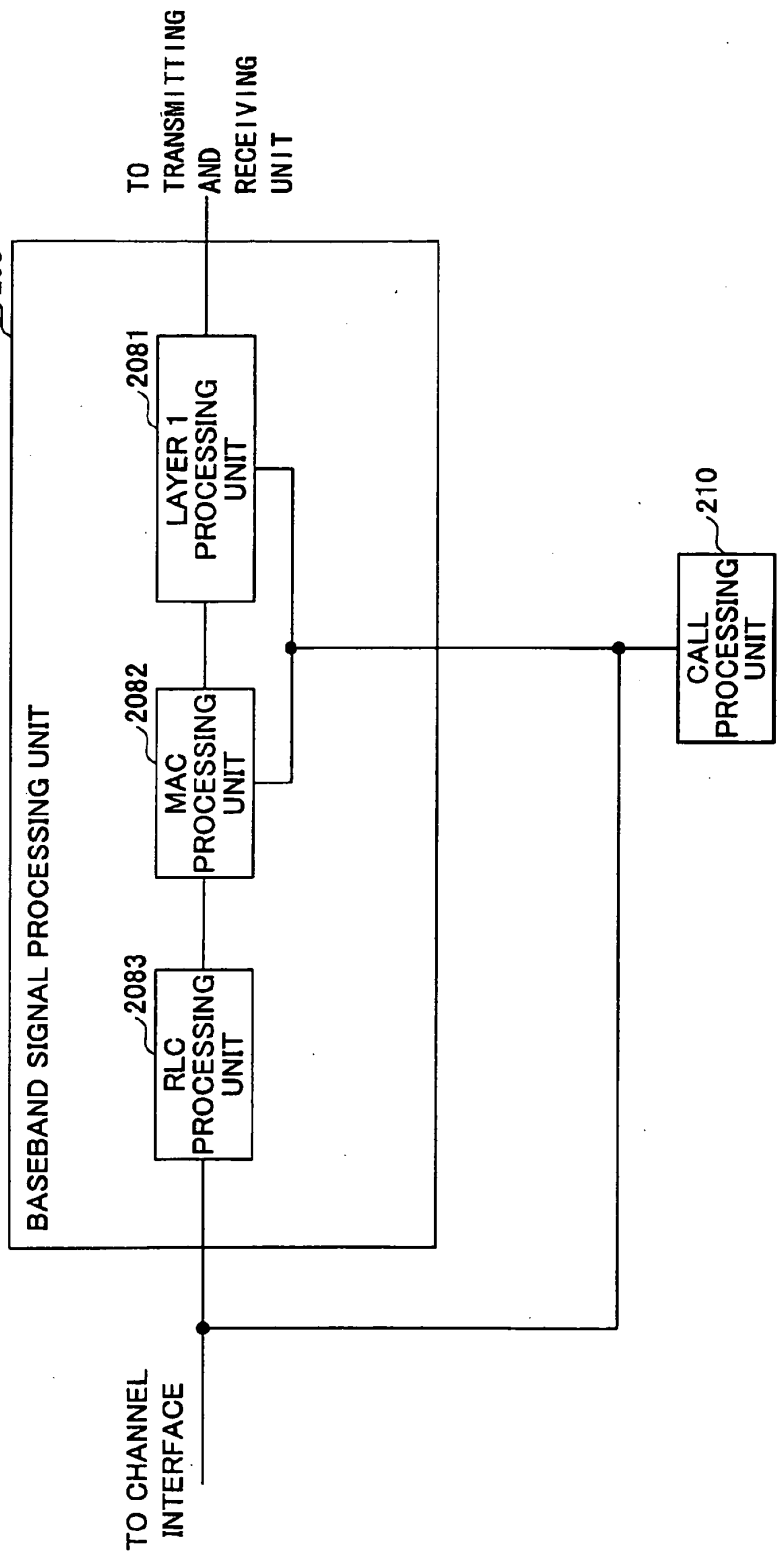

SUBFRAME NUMBER
#i
#i+1
#i+2
#i+3
#i+4
DOWNLINK CONTROL CHANNEL
PDSCH
PUCCH
1msec
1102
1104
1106
1108
BASE STATION APPARATUS 200
MOBILE STATION 100n
TRANSMIT DELAY
(A)
NO ACKNOWLEDGEMENT INFORMATION
1112
1114
1116
1118
FAILURE
NO ACKNOWLEDGEMENT
(B)

FIG.7

FIG.8A


TO TRANSMITTING AND RECEIVING UNIT
208
BASEBAND SIGNAL PROCESSING UNIT
2081
LAYER 1 PROCESSING UNIT
2082
MAC PROCESSING UNIT
2083
RLC PROCESSING UNIT
210
CALL PROCESSING UNIT
TO CHANNEL INTERFACE

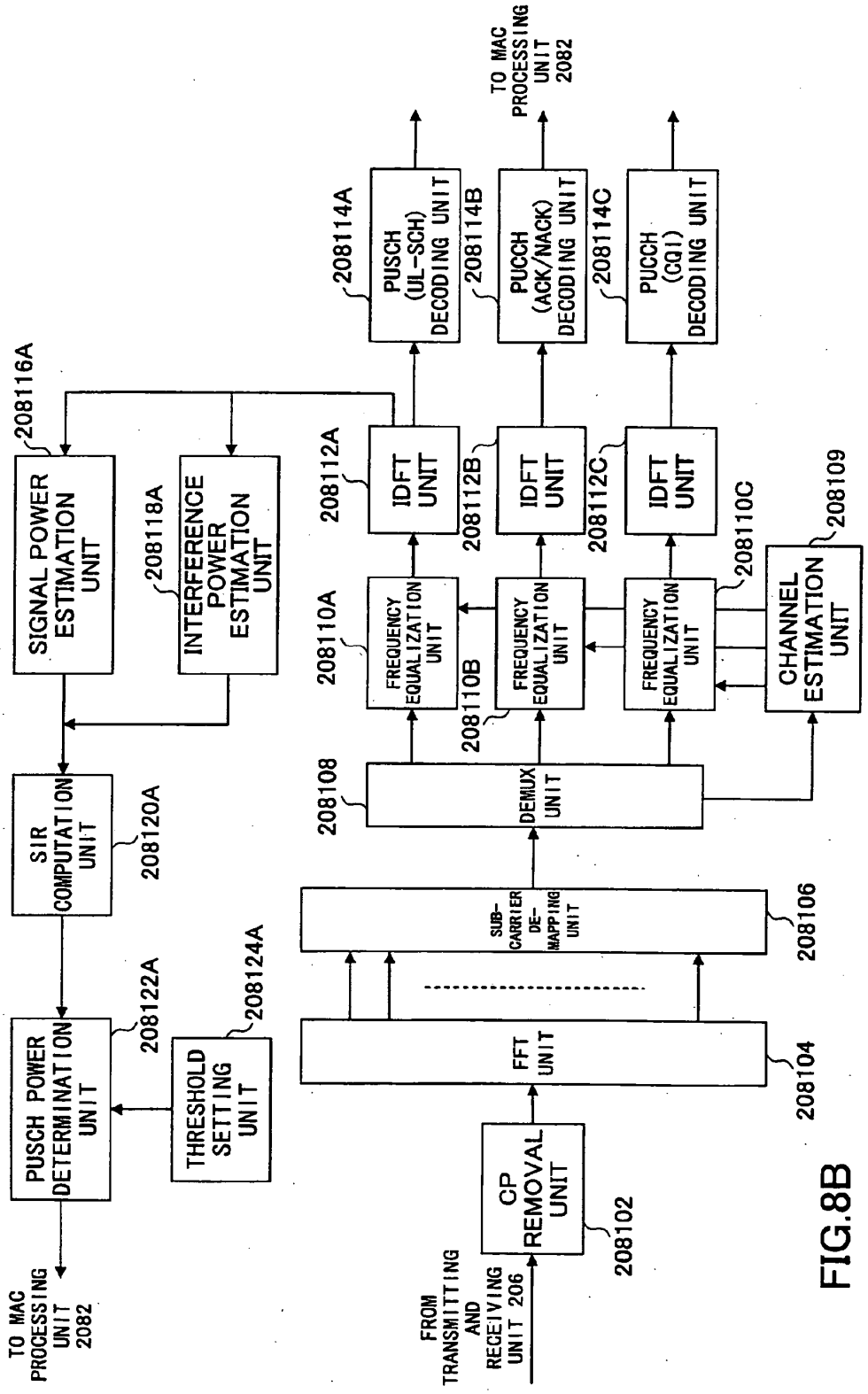

TO MAC PROCESSING UNIT 2082
208114A
PUSCH (UL-SCH) DECODING UNIT
208114B
PUCCH (ACK/NACK) DECODING UNIT
208114C
PUCCH (CQI) DECODING UNIT
208116A
SIGNAL POWER ESTIMATION UNIT
208118A
INTERFERENCE POWER ESTIMATION UNIT
208112A
IDFT UNIT
208112B
IDFT UNIT
208112C
IDFT UNIT
208110A
FREQUENCY EQUALIZATION UNIT
208110B
FREQUENCY EQUALIZATION UNIT
208110C
FREQUENCY EQUALIZATION UNIT
208109
CHANNEL ESTIMATION UNIT
208108
DEMUX UNIT
SIR COMPUTATION UNIT
208120A
SUB-CARRIER DE-MAPPING UNIT
208106
208122A
PUSCH POWER DETERMINATION UNIT
208124A
THRESHOLD SETTING UNIT
FFT UNIT
208104
CP REMOVAL UNIT
208102
TO MAC PROCESSING UNIT 2082
FROM TRANSMITTING AND RECEIVING UNIT 206

FIG.8B

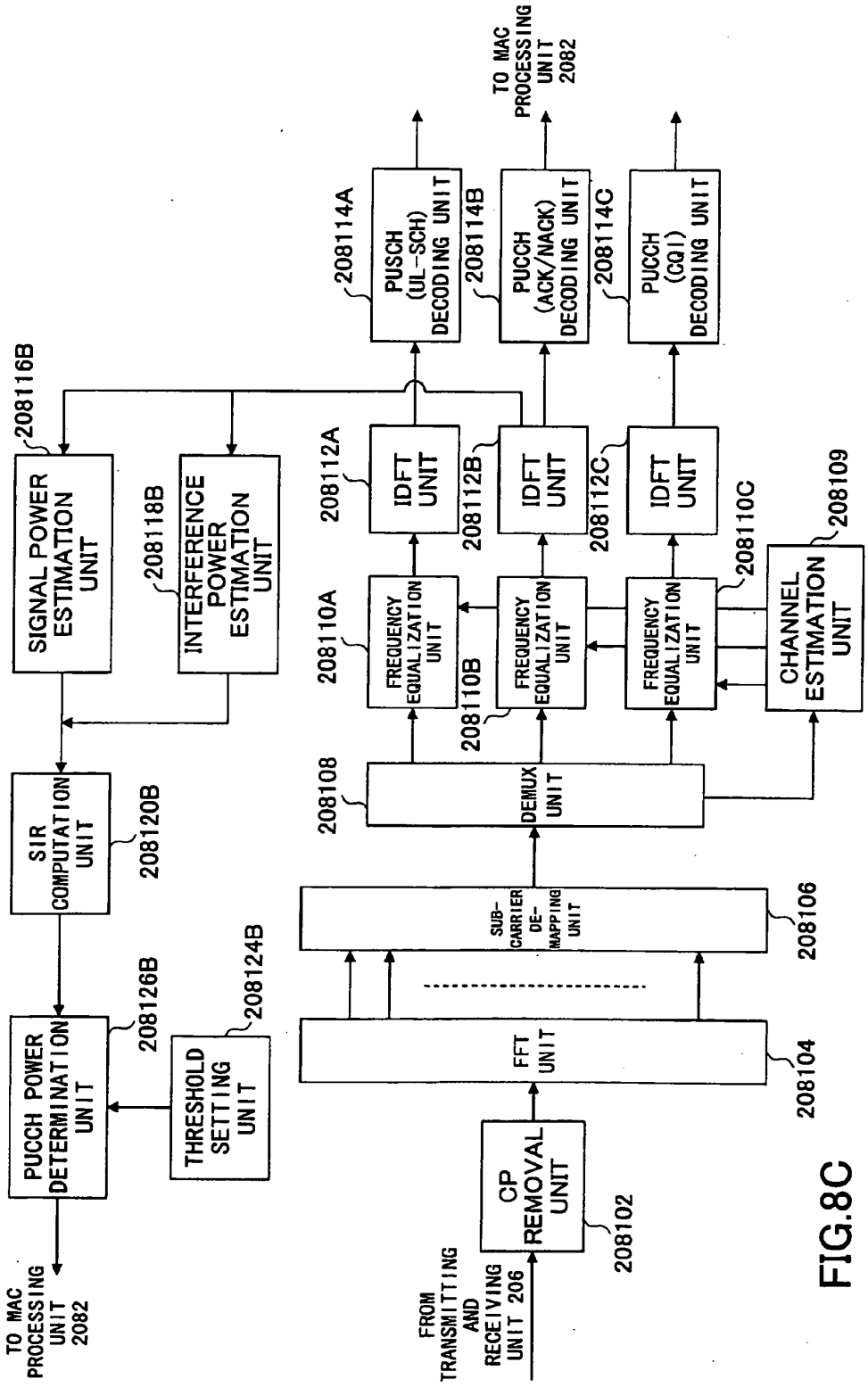

TO MAC PROCESSING UNIT 2082
208114A
PUSCH (UL-SCH) DECODING UNIT
208114B
PUCCH (ACK/NACK) DECODING UNIT
208114C
PUCCH (CQI) DECODING UNIT
208116B
SIGNAL POWER ESTIMATION UNIT
208118B
INTERFERENCE POWER ESTIMATION UNIT
208112A
IDFT UNIT
208112B
IDFT UNIT
208112C
IDFT UNIT
208110A
FREQUENCY EQUALIZATION UNIT
208110B
FREQUENCY EQUALIZATION UNIT
208110C
FREQUENCY EQUALIZATION UNIT
208109
CHANNEL ESTIMATION UNIT
208108
DEMUX UNIT
SUB-CARRIER DE-MAPPING UNIT
208106
FFT UNIT
208104
CP REMOVAL UNIT
208102
FROM TRANSMITTING AND RECEIVING UNIT 206
SIR COMPUTATION UNIT
208120B
PUCCH POWER DETERMINATION UNIT
208126B
THRESHOLD SETTING UNIT
208124B
TO MAC PROCESSING UNIT 2082

FIG.8C

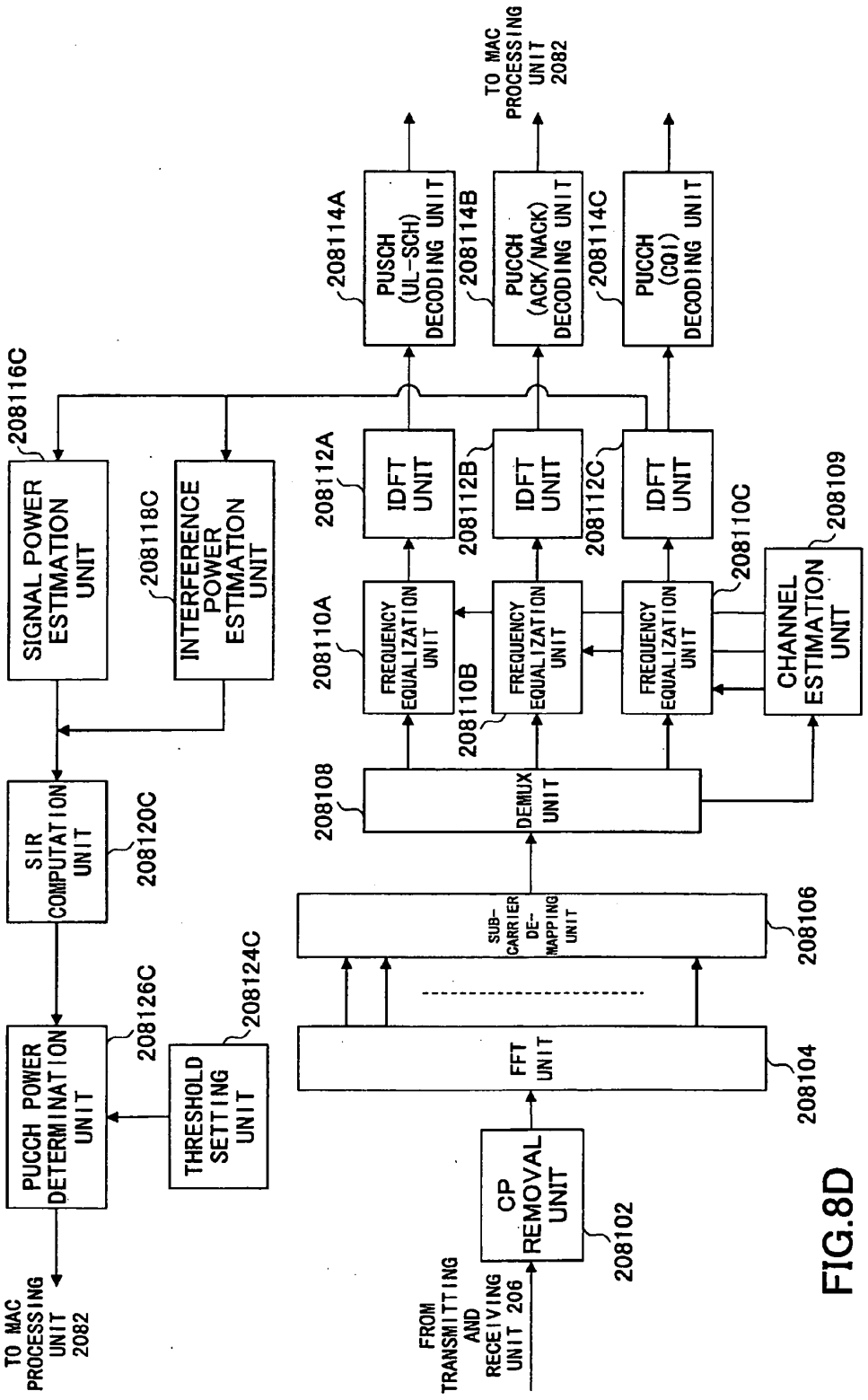

TO MAC PROCESSING UNIT 2082
208114A
PUSCH (UL-SCH) DECODING UNIT
208114B
PUCCH (ACK/NACK) DECODING UNIT
208114C
PUCCH (CQI) DECODING UNIT
208116C
SIGNAL POWER ESTIMATION UNIT
208118C
INTERFERENCE POWER ESTIMATION UNIT
208112A
IDFT UNIT
208112B
IDFT UNIT
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208110B
FREQUENCY EQUALIZATION UNIT
208110C
FREQUENCY EQUALIZATION UNIT
208109
CHANNEL ESTIMATION UNIT
208108
DEMUX UNIT
SUB-CARRIER DE-MAPPING UNIT
208106
FFT UNIT
208104
CP REMOVAL UNIT
208102
FROM TRANSMITTING AND RECEIVING UNIT 206
SIR COMPUTATION UNIT
208120C
PUCCH POWER DETERMINATION UNIT
208126C
THRESHOLD SETTING UNIT
208124C
TO MAC PROCESSING UNIT 2082

FIG.8D

FIG.9

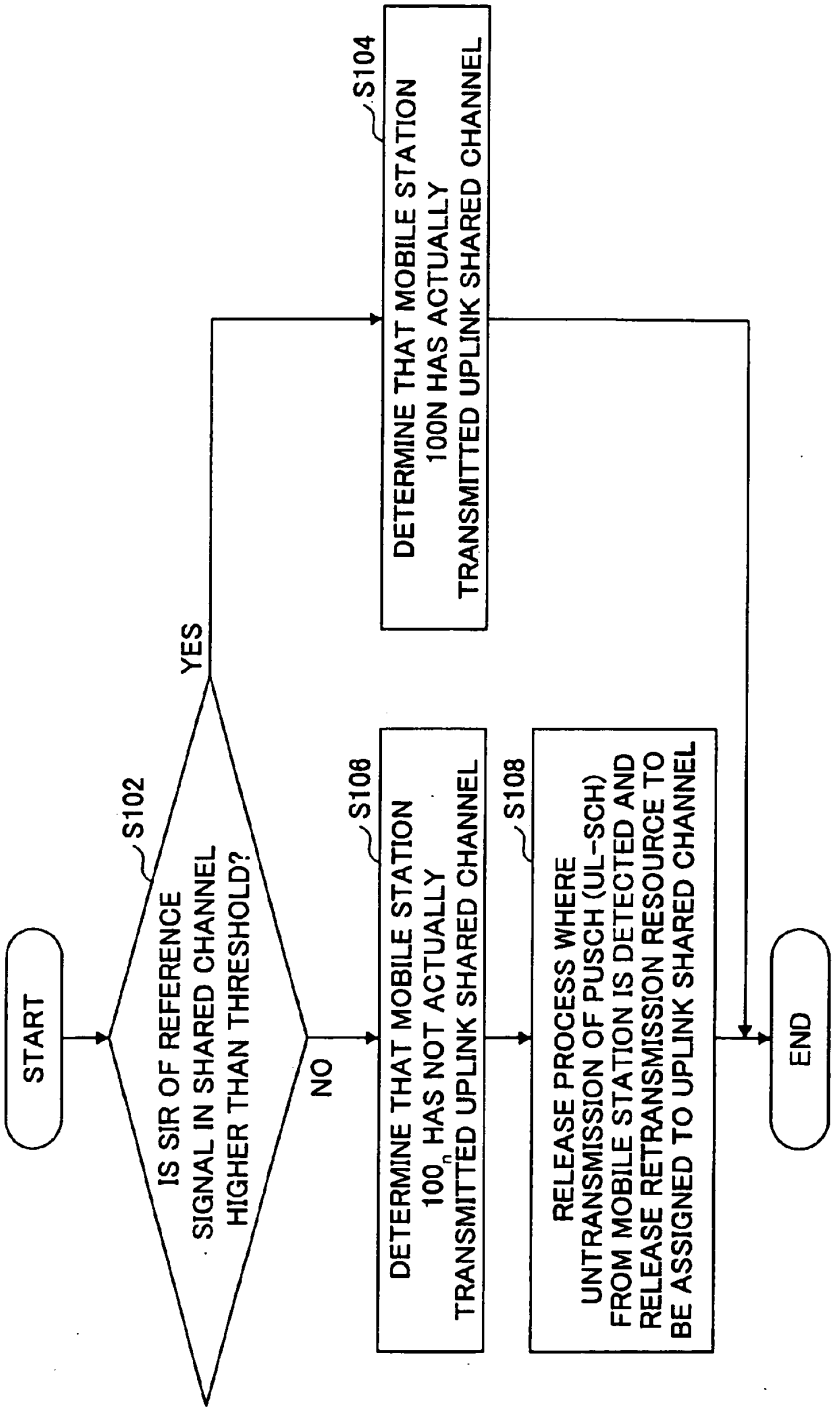

START
S102
IS SIR OF REFERENCE SIGNAL IN SHARED CHANNEL HIGHER THAN THRESHOLD?
YES
NO
S104
DETERMINE THAT MOBILE STATION 100N HAS ACTUALLY TRANSMITTED UPLINK SHARED CHANNEL
S106
DETERMINE THAT MOBILE STATION 100n HAS NOT ACTUALLY TRANSMITTED UPLINK SHARED CHANNEL
S108
RELEASE PROCESS WHERE UNTRANSMISSION OF PUSCH (UL-SCH) FROM MOBILE STATION IS DETECTED AND RELEASE RETRANSMISSION RESOURCE TO BE ASSIGNED TO UPLINK SHARED CHANNEL
END

FIG.10

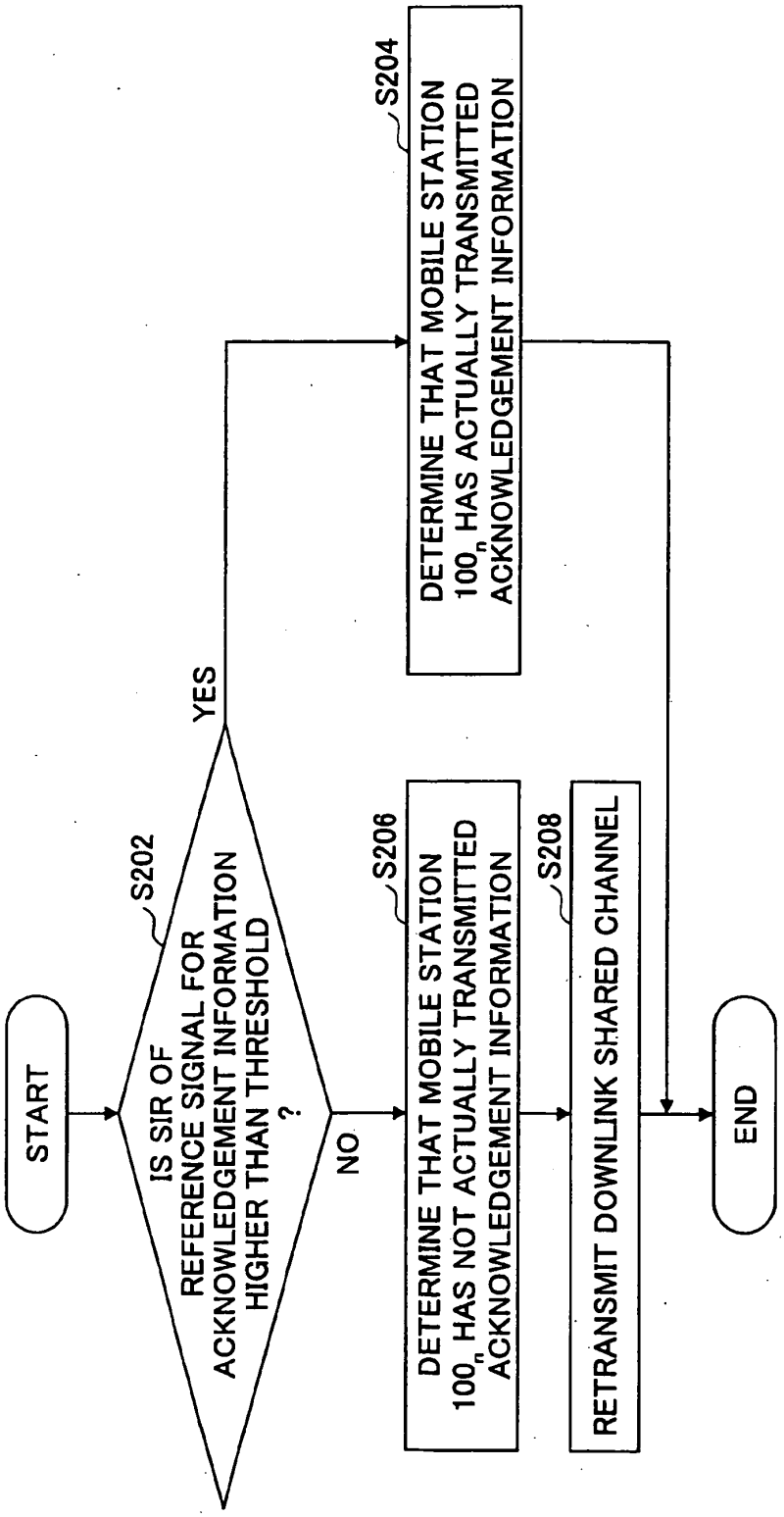

START
S202
IS SIR OF REFERENCE SIGNAL FOR ACKNOWLEDGEMENT INFORMATION HIGHER THAN THRESHOLD ?
YES
NO
S204
DETERMINE THAT MOBILE STATION 100n HAS ACTUALLY TRANSMITTED ACKNOWLEDGEMENT INFORMATION
S206
DETERMINE THAT MOBILE STATION 100n HAS NOT ACTUALLY TRANSMITTED ACKNOWLEDGEMENT INFORMATION
S208
RETRANSMIT DOWNLINK SHARED CHANNEL
END

FIG.11

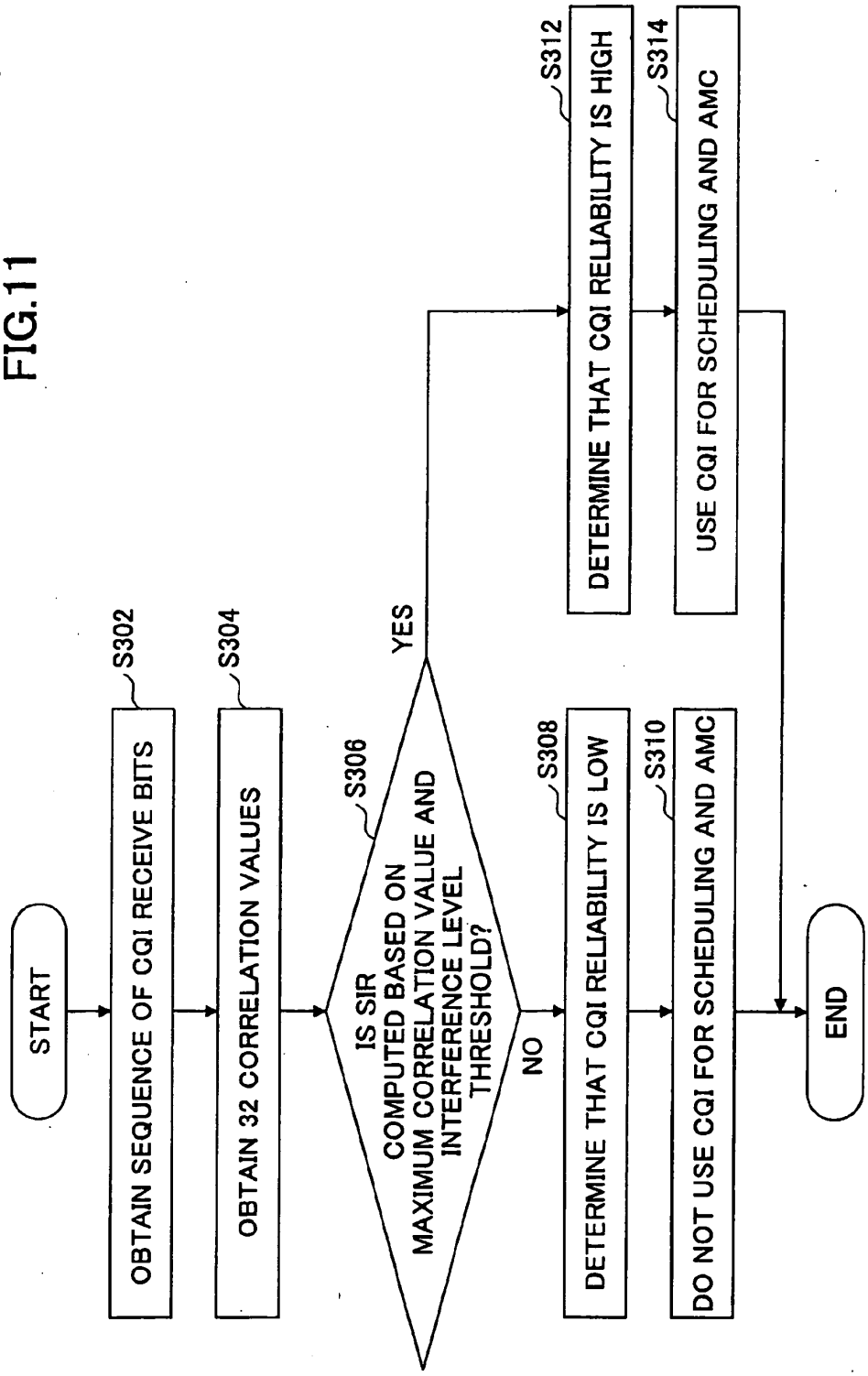

START
S302
OBTAIN SEQUENCE OF CQI RECEIVE BITS
S304
OBTAIN 32 CORRELATION VALUES
S306
IS SIR COMPUTED BASED ON MAXIMUM CORRELATION VALUE AND INTERFERENCE LEVEL THRESHOLD?
YES
NO
S312
DETERMINE THAT CQI RELIABILITY IS HIGH
S314
USE CQI FOR SCHEDULING AND AMC
S308
DETERMINE THAT CQI RELIABILITY IS LOW
S310
DO NOT USE CQI FOR SCHEDULING AND AMC
END

FIG.12

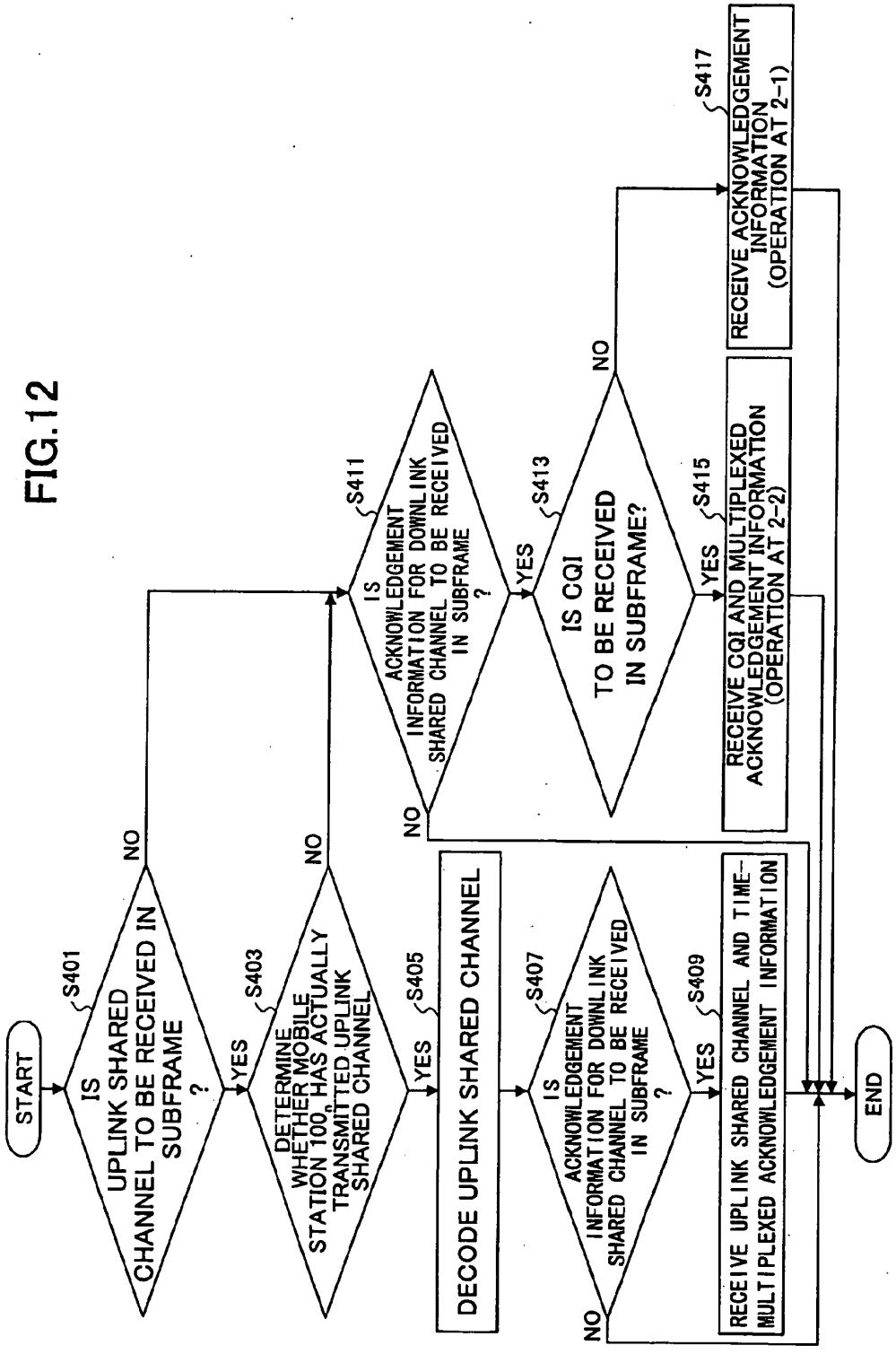

START
S401
IS UPLINK SHARED CHANNEL TO BE RECEIVED IN SUBFRAME ?
NO
YES
S403
DETERMINE WHETHER MOBILE STATION 100n HAS ACTUALLY TRANSMITTED UPLINK SHARED CHANNEL
NO
YES
S405
DECODE UPLINK SHARED CHANNEL
S407
IS ACKNOWLEDGEMENT INFORMATION FOR DOWNLINK SHARED CHANNEL TO BE RECEIVED IN SUBFRAME ?
NO
YES
S409
RECEIVE UPLINK SHARED CHANNEL AND TIME-MULTIPLEXED ACKNOWLEDGEMENT INFORMATION
S411
IS ACKNOWLEDGEMENT INFORMATION FOR DOWNLINK SHARED CHANNEL TO BE RECEIVED IN SUBFRAME ?
NO
YES
S413
IS CQI TO BE RECEIVED IN SUBFRAME?
NO
YES
S415
RECEIVE CQI AND MULTIPLEXED ACKNOWLEDGEMENT INFORMATION (OPERATION AT 2-2)
S417
RECEIVE ACKNOWLEDGEMENT INFORMATION (OPERATION AT 2-1)
END

FIG.13

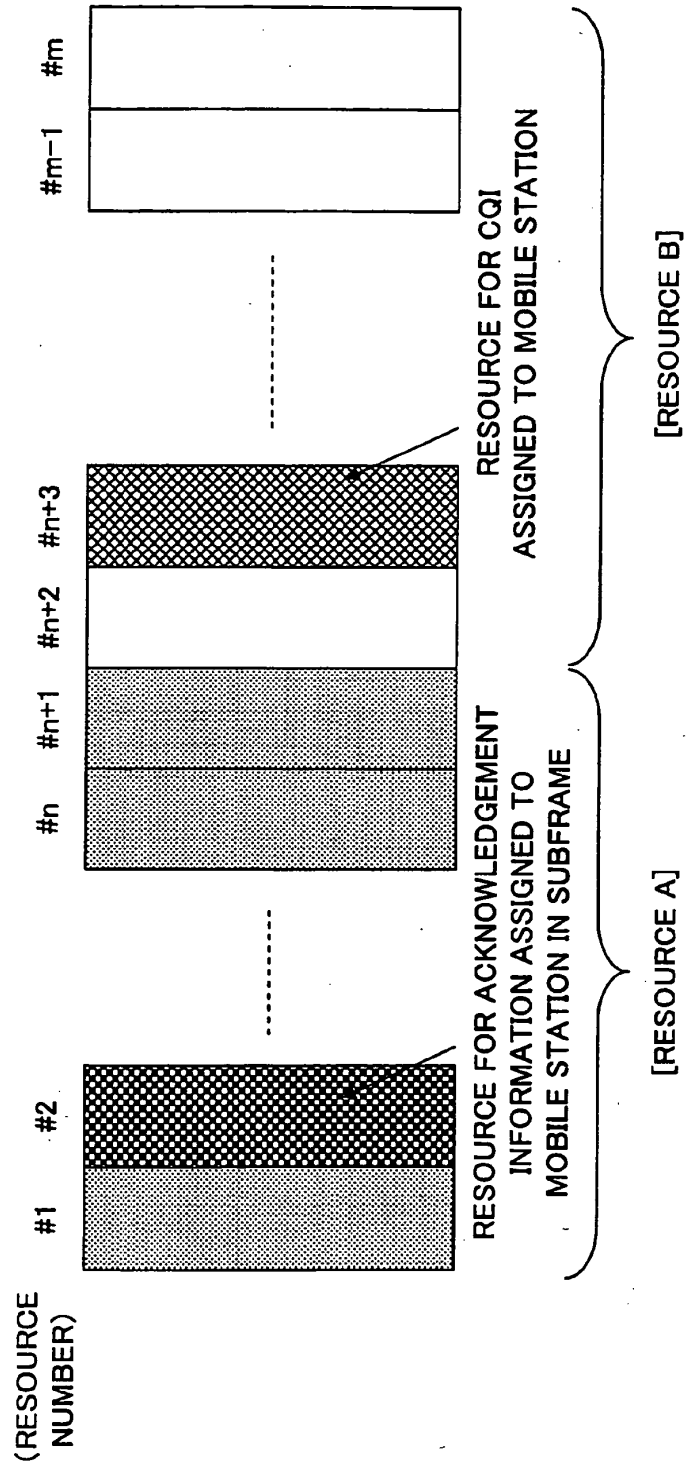
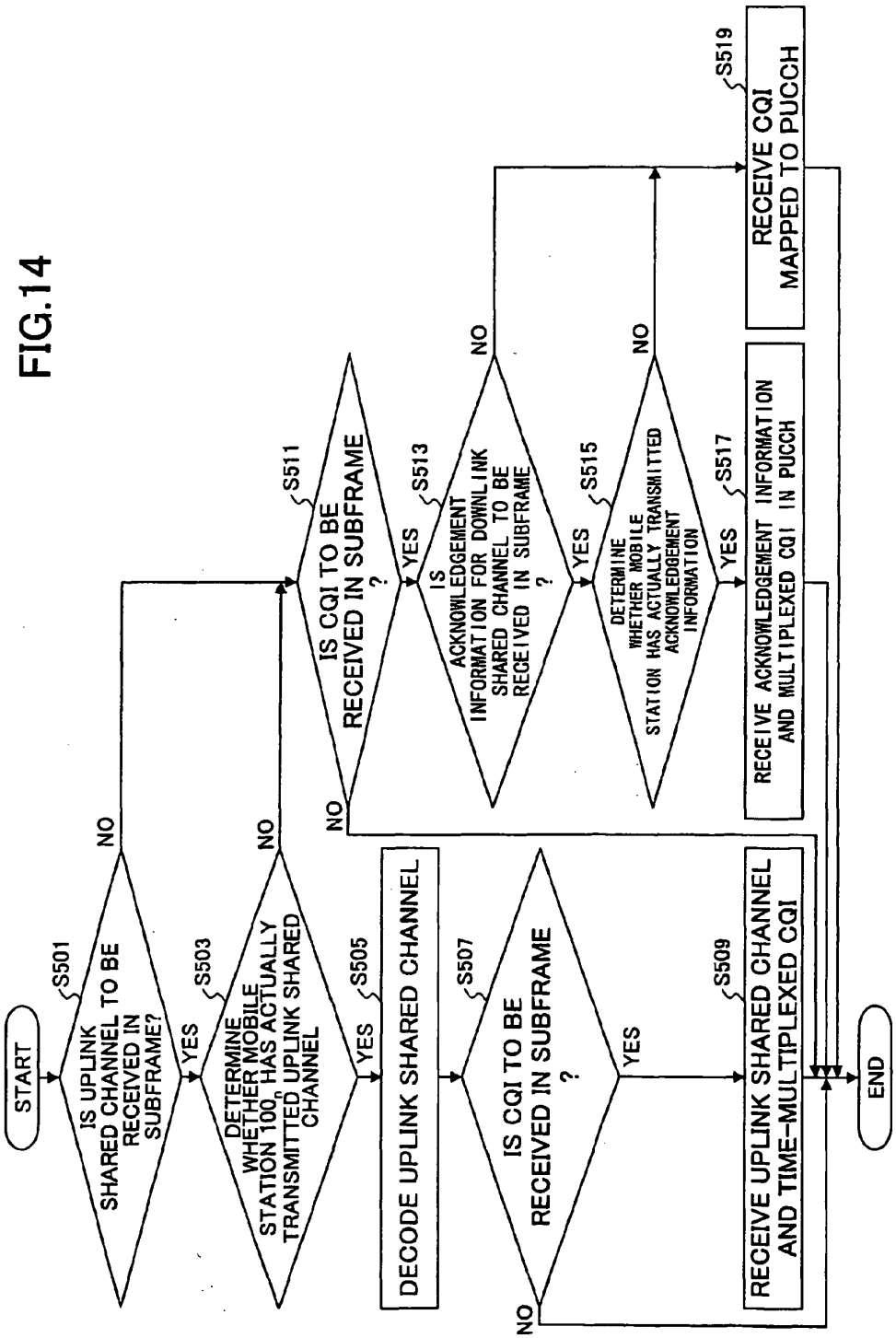

(RESOURCE NUMBER)
#1
#2
#n
#n+1
#n+2
#n+3
#m-1
#m
RESOURCE FOR ACKNOWLEDGEMENT INFORMATION ASSIGNED TO MOBILE STATION IN SUBFRAME
RESOURCE FOR CQI ASSIGNED TO MOBILE STATION
[RESOURCE A]
[RESOURCE B]

FIG.14


START
S501
IS UPLINK SHARED CHANNEL TO BE RECEIVED IN SUBFRAME?
NO
YES
S503
DETERMINE WHETHER MOBILE STATION 100, HAS ACTUALLY TRANSMITTED UPLINK SHARED CHANNEL
NO
YES
S505
DECODE UPLINK SHARED CHANNEL
S507
IS CQI TO BE RECEIVED IN SUBFRAME ?
NO
YES
S509
RECEIVE UPLINK SHARED CHANNEL AND TIME-MULTIPLEXED CQI
END
S511
IS CQI TO BE RECEIVED IN SUBFRAME ?
NO
YES
S513
IS ACKNOWLEDGEMENT INFORMATION FOR DOWNLINK SHARED CHANNEL TO BE RECEIVED IN SUBFRAME ?
NO
YES
S515
DETERMINE WHETHER MOBILE STATION HAS ACTUALLY TRANSMITTED ACKNOWLEDGEMENT INFORMATION
NO
YES
S517
RECEIVE ACKNOWLEDGEMENT INFORMATION AND MULTIPLEXED CQI IN PUCCH
S519
RECEIVE CQI MAPPED TO PUCCH

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2008/053320

A. CLASSIFICATION OF SUBJECT MATTER
H04Q7/38(2006.01)i, *H04J1/00*(2006.01)i, *H04J11/00*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04Q7/38, H04J1/00, H04J11/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2008
Kokai Jitsuyo Shinan Koho 1971-2008 Toroku Jitsuyo Shinan Koho 1994-2008

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	Ericsson, HARQ-ARQ Interactions for NACK - ACK error, 3GPP TSG-RAN WG2 #56bis, Tdoc R2-070059, 3GPP, 2007.01.15, p.1-7	1-4,8-12 5-7
Y A	WO 06/007317 A1 (QUALCOMM Inc.), 19 January, 2006 (19.01.06), Par. Nos. [0021], [0032] & US 2005/0283715 A1 & EP 1766829 A1 & JP 2008-503924 A	1-4,8-12 5-7
A	3GPP Organizational Partners, 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Physical layer procedures (Release 8), 3GPP TS 36.213 V0.2.1, 3GPP, 2006.10, p.10	1-12

[x] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 May, 2008 (14.05.08)	27 May, 2008 (27.05.08)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2008/053320

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	LG Electronics Inc., Impact of ACK to NACK signalling error, 3GPP TSG RAN WG2 #56bis, Tdoc R2-070262, 3GPP, 2006.11.06, p.1-3	1-12
A	JP 2000-134136 A (NEC Corp.), 12 May, 2000 (12.05.00), Par. No. [0056] (Family: none)	1-12

Form PCT/ISA/210 (continuation of second sheet) (April 2007)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2007052112 A **[0185]**
- JP 2007121301 A **[0185]**

Non-patent literature cited in the description

- Physical Layer Aspects for Evolved UTRA. *3GPP TR 25.814 (V7.0.0)*, June 2006 **[0002]**

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(21) International Application Number: PCT/US2004/012043

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(71) Applicant *(for all designated States except US)*: **MOTOROLA INC.** [US/US]; 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **KUCHIBHOTLA, Ravi** [IN/US]; 1093 Smithfield Court, Gurnee, IL 60031 (US). **LOVE, Robert, T.** [US/US]; 817 South Hough Street, Barrington, IL 60010 (US).

(74) Agents: **CHEN, Sylvia, Y.** et al.; 600 North US Highway 45, Libertyville, IL 60048 (US).

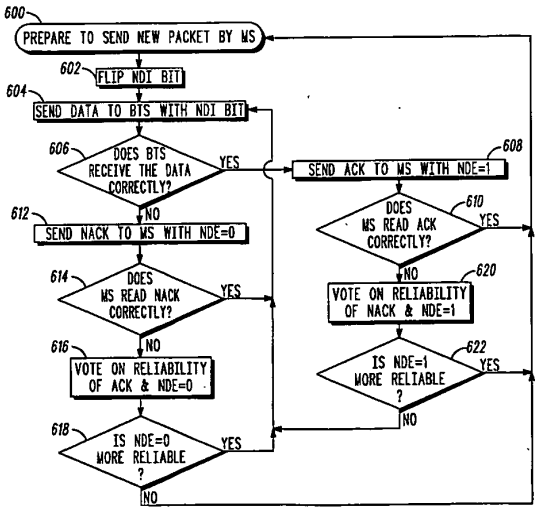
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

[Continued on next page]

(54) Title: ACK/NACK DETERMINATION RELIABILITY FOR A COMMUNICATION DEVICE



(57) Abstract: A method for ACK/NACK determination reliability for a communication device includes a first step of defining (602) a supplementary indicator of message acceptability. A next step includes sending (604) data from a communication device to a BTS on an uplink channel. A next step includes checking (606) the data to see if it was properly received. A next step includes providing (608, 612) the supplementary indicator of message acceptability to the communication device in addition to ACK/NACK information. A next step includes utilizing (610, 614) the supplementary indicator of message acceptability to determine a reliability of the ACK/NACK information.

WO 2004/102980 A2

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

ACK/NACK DETERMINATION RELIABILITY FOR A COMMUNICATION DEVICE

FIELD OF THE INVENTION

The present invention relates generally to a wireless communication device, and more specifically to reliability in receiving message acknowledgements.

BACKGROUND OF THE INVENTION

In a Universal Mobile Telecommunications System (UMTS), such as that proposed for the next of the third generation partnership project (3GPP2) standards for the UMTS Terrestrial Radio Access Network (UTRAN), such as wideband code division multiple access (WCDMA) or cdma2000 for example, user equipment (UE) such as a mobile station (MS) communicates with any one or more of a plurality of base station subsystems (BSSs) dispersed in a geographic region. The mobile station is typically a cellular communication device. Each BSS continuously transmits a downlink physical control (pilot) channel signal having the same spreading code but with a different code phase offset. Phase offset allows the pilot signals to be distinguished from one another, which in turn allows the base stations to be distinguished. Hereinafter, a pilot signal of a BSS will be simply referred to as a pilot. The MS monitors the pilots and measures the received energy of the pilots.

In the WCDMA system, there are a number of states and channels for communications between the MS and the BSS. For example, in the Mobile Station Control on the Traffic State, the BSS communicates with the MS over a Forward Traffic Channel in a forward link and the MS communicates with the BSS over a Reverse Traffic Channel in a reverse link. During a call, the MS must constantly monitor and maintain four sets of pilots. The four sets of pilots are

collectively referred to as the Pilot Set and include an Active Set, a Candidate Set, a Neighbor Set, and a Remaining Set.

The Active Set includes pilots associated with the Forward Traffic Channel assigned to the MS. This set is active in that the pilots associated with this set are all within soft handoff range of the MS. The Candidate Set includes pilots that are not currently in the Active Set but have been received by the MS with sufficient strength to indicate that an associated Forward Traffic Channel could be successfully demodulated. The Neighbor Set includes pilots that are not currently in the Active Set or Candidate Set but are likely candidates for handoff. The Remaining Set includes all possible pilots in the current system on the current WCDMA frequency assignment, excluding the pilots in the Neighbor Set, the Candidate Set, and the Active Set.

Typically, a BSS services a coverage area that is divided up into multiple sectors. In turn, each sector is serviced by one or more of multiple base transceiver stations (BTSs) included in the BSS. When the MS is serviced by a first BTS, the MS constantly searches pilot channels of neighboring BTSs for a pilot that is sufficiently stronger than a threshold value. The MS signals this event to the first, serving BTS using a Pilot Strength Measurement Message. As the MS moves from a first sector serviced by a first BTS to a second sector serviced by a second BTS, the communication system promotes certain pilots from the Candidate Set to the Active Set and from the Neighbor Set to the Candidate Set. The serving BTS notifies the MS of the promotions via a Handoff Direction Message. Afterwards, for the MS to commence communication with a new BTS that has been added to the Active Set before terminating communications with an old BTS, a "soft handoff" will occur.

For the reverse link, typically each BTS in the Active Set independently demodulates and decodes each frame or packet received from the MS. It is then up to a switching center or selection distribution unit (SDU) normally located in a Base Station Site Controller (BSC), which is also known as a Radio Network

Controller (RNC) using WCDMA terminology, to arbitrate between the each BTS's decoded frames. Such soft handoff operation has multiple advantages. Qualitatively, this feature improves and renders more reliable handoff between BTSs as a user moves from one sector to the adjacent one. Quantitatively soft-handoff improves the capacity/coverage in a WCDMA system. However, with the increasing amount of demand for data transfer (bandwidth), problems can arise.

Several third generation standards have emerged, which attempt to accommodate the anticipated demands for increasing data rates. At least some of these standards support synchronous communications between the system elements, while at least some of the other standards support asynchronous communications. At least one example of a standard that supports synchronous communications includes cdma2000. At least one example of a standard that supports asynchronous communications includes WCDMA.

While systems supporting synchronous communications can sometimes allow for reduced search times for handover searching and improved availability and reduced time for position location calculations, systems supporting synchronous communications generally require that the base stations be time synchronized. One such common method employed for synchronizing base stations includes the use of global positioning system (GPS) receivers, which are co-located with the base stations that rely upon line of sight transmissions between the base station and one or more satellites located in orbit around the earth. However, because line of sight transmissions are not always possible for base stations that might be located within buildings or tunnels, or base stations that may be located under the ground, sometimes the time synchronization of the base stations is not always readily accommodated.

However, asynchronous transmissions are not without their own set of concerns. For example, the timing of uplink transmissions in an environment supporting autonomous scheduling by the individual subscribers can be quite sporadic and/or random in nature. While traffic volume is low, the autonomous scheduling of uplink transmissions is less of a concern, because the likelihood of a collision (i.e.

overlap) of data from data being simultaneously transmitted by multiple subscribers is lower. Furthermore, in the event of a collision, there is spare bandwidth available to accommodate the need for any retransmissions. However, as traffic volume increases, the likelihood of data collisions (overlap) also increases. The need for any retransmissions also correspondingly increases, and the availability of spare bandwidth to support the increased amount of retransmissions correspondingly diminishes. Consequently, the introduction of explicit scheduling by a scheduling controller can be beneficial.

However even with explicit scheduling, given the disparity of start and stop times of asynchronous communications and more particularly the disparity in start and stop times relative to the start and stop times of different uplink transmission segments for each of the non-synchronized base stations, gaps and overlaps can still occur. Gaps correspond to periods of time where no subscriber is transmitting. Overlaps correspond to periods of time where multiple subscribers are transmitting simultaneously. Both gaps and overlaps represent inefficiencies in the usage of the available bandwidth and the management of accurate communication.

For example, FIG. 1 is a block diagram of communication system 100 of the prior art. Communication system 100 can be a cdma2000 or a WCDMA system. Communication system 100 includes multiple cells (seven shown), wherein each cell is divided into three sectors (a, b, and c). A BSS 101-107 located in each cell provides communications service to each mobile station located in that cell. Each BSS 101-107 includes multiple BTSs, which BTSs wirelessly interface with the mobile stations located in the sectors of the cell serviced by the BSS. Communication system 100 further includes a radio network controller (RNC) 110 coupled to each BSS and a gateway 112 coupled to the RNC. Gateway 112 provides an interface for communication system 100 with an external network such as a Public Switched Telephone Network (PSTN) or the Internet.

The quality of a communication link between an MS, such as MS 114, and the BSS servicing the MS, such as BSS 101, typically varies over time and

movement by the MS. As a result, as the communication link between MS 114 and BSS 101 degrades, communication system 100 provides a soft handoff (SHO) procedure by which MS 114 can be handed off from a first communication link whose quality has degraded to another, higher quality communication link. For example, as depicted in FIG. 1, MS 114, which is serviced by a BTS servicing sector b of cell 1, is in a 3-way soft handoff with sector c of cell 3 and sector a of cell 4. The BTSs associated with the sectors concurrently servicing the MS, that is, the BTSs associated with sectors 1-b, 3-c, and 4-a, are known in the art as the Active Set of the MS. The communication system 100 also provides a message acknowledgment/ no acknowledgement (ACK/NACK) procedure by which an active BTS can notify the MS 114 that their last message was not received properly and requires a retransmission or other suitable action.

Referring now to FIG. 2, a communication procedure performed by communication system 100 is illustrated. FIG. 2 is a block diagram of a hierarchical structure of communication system 100. As depicted in FIG. 2, RNC 110 includes an ARQ function 210, a scheduler 212, and a soft handoff (SHO) function 214. FIG. 2 further depicts multiple BTSs 201-207, wherein each BTS provides a wireless interface between a corresponding BSS 101-107 and the MSs located in a sector serviced by the BSS.

When performing a soft handoff, each BTS 201, 203, 204 in the Active Set of the MS 114 receives a transmission from MS 114 over a reverse link of a respective communication channel 221, 223, 224. The Active Set BTSs 201, 203, and 204 are determined by SHO function 214. Upon receiving the transmission from MS 114, each Active Set BTS 201, 203, 204 demodulates and decodes the contents of a received radio frame along with related frame quality information.

At this point, each Active Set BTS 201, 203, 204 then conveys the demodulated and decoded radio frame to RNC 110, along with related frame quality information. RNC 110 receives the demodulated and decoded radio frames along with related frame quality information from each BTS 201, 203, 204

in the Active Set and selects a best frame based on frame quality information. Scheduler 212 and ARQ function 210 of RNC 110 then generate control channel information that is distributed as identical pre-formatted radio frames to each BTS 201, 203, 204 in the Active Set. Alternatively, the BTS of the current cell where the MS is camped (BTS 202) can include its own scheduler and bypass the RNC 110 when providing scheduling information to the MS. The Active Set BTSs 201, 203, 204 then simulcast the pre-formatted radio frames over the forward link. The control channel information is then used by MS 114 to determine what transmission rate to use. Further, the ARQ function is associated with an ACK/NACK channel for use by the BTS to communicate whether the previous message from the MS was received properly by the BTS.

The scheduling function allows a mobile station (MS) to signal control information corresponding to an enhanced reverse link transmission to Active Set base transceiver stations (BTSs) and by allowing the BTSs to perform control functions. The MS in a SHO region can choose a scheduling assignment corresponding to a best transport format and transport-related information (TFRI) out of multiple scheduling assignments that the MS receives from multiple active set BTS. As a result, the uplink channel can be scheduled during SHO, without any explicit communication between the BTSs. In either case, data rate constraints are provided by a scheduler, which is used by the MS 114, along with control channel information, to determine what transmission rate to use.

As proposed for the UMTS system, a MS can use an enhanced uplink dedicated transport channel (EUDCH) to achieve an increased data rate coverage of a reverse link. The MS must determine the data rate to use for the enhanced uplink based on local measurements at the MS and information provided by the UTRAN rate constraints. Moreover, to achieve higher throughput on the reverse link, communication systems such as communication system 100 have adapted techniques such as Hybrid Automatic Repeat ReQuest (H-ARQ) that involves retransmission of erroneous information and Adaptive Modulation and Coding (AMC), as are known in the art.

Adaptive Modulation and Coding (AMC) provides the flexibility to match the modulation and forward error correction (FEC) coding scheme to the average channel conditions for each user, or MS, serviced by the communication system. AMC promises a large increase in average data rate for users that have a favorable channel quality due to their proximity to a BTS or other geographical advantage. Enhanced GSM systems using AMC offer data rates as high as 384 kbps compared to 100 kbps without AMC. Likewise, 5 MHz CDMA systems can offer downlink and uplink peak data rates as high as 10 Mbps and 2 Mbps respectively through AMC, where 2 Mbps and 384 kbps was typical without AMC.

AMC has several drawbacks. AMC is sensitive to measurement error and delay. In order to select the appropriate modulation, the scheduler, such as scheduler 212, must be aware of the channel quality. Errors in the channel estimate will cause the scheduler to select the wrong data rate and either transmit at too high a power, wasting system capacity, or too low a power, raising the block error rate. Delay in reporting channel measurements also reduces the reliability of the channel quality estimate due to constantly varying mobile channel. To overcome measurement delay, a frequency of the channel measurement reports may be increased. However, an increase in measurement reports consumes system capacity that otherwise might be used to carry data.

Hybrid ARQ is an implicit link adaptation technique. Whereas, in AMC explicit C/I measurements or similar measurements are used to set the modulation and coding format, in H-ARQ, link layer acknowledgements are used for re-transmission decisions. Many techniques have been developed for implementing H-ARQ, such as Chase combining, Rate compatible Punctured Turbo codes, and Incremental Redundancy. Incremental Redundancy, or H-ARQ-type-II, is an implementation of the H-ARQ technique wherein instead of sending simple repeats of the entire coded packet, additional redundant information is incrementally transmitted if the decoding fails on the first attempt.

H-ARQ-type-III also belongs to the class of Incremental Redundancy ARQ schemes. However, with H-ARQ-type-III, each retransmission is self-decodable, which is not the case with H-ARQ-type II. Chase combining (also called H-ARQ-type-III with one redundancy version) involves the retransmission by the transmitter of the same coded data packet. The decoder at the receiver combines these multiple copies of the transmitted packet weighted by the received SNR. Diversity (time) gain as well as coding gain (for IR only) is thus obtained after each re-transmission. In H-ARQ-type-III with multiple redundancy, different puncture bits are used in each retransmission. The details for how to implement the various H-ARQ schemes are commonly known in the art and therefore are not discussed herein.

H-ARQ combined with AMC can greatly increase user throughputs, potentially doubling/trebling system capacity. In effect, Hybrid ARQ adapts to the channel by sending additional increments of redundancy, which increases the coding rate and effectively lowers the data rate to match the channel. Hybrid ARQ does not rely only on channel estimates but also relies on the errors signaled by the ARQ protocol.

In the enhanced uplink dedicated channel, the mobile is scheduled by the scheduler, or the mobile can be transmitting in autonomous mode. The BTS sends an ACK/NACK indication to the mobile in response to a message. An ACK (acknowledged) indication acknowledges that the message was properly received. A NACK (not acknowledged) indication indicates that the message was not properly received and should be resent by the MS to the BTS. Optionally, a lack of response from a BTS can be interpreted by the MS as a NACK.

A number of error cases can arise that will degrade the maximum attainable throughput, since an error will generally require a retransmission of the same data. Moreover, the error case of a NACK sent by the BTS being considered an ACK by the mobile can lead to disastrous conditions. In this case, the mobile would have flushed from it's buffer the data packets as soon as an ACK is

perceived and this data is lost forever in the case of streaming applications. However, even in non-streaming applications, this type of error would negatively impact system throughput since Receiver-Driven Layered Multicast Congestion Control (RLC) retransmission would be triggered, or in the worst case Transport Control Protocol (TCP) slow start would be triggered, both of which seriously affect data throughput. Additionally, when receiving another scheduling assignment message on the downlink from the BTS, the mobile would now send a different uplink data transmission with contents different from the prior transmission and the BTS would then erroneously soft-combine this in an ARQ operation with information in it's soft buffer that corresponds to previous data, thus affecting the success of transmission of this new packet as well. Solving this problem is therefore important to ensure a high throughput of good data in the uplink. In another error case, the BTS can sent an ACK that the mobile determines to be a NACK, wherein the MS may needlessly retransmit the same data that has already been successfully received at the BTS. This also reduces overall system throughput.

Therefore, a need exists for a new technique to enhance the reliability of the determination of ACK/NACK information, thereby resolving the issues of erroneous determination of an ACK as a NACK and NACK as an ACK, both with and without soft handoff (SHO). In particular, it would be of benefit to set up a technique to allow the feedback of information between the MS and active set BTSs such that a macro selection diversity benefit is obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the present invention, which are believed to be novel, are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood by reference to the following

description, taken in conjunction with the accompanying drawings, in the several figures of which like reference numerals identify like elements, and in which:

FIG. 1 is a block diagram of an exemplary communication system of the prior art;

FIG. 2 is a block diagram of a hierarchical structure of the communication system of FIG. 1;

FIG. 3 depicts a distributed network architecture in accordance with an embodiment of the present invention;

FIG. 4 is a message flow diagram in accordance with an embodiment of the present invention;

FIG. 5 is a block diagram of an exemplary communication system, in accordance with the present invention;

FIG. 6 is a graph of a prior art ACK to NACK interpretation;

FIG. 7 is a flow chart of the operation of FIG. 8;

FIG. 8 is a graph of an ACK to NACK interpretation, in accordance with the present invention;

FIG. 9 is a graph of a prior art NACK to ACK interpretation;

FIG. 10 is a graph of an NACK to ACK interpretation, in accordance with the present invention;

FIG. 11 is a graph of a soft handoff NACK to ACK interpretation, in accordance with the present invention;

FIG. 12 is a flow chart of the operation of FIG. 11; and

FIG. 13 is a chart for reliability interpretation, in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a method to enhance the reliability of the determination of ACK/NACK information, thereby resolving the issues of erroneous determination of an ACK as a NACK and NACK as an ACK both in and without soft handoff (SHO). This is achieved through a novel technique of

using channel quality and "new data expected" indicators in a scheduling assignment message from a BTS to a communication device (MS). This technique allows the set up of feedback information between the MS and active set BTSs such that a macro selection diversity benefit is obtained.

In general, the present invention supports active set handoff and scheduling functions by allowing a mobile station (MS) to provide HARQ ACK/NACK coding information to improve data throughput of an enhanced reverse link transmission to Active Set base transceiver stations (BTSs). The present invention allows more efficient implementation of an enhanced reverse link channel with adaptive modulation and coding (AMC), Hybrid ARQ (HARQ), and fast scheduling with reduced ARQ delay. HARQ, AMC, active set handoff, and scheduling functions are preferably supported in a distributed fashion by allowing a mobile station (MS) to signal control information corresponding to an enhanced reverse link transmission to *Active Set* base transceiver stations (BTSs) and by allowing the BTSs to perform control functions. Time and signal-to-noise ratio (SNR)-based HARQ flush functions are supported at the BTSs during soft handoff (SHO), and provides an efficient control channel structure to support scheduling, HARQ, AMC functions for an enhanced reverse link, or uplink, channel in order to maximize throughput, and enables an MS in a SHO region to choose a scheduling assignment corresponding to a best transport format and resource-related information (TFRI) out of multiple scheduling assignments that the MS receives from multiple active set BTS. As a result, the enhanced uplink channel can be scheduled during SHO, while supporting HARQ and AMC, without any explicit communication between the BTSs.

The present invention may be more fully described with reference to FIGs. 3-5. FIG. 5 is a block diagram of a communication system 1000 in accordance with an embodiment of the present invention. Preferably, communication system 1000 is a Code Division Multiple Access (CDMA) communication system, such as cdma2000 or Wideband CDMA (WCDMA) communication system, that includes multiple communication channels. Those who are of ordinary skill in the

art realize that communication system 1000 may operate in accordance with any one of a variety of wireless communication systems, such as a Global System for Mobile communication (GSM) communication system, a Time Division Multiple Access (TDMA) communication system, a Frequency Division Multiple Access (FDMA) communication system, or an Orthogonal Frequency Division Multiple Access (OFDM) communication system.

Similar to communication system 100, communication system 1000 includes multiple cells (seven shown). Each cell is divided into multiple sectors (three shown for each cell - sectors a, b, and c). A base station subsystem (BSS) 1001-1007 located in each cell provides communications service to each mobile station located in that cell. Each BSS 1001-1007 includes multiple base stations, also referred to herein as base transceiver stations (BTSs) or Node-Bs, which wirelessly interface with the mobile stations located in the sectors of the cell serviced by the BSS. Communication system 1000 further includes a radio network controller (RNC) 1010 coupled to each BSS, preferably through a 3GPP TSG UTRAN Iub Interface, and a gateway 1012 coupled to the RNC. Gateway 1012 provides an interface for communication system 1000 with an external network such as a Public Switched Telephone Network (PSTN) or the Internet.

Referring now to FIGs. 3 and 5, communication system 1000 further includes at least one mobile station (MS) 1014. MS 1014 may be any type of wireless user equipment (UE), such as a cellular telephone, a portable telephone, a radiotelephone, or a wireless modem associated with data terminal equipment (DTE) such as a personal computer (PC) or a laptop computer. MS 1014 is serviced by multiple BTSs, that are included in an Active Set associated with the MS. MS 1014 wirelessly communicates with each BTS in communication system 1000 via an air interface that includes a forward link (from the BTS to the MS) and a reverse link (from the MS to the BTS). Each forward link includes multiple forward link control channels including an ACK/NACK channel, a paging channel, and traffic channel. Each reverse link includes multiple reverse link control channels, a paging channel, and a traffic channel. However, unlike

communication system 100 of the prior art, each reverse link of communication system 1000 further includes another traffic channel, an Enhanced Uplink Dedicated Transport Channel (EUDCH), that facilitates high speed data transport by permitting a transmission of data that can be dynamically modulated and coded, and demodulated and decoded, on a sub-frame by sub-frame basis.

In operation, FIG. 4 shows a message flow diagram 400 illustrates an exchange of communications between an MS of communication system 1000, such as MS 1014, and each of the multiple BTSs included in an Active Set of the MS, that is, BTSs 301, 303, and 304. MS 1014 communicates scheduling information 402 to each Active Set BTS 301, 303, 304 using a first reverse link control channel 406 with a known fixed modulation and coding rate and transport block size. A corresponding code assignment for the first reverse link control channel is done on a semi-static basis. Preferably, MS 1014 does not transmit control information when the MS's corresponding data queue is empty.

Each Active Set BTS 301, 303, 304 receives scheduling information 402 from the MS 1014 serviced by the BTS via the first reverse link control channel 406. The scheduling information 402 may include the data queue status and the power status of the MS. Based on the scheduling information 402 received from each MS serviced by a BTS, each serving, or Active Set, BTS 301, 303, 304 schedules one or more of the MSs serviced by the BTS, that is, MS 1014, for each scheduling transmission interval 410.

Each Active Set BTS 301, 303, 304 uses reverse link interference level, MS scheduling information 402, and power control information to determine a maximum allowed power margin target or limit for each MS 1014 serviced by the BTS. Power margin is the difference between a current DPCCH power level and the maximum power level supported by the MS. The pilot is a reverse link channel that is used for demodulation purposes such as automatic frequency control, synchronization, and power control. For example, in a WCDMA system

this channel is referred to as a DPCCH. A maximum EUDCH to DPCCH power ratio target can also be determined.

Upon choosing an MS (e.g. MS 1014) to be scheduled, each Active Set BTS 301, 303, 304 conveys a scheduling assignment 418 to the chosen MS, such as MS 1014, on a first forward link control channel 426. The first forward link control channel 426 can use the 10ms frame format depicted in FIG. 4, which format includes a scheduling assignment 418, tail bits, and a CRC. Alternatively, the first forward link control channel 426 frame size may use a frame format of 2ms. The first forward link control channel 426 is staggered to avoid additional latency. The scheduling assignment 418 consists of the maximum allowed 'power margin' limit or target and a map of the allowed EUDCH sub-frame transmission intervals, such as a 2ms sub-frame interval, for the next 10ms transmission interval using a first forward link control channel 426.

Referring back to FIG. 5, communication system 1000 includes a soft handoff (SHO) procedure by which MS 1014 can be handed off from a first air interface whose quality has degraded to another, higher quality air interface. For example, as depicted in FIG. 5, MS 1014, which is serviced by a BTS servicing sector b of cell 1, is in a 3-way soft handoff with sector c of cell 3 and sector a of cell 4. The BTSs associated with the sectors concurrently servicing the MS, that is, the BTSs associated with sectors 1-b, 3-c, and 4-a, are the Active Set of the MS. In other words, MS 1014 is in soft handoff (SHO) with the BTSs 301, 303, and 304, associated with the sectors 1-b, 3-c, and 4-a servicing the MS, which BTSs are the Active Set of the MS. As used herein, the terms 'Active Set' and 'serving,' such as an Active Set BTS and a serving BTS, are interchangeable and both refer to a BTS that is in an Active Set of an associated MS. Furthermore, although FIGs. 3 and 5 depict BTSs 301, 303, and 304 as servicing only a single MS, those who are of ordinary skill in the art realize that each BTS 301-307 may concurrently schedule, and service, multiple MSs, that is, each BTS 301-307 may concurrently be a member of multiple Active Sets.

FIG. 3 depicts a network architecture 300 of communication system 1000 in accordance with an embodiment of the present invention. As depicted in FIG. 3, communication system includes multiple BTSs 301-307, wherein each BTS provides a wireless interface between a corresponding BSS 1001-1007 and the MSs located in a sector serviced by the BTS. Preferably, a scheduling function 316, an ARQ function 314 and a SHO function 318 are distributed in each of the BTSs 301-307. RNC 1010 is responsible for managing mobility by defining the members of the Active Set of each MS serviced by communication system 1000, such as MS 1014, and for coordinating multicast/multireceive groups. For each MS in communication system 1000, Internet Protocol (IP) packets are multi-cast directly to each BTS in the Active Set of the MS, that is, to BTSs 301, 303, 304 in the Active Set of MS 1014.

Preferably, each BTS 301-307 of communication system 1000 includes a SHO function 318 that performs at least a portion of the SHO functions. For example, SHO function 318 of each BTS 301, 303, 304 in the Active Set of the MS 1014 performs SHO functions such as frame selection and signaling of a new data indicator. Each BTS 301-307 can include a scheduler, or scheduling function, 316 that alternatively can reside in the RNC 110. With BTS scheduling, each Active Set BTS, such as BTSs 301, 303, and 304 with respect to MS 1014, can choose to schedule the associated MS 1014 without need for communication to other Active Set BTSs based on scheduling information signaled by the MS to the BTS and local interference and SNR information measured at the BTS. By distributing scheduling functions 306 to the BTSs 301-307, there is no need for Active Set handoffs of a EUDCH in communication system 1000. The ARQ function 314 and AMC function, which functionality also resides in RNC 110 of communication system 100, can also be distributed in BTSs 301-307 in communication system 1000. As a result, when a data block transmitted on a specific Hybrid ARQ channel has successfully been decoded by an Active Set BTS, the BTS acknowledges the successful decoding by conveying an ACK to the

source MS (e.g. MS 1014) without waiting to be instructed to send the ACK by the RNC 1010.

In order to allow each Active Set BTS 301, 303, 304 to decode each EUDCH frame, MS 1014 conveys to each Active Set BTS, in association with the EUDCH frame, modulation and coding information, incremental redundancy version information, HARQ status information, and transport block size information from MS 1014, which information is collectively referred to as transport format and resource-related information (TFRI). The TFRI only defines rate and modulation coding information and H-ARQ status. The MS 1014 codes the TFRI and sends the TFRI over the same frame interval as the EUDCH.

For example, as is known in the art, during reverse link communications, the MS 1114 transmits frames to a plurality of BTSs 301, 303, 304. The structure of the frames, includes: (a) a flush bit which indicates to the BTS when to combine a current frame with a previously stored frame or to flush the current buffer; (b) data; (c) a cyclic redundancy check (CRC) bit which indicates whether a frame decoded successfully or not (i.e., whether the frame contained any errors); and (d) a tail bit for flushing the channel decoder memory. The information contained in the frame is referred to herein as soft information. The BTSs can combine frames from multiple re-transmissions using an H-ARQ scheme. The MS 1114 can also transmit supplemental reliability bits, as will be explained below.

After receiving a frame from the MS 1114, the BTSs 301, 303, 304 will process the frame and communicate to the MS 1114 over a forward control channel whether the frame contained any errors (ACK/NACK). At the present time, if all BTSs communicate that the frame contains errors, the MS 1114 will retransmit the same frame to all BTSs, with the F bit set to instruct the BTSs to combine the retransmitted frame with the original stored frame. If only one or none of the BTSs communicates that the frame contains errors, the MS 1114 will transmit the next frame to all the BTSs with the F bit set to instruct all BTSs to erase the previous frame from memory and not to combine the previous frame

with the current frame. This wastes resources. In addition, the MS cannot address individual non-scheduling BTSs, but only the scheduling BTS, because the MS does not know which code channel to listen to from the other non-scheduling active set BTSs. Further, the mobile may misinterpret a NACK indication from the BTS as an ACK, or vice versa. These problems are solved in the present invention.

In particular, the present invention encompasses a method for ACK/NACK determination reliability for a communication device. Specifically, the present invention provides a supplementary indicator of message acceptability that is used in conjunction with the ACK/NACK information. In a first embodiment, the supplementary indicator is a New Data Expected (NDE) indicator that is sent in a subsequent scheduling assignment message (SAM) from the BTS. In this embodiment, following the reception of ACK/NACK information on the ACK/NACK channel, the MS does not flush data in its buffer until a NDE is received in a subsequent SAM. By coupling the both the ACK/NACK information and the NDE indicator, the mobile is able to make a more reliable conclusion regarding the success of the previous transmission.

In a second embodiment of the invention, operational in soft handoff, the MS uses the downlink pilot signal level from each active set BTS for the supplementary indicator of message acceptability. The downlink pilot signal level can be used to infer the downlink channel quality, wherein if the quality is good it is more likely that a received ACK message is correct. Alternatively, the MS can use the downlink Transmit Power Control (TPC) command information (sent on the uplink to active set BTSs) to determine the reliability of the ACK/NACK channel for a particular BTS. For example, if a MS receives a NACK from a scheduling BTS and a ACK from a non-scheduling BTS, the MS could base its final determination on the above mentioned information.

Preferably, when sending data in the uplink corresponding to a new packet after determining that a previous transmission was successful, the MS can set a

New Data Indicator (NDI) bit(s) in the transport format related information, TFRI (rate information sent on control channel to assist in decoding data sent on uplink data channel), so that the BTS that sent a NACK for the previous transmission does not erroneously soft combine the data bits of the new packet with the soft decision bits corresponding to the previous packet. Note that even if a single BTS (not in SHO) has sent the indication (and no energy was detected on the ACK/NACK channel of other BTSs thus implying a NACK), the mobile could base its decision of ACK/NACK on the channel quality of the downlink. In SHO, the above techniques can be used in combination to provide increased reliability of the ACK/NACK channel in combination with the "new data indicator" bit(s) sent by the mobile in the uplink on the TFRI channel.

Efficient layer 1 signaling is needed to enable fast explicit and autonomous scheduling with Hybrid ARQ at the BTS for enhanced uplink. To enable uplink Hybrid ARQ an acknowledged/not acknowledged (ACK/NACK) feedback code channel can be used. The MS is told by a scheduling BTS which downlink code channel it should listen to for receiving ACK/NACK information. Alternatively, the ACK/NACK information can be coded in the SAM from the BTS to the MS. In the explicit mode, the BTSs in the active set sends dedicated scheduling assignment messages (SAM) to each mobile that describes a data transmission opportunity on the enhanced uplink channel. The scheduling assignment can be sent over a 10 ms or a 2 ms long frame. Although other frame lengths are certainly possible, 10 ms and 2 ms frame lengths are more common in 3GPP. In the case of a 10 ms scheduling assignment message, there is sufficient room for additional bits to provide indication of ACK/NACK of previously received transmissions. In addition CRC protection can be used to provide sufficient reliability of the ACK/NACK information. However, the 10 ms SAM message suffers from not being able to rely on the latest radio conditions due to its length. The latter is not critical though since the MS can be required to use the power control information in addition to the power margin information in the SAM message to determine the uplink rate. This could still lead to reduced throughput in case the scheduled MS's radio conditions improved and the BTS did not

schedule enough number of MSs in Code Division Multiplex (CDM), whereby two or more users are simultaneously assigned transmission opportunities within the same time period, to utilize the left-over noise rise margin. Also note that the 10 ms case suffers from the additional disadvantage of potentially low overall throughput in the case where the SAM message is lost and therefore the resource is wasted due to loss of a complete 10 ms worth of transmission opportunity.

When a 2ms frame length is used for the SAM message, the BTS is able to react quickly to changing radio conditions at the mobile and schedule it on an up-fade. In this case, it is useful to use a separate ACK/NACK channel to provide an indication to the mobile on the success or lack thereof of the mobile's uplink data transmission due to insufficient number of available bits on the downlink scheduling assignment channel over 2 ms. Due to the lack of CRC information of the ACK/NACK information itself (ACK/NACK in this case being merely a detection of pilot energy by the mobile) there is potential for erroneous determination of ACK/NACK by the mobile. However, CRC protection can still be provided in a 2 ms SAM by piggy backing ACK/NACK information on the 2ms SAM message (which itself has a CRC) with a two bit ACK/NACK field.

There are a number of benefits to sending the ACK/NACK on a separate code channel. Coherent BPSK is very reliable given a 2ms interval. Use repetition to avoid need for CRC in SHO. In other words, repetition of SAM cannot be used. But by using repetition of the ACK/NACK, it can be ensured that the mobile receives the information with minimal error. There is anti-correlation between SAM and ACK/NACK usage for asynchronous HARQ since typically non-contiguous frame scheduling is expected. In other words, one does not want to send a larger SAM message if all that is needed is to send a simple ACK/NACK indication. In particular, the user may not be scheduled again and not receive a subsequent SAM. Similarly, the built-in overhead of combined SAM and ACK/NACK is especially significant for non-scheduling BTSs. For example, non-scheduling BTSs that only want to send an ACK/NACK indication presently need to send a SAM message, even if not scheduling, if ACK/NACK is combined

with the SAM. In addition, there would be a need for more ACK/NACK bits per HARQ channel if ACK/NACK is piggy backed on the SAM.

Additionally in SHO, multiple BTS's may receive the uplink data and send a ACK/NACK indication. The BTS may or may not send a scheduling assignment message following this to the mobile. In this case it is useful to have a mechanism that assists the mobile to determine which BTS's ACK/NACK channel it should base its decision of ACK/NACK on. In this case, if the scheduling BTS has sent a NACK but the mobile receives an ACK from another non-scheduling BTS the mobile could make an erroneous determination.

The present invention requires that the mobile not flush its buffer immediately on receiving the ACK/NACK indication from the BTS. The present invention further adds a one bit "new data expected" indicator to the scheduling assignment message sent on another code channel and the mobile is required to read this to determine if the BTS (that sent it the previous SAM message) is expecting new information or a retransmission of the previous transmission. If the mobile receives a "new data expected" indicator in the scheduling assignment message it can reliably determine that the BTS has in fact successfully received the previous packet and it can then flush this packet from its buffer. The "new data expected" indicator is included in the scheduling assignment message and therefore has CRC protection, and hence the potential for falsing is low. In addition, it should be noted that the memory requirement on the mobile is not increased due to having to store the (packet) transmission (it is not stored as soft bits) until reading of the scheduling assignment message. Note that this mechanism is also useful in the case where the mobile receives an ACK from the BTS and interprets it as a NACK (a more probable erroneous condition).

Another embodiment of the invention, operational in SHO, requires the mobile to use the downlink pilot signal level (e.g. downlink channel quality) from each active set BTS or equivalently the downlink TPC command information (sent on the uplink to active set BTSs) to determine the reliability of the ACK/NACK channel for a

particular BTS. In case the mobile receives a NACK from the scheduling BTS and an ACK from a non-scheduling BTS, the mobile could base its final determination on the above mentioned information. When sending data in the uplink corresponding to a new packet after determining that the previous transmission was successful, the mobile would set the "new data indicator" bit(s) in the TFRI (rate information sent on control channel to assist in decoding data sent on uplink data channel) so that BTSs that sent a NACK for the previous transmission do not erroneously soft combine the data bits of the new packet with the soft decision bits corresponding to the previous packet. Note that even if a single BTS has sent the indication (and no energy was detected on the ACK/NACK channel of other BTSs thus implying a NACK), the mobile could base its decision of ACK/NACK on the channel quality of the downlink.

In SHO, the above mechanisms in combination would provide increased reliability of the ACK/NACK channel in combination with the "new data indicator" bit(s) sent by the mobile in the uplink on the TFRI channel.

In a preferred embodiment, if the mobile makes a final determination of a NACK, then it would await a further SAM message and after a time T1 (if a SAM was not already received and therefore no "new data expected" indicator was received), and either flush the data (concluding that it's determination was incorrect) or, if no SAM message was received for a time T2 (could be equal to T1), revert to an autonomous mode and send the packet again. Note the lack of receipt of the SAM message could also serve as an indication that the BTS did successfully receive the packet and be used as input in the determination process (if for time T1 no SAM was received). Timers T1 and T2 could be network determined timers based on the service that is mapped to this channel and the quality of service expected. If before the expiry of T1 the mobile does not receive a SAM message from the same BTS but receives a SAM message from another BTS, the mobile can simply choose a different HARQ channel identity to send another packet, and at the expiry of T1 continue its actions for the previous packet as above. Therefore, there is no stall in data transfer.

Note that the NDE (new data expected indicator) is not the same as sending the ACK/NACK bit twice, i.e. once on the ACK/NACK channel and again later on the SAM channel where it is called the NDE bit. This relieves non-scheduling BTSs from having to send the SAM channel if only the NDE (truly the ACK/NACK bit in this case) is sent and not both a ACK/NACK and NDE. That is, if the non-scheduling BTS did not send the SAM with the NDE and did not send the ACK/NACK then there would be no macro-selection diversity benefit possible. Also there are significant benefits for having a separate ACK/NACK and SAM channel as discussed earlier which are independent of whether a NDE exists or not. There are additional reliability benefits by having both a NDE and an ACK/NACK which have also been discussed above.

The present invention corresponds to uplink data transmission where a delayed flush technique is used to provide additional reliability for the ACK/NACK indication. Also a new technique for determining ACK/NACK in the case of SHO (or even in the case of a single BTS providing indication) is provided. This technique can also be used in HSDPA at the BTS by utilizing the uplink channel quality information to determine the reliability of the ACK/NACK indication sent by the mobile.

The present invention includes several novel aspects, some of which are listed as follows. Firstly, the present invention requires the mobile to not flush its buffer immediately on reading the ACK/NACK channel. Secondly, the present invention provides a "new data expected" indicator in the downlink scheduling assignment message to provide additional reliability for the ACK/NACK indication. Thirdly, the present invention can utilize the downlink channel quality (pilot bits, power control command information) to make a determination of the ACK/NACK indication. Fourthly, the present invention includes the use of timers to determine actions if no SAM is subsequently received.

FIGs. 6-13 are charts demonstrating the operation of the present invention as compared to the prior art. In each case, distributed scheduling of users on data channels requires reliable ACK/NACK determination to ensure maximum throughput.

Reading errors, such as reading an ACK as a NACK, and reading NACK as an ACK cause substantial negative impacts. The impact for reading NACK as an ACK is significant since it can result in either data being permanently lost or incurring transport delay due to upper layer transport protocol retransmissions. Also wasted transmissions occur when an ACK is read as NACK, which reduces throughput. In the examples below, the "new data indicator" (NDI) bit corresponds to the F (flush) bit previous described. The NDI bit has a flip function wherein NDI changes state (from 0 to 1 or from 1 to 0) for each successfully transmitted and received packet from the MS to the BTS.

Referring to FIG. 6, a present situation is shown where a BTS sends an ACK (acknowledge) indicating the data from the MS was properly received. However, the MS misreads this as a NACK. In this example, in the first row, an MS has transmitted a previous packet (here with NDI=0), which the BTS has successfully received and sent an ACK on the ACK/NACK channel to the MS. The MS properly receives the ACK indication which completes the transmission of the previous packet. The MS then prepares to send a new packet. As shown in the second row, the NDI bit is state flipped (from 0 to 1 in this example) and the data is sent to the BTS with the NDI bit. The flip of the NDI bit indicates to the BTS that this is new data. In this case, the data is not received by the BTS properly, which indicates this as a NACK. The MS also receives the NACK properly and prepares to retransmit the data. Therefore, in the third row, the NDI bit is not flipped (i.e. it remains 1 indicating to the BTS that the same data is being sent). In this case, the BTS properly receives that data and indicates this with an ACK. However, the MS has an error and misreads the ACK as a NACK. Thereafter, in the fourth row, the NDI bit is not flipped (i.e. it remains 1 indicating to the BTS that the same data is being sent), and the data is resent until an ACK is properly sent and received. This waste resources and throughput as the BTS has already received the data properly.

The present invention solves this problem by incorporating a "new data expected" (NDE) indicator sent by the BTS to the MS. The NDE correlates to the ACK signal from the BTS, as explained in FIGs. 7 and 8, but is delayed (shown by the

diagonal arrow) due to its being in a SAM from the BTS. The SAM is delayed a time *t* from the ACK/NACK channel. The MS now retains the previous packet in its buffer until the SAM is received and proper reception of the data by the BTS can be determined. In this example, once again in the first row, an MS has transmitted a previous packet, which the BTS has successfully received and sent an ACK on the ACK/NACK channel to the MS. In addition, in this case the BTS also sends an NDE of 1, which is a supplemental indication that the data was properly received. Although the MS properly receives the ACK indication, the MS also receives an NDE indicator of 1, which indicates that the BTS is now expecting new data (i.e. the previous packet was received properly). This completes the transmission of the previous packet. The MS then prepares 600 to send a new packet of data. As shown in the second row, the NDI bit is state flipped 602 (from 0 to 1 in this example) and the data is sent 604 to the BTS with the NDI bit. The flip of the NDI bit indicates to the BTS that this is new data. In this case, the data is not received by the BTS properly 606, which indicates this 612 as a NACK and sends an NDE of 0, indicating that the data was not received properly and that new data is not expected (i.e. the previous, old data is expected to be retransmitted). In this row, the MS also reads 614 the NACK properly along with the later transmitted (in the SAM) NDE which confirms the NACK. If the ACK/NACK and NDE disagreed, a voting procedure 616 would be used, as will be explained below. In this case there is agreement between the NACK and NDE=0, so the MS will retransmit the data 604. Therefore, in the third row, the NDI bit is not flipped (i.e. it remains 1 indicating to the BTS that the same data is being sent). In this case, the BTS properly receives 606 the retransmitted data and indicates this with an ACK 608 and the sending of and NDE of 1. However, the MS has an error and misreads 610 the ACK as a NACK, but correctly receives the NDE. The MS must then vote 620 on the reliability of the misread NACK or the NDE=1. Since the NDE is sent in a SAM that has a CRC check and the ACK/NACK channel does not have a CRC check, the MS determines that the NDE=1 is more reliable 622, ignoring the misread NACK and preparing to send a new packet 600. Thereafter, in the fourth row, the NDI bit is flipped 602, and new data is sent 604 with the new NDI bit, which is properly received by the BTS 606 and MS 610. Therefore,

the present invention provides a solution to the wasted resources and throughput that can presently occur when a MS misreads a BTS ACK as a NACK. The discussion can now turn to the instance where a MS misreads a BTS NACK as an ACK, which is a more serious condition since data can be lost.

Referring to FIG. 9, a present situation is shown where a BTS sends a NACK (not acknowledged) indicating the data from the MS was not properly received. However, the MS misreads this as an ACK. In this example, in the first row, an MS has transmitted a previous packet (here with NDI=0), which the BTS has successfully received and sent an ACK on the ACK/NACK channel to the MS. The MS properly receives the ACK indication which completes the transmission of the previous packet. The MS then prepares to send a new packet. As shown in the second row, the NDI bit is state flipped (from 0 to 1 in this example) and the data is sent to the BTS with the NDI bit. The flip of the NDI bit indicates to the BTS that this is new data. In this case, the data is not received by the BTS properly, which indicates this as a NACK. The MS also receives the NACK properly and prepares to retransmit the data. Therefore, in the third row, the NDI bit is not flipped (i.e. it remains 1 indicating to the BTS that the same data is being sent). In this case, the BTS still does not properly receive that data and indicates this with an NACK. However, the MS has an error and misreads the NACK as an ACK. This has serious consequences as the MS flushes its buffer thinking that the BTS has properly received that data. Thereafter, in the fourth row, the NDI bit is flipped since new data is loaded into the buffer and the new data is sent. This also has serious consequences since the flipped NDI bit tells the BTS to flush any soft data that it had that might have been useful in recovering the original message. This data is permanently lost, not to mention the wasted resources, throughput and the increased delay die to TCP/RLC retransmissions.

The present invention also solves this problem by incorporating the "new data expected" (NDE) indicator sent by the BTS to the MS, as explained in FIGs. 7 and 10, but is delayed (shown by the diagonal arrow) due to its being in a SAM from the BTS. The SAM is delayed a time *t* from the ACK/NACK channel. As before, the MS retains the previous packet in its buffer until the SAM is received and proper reception

of the data by the BTS can be determined. In this example, once again in the first row, an MS has transmitted a previous packet, which the BTS has successfully received and sent an ACK on the ACK/NACK channel to the MS. In addition, in this case the BTS also sends an NDE of 1, which is the supplemental indication that the data was properly received. Although the MS properly receives the ACK indication, the MS also receives an NDE indicator of 1, which indicates that the BTS is now expecting new data (i.e. the previous packet was received properly). This completes the transmission of the previous packet. The MS then prepares 600 to send a new packet of data. As shown in the second row, the NDI bit is state flipped 602 (from 0 to 1 in this example) and the data is sent 604 to the BTS with the NDI bit. The flip of the NDI bit indicates to the BTS that this is new data. In this case, the data is not received by the BTS properly 606, which indicates this 612 as a NACK and sends an NDE of 0, indicating that the data was not received properly and that new data is not expected (i.e. the previous, old data is expected to be retransmitted). In this row, the MS also reads 614 the NACK properly along with the later transmitted (in the SAM) NDE which confirms the NACK. If the ACK/NACK and NDE disagreed, a voting procedure 616 would be used, as will be explained below. In this case there is agreement between the NACK and NDE=0, so the MS will retransmit the data 604. Therefore, in the third row, the NDI bit is not flipped (i.e. it remains 1 indicating to the BTS that the same data is being sent). In this case, the BTS still does not properly receive 606 the retransmitted data and indicates this with a NACK 612 and the sending of and NDE of 0. However, the MS has an error and misreads 614 the NACK as an ACK, but correctly receives the NDE. The MS must then vote 616 on the reliability of the misread ACK or the NDE=0. Since the NDE is sent in a SAM that has a CRC check and the ACK/NACK channel does not have a CRC check, the MS determines that the NDE=0 is more reliable 618, ignoring the misread ACK and preparing to send the old packet 604. Thereafter, in the fourth row, the NDI bit is not flipped, and old data is sent 604 with the same NDI bit, which is now properly received by the BTS 606 and MS 610. Therefore, the present invention provides a solution to the wasted resources and throughput and lost data that can presently occur when a MS misreads a BTS NACK as an ACK. The discussion can now turn to the

instance where a MS is on soft handoff and in communication with more than one BTS.

Referring to FIGs. 11 and 12, a present situation is shown where an MS is in soft handoff with a scheduling BTS and one or more non-scheduling BTSs in its active set. In this instance, a separate ACK/NACK code is used for the non-scheduling BTS(s), i.e. the non-scheduling BTS sends no SAM. This example is meant to show a scheduling BTS that sends a NACK (not acknowledged) indicating the data from the MS was not properly received, and the MS misreads this as an ACK. Further, a non-scheduling BTSI can send a conflicting ACK/NACK indication to the MS, which is also addressed in the present invention. In the first row, an MS has transmitted 1204 a previous packet (here with NDI=0), which the scheduling BTS has successfully received and sent 1208 an ACK on the ACK/NACK channel to the MS. The scheduling BTS also sends and "new data expected" indication (NDE=1) in a SAM to the MS. The MS properly receives 1210 the ACK indication and confirming NDE. Therefore, the MS does not need to determine the reliability 1220, 1221 in this case. Since the MS has confirming evidence of a properly received packet by the scheduling BTS, even where a non-scheduling BTS sends a NACK, the MS accepts the evidence as a valid transmission, which completes the transmission of the previous packet so the MS can flush the previous packet. In other words, an MS will ignore non-scheduling BTS(s) as long as there is proper communication with a scheduling BTS. Since the first row show a properly received packet, the MS then prepares to send a new packet 1200. As shown in the second row, the NDI bit is state flipped 1202 (from 0 to 1 in this example) and the data is sent 1204 to the BTS(s) with the NDI bit. The flip of the NDI bit indicates to the BTS(s) that this is new data. In this case, the data is not received by the scheduling BTS properly 1206, which indicates this 1212 as a NACK and sends an NDE of 0, indicating that the data was not received properly and that new data is not expected (i.e. the previous, old data is expected to be retransmitted). However, in contrast to the previous row, the present invention must consider whether any non-scheduling BTS(s) may have properly received 1224 the packet. Therefore, even if the MS reads the NACK correctly 1214 and has confirming

evidence (NDE=0) of a misread packet by the scheduling BTS, the MS will check if a non-scheduling BTS sent 1226 an ACK. However, in this second row the non-scheduling BTS also misread 1224 the packet which confirms that no active set BTS has given an indication of properly receiving the packet. Therefore, the MS will retransmit the previous packet. Therefore, in the third row, the NDI bit is not flipped (i.e. it remains 1 indicating to the BTS that the same data is being sent), and the packet is resent 1204. In this case, the BTS still does not properly receive 1206 the retransmitted data and indicates this with a NACK 1212 and the sending of and NDE of 0. However, the MS has an error and misreads 1214 the NACK as an ACK, but correctly receives the NDE=0. The MS will then vote 1216 on the reliability. Since the NDE is sent in a SAM that has a CRC check and the ACK/NACK channel does not have a CRC check, the MS determines that the NDE=0 is more reliable than the ACK, and would normally resend the packet. However, there is another parameter here to consider, in accordance with the present invention, as a non-scheduling BTS may have sent an ACK (ACK2). If NDE=0 (ACK) and there is an ACK2, the MS can determine 1228 if the scheduling BTS (NDE=0) or non-scheduling BTS (ACK2) is more reliable.

Referring to FIG. 13, reliability between BTSs can be determined through several means. For example, if the channel quality (e.g. signal-to-interference ratio) has improved for the non-scheduling BTS (B2) while the channel quality has degraded for the scheduling BTS (B1), then the ACK from B2 can indicate that it would be appropriate for the MS to switch 1230 to B2 as the scheduling BTS. In this case, a new packet can then be sent to B2 with communication continuing normally. This would prevent a waste of time and resources. However, if this change of channel quality is not the case, then the MS would check to see if the NDE=0 is more reliable than the misread ACK (see 616, 618 from FIG. 7) from the scheduling BTS, which is not likely as the NDE is sent in a SAM that has a CRC check and the ACK/NACK channel does not have a CRC check. In this case, the packet would be resent. Similarly, a received signal strength level (e.g. RSSI) can be used to determine if a signal from one BTS is stronger (i.e. ACK more reliable) than another BTS, wherein

the MS could switch 1230 to the stronger BTS as scheduler and continue with sending new packets. Further, uplink power control commands can be used in the same way, wherein a BTS that is signaling for an ever increasing power control bit would imply that it is losing the signal and is less reliable, indicating that the MS could switch 1230 to B2 and continue with sending new packets.

Referring back to FIGs. 11 and 12, the example considers the case where the non-scheduling ACK is not more reliable than the scheduling ACK, and the scheduling ACK conflicts with the NDE=0. This calls for a retransmit. Therefore, in the fourth row, the NDI bit is not flipped, and old data is sent 1204 with the same NDI bit, which is now properly received 1206 by BTS1 and properly read 1210 by the MS. In this case, the non-scheduling BTS (B2) previously received the packet correctly and can take notice that the NDI bit from the MS indicates that the same packet is being sent. Upon this notice, the B2 can ignore the packet and attend to other communication in discontinuous transmit (DTX) mode, or the B2 can re-ACK since it has already received the packet. In this way, the present invention provides a solution to the wasted resources and throughput and lost data that can presently occur when a MS misreads a BTS NACK as an ACK in soft handoff.

In a further embodiment of the present invention, if an MS receives an ACK/NACK indication but no new scheduling assignment message (SAM) from either the last scheduling BTS or new BTS (i.e. no NDE received), the MS can flush the data packet from its buffer if a first timer expires. T1 can be configured by the scheduler at set-up. However, if an MS Mobile receives a SAM from a new BTS (but not last scheduling BTS) and timer T1 has not expired, it can choose another HARQ channel to send new packets. These actions would depend on what the new BTS sent in terms of ACK/NACK for the last transmission, and if any and what the NDE is set to. One value for the NDE bits could be "1st transmission" used when the BTS has not previously sent any ACK/NACK and new data is expected for this assignment. In addition, a second timer, T2, could also be configured by scheduler such that if timer T2 expires following a last transmission (or ACK/NACK reception), the mobile reverts to an autonomous mode and sends a retransmission if the last transmission was

determined to be a NACK. Lack of reception of a SAM for T1 duration can also be used in a determination process (e.g. scheduler may not schedule based on QoS considerations) and subsequent flushing of data from the MS data buffer.

Note that the NDE indicator is not the same as sending the ACK/NACK bit twice, i.e. once on the ACK/NACK channel and again later on the SAM channel where it is called the NDE bit. This relieves non-scheduling BTSs from having to send the SAM channel if only the NDE (truly the ACK/NACK bit in this case) is sent and not both an ACK/NACK and NDE. That is, if the non-scheduling BTSs did not send the SAM with the NDE and did not send the ACK/NACK then there would be no macro-selection diversity benefit possible. Also, there are significant benefits for having a separate ACK/NACK and SAM channel as discussed earlier which are independent of whether a NDE exists or not. There are additional reliability benefits by having both a NDE and an ACK/NACK which have also been discussed above.

While the present invention has been particularly shown and described with reference to particular embodiments thereof, it will be understood by those skilled in the art that various changes may be made and equivalents substituted for elements thereof without departing from the scope of the invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather then a restrictive sense, and all such changes and substitutions are intended to be included within the scope of the present invention.

Benefits, other advantages, and solutions to problems have been described above with regard to specific embodiments. However, the benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential feature or element of any or all the claims. As used herein, the terms "comprises," "comprising," or any variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not include only those elements

but may include other elements not expressly listed or inherent to such process, method, article, or apparatus.

CLAIMS

What is claimed is:

1. A method for ACK/NACK determination reliability for a communication device, the method comprising steps of:

defining (602) a supplementary indicator of message acceptability;

sending (604) data from a communication device to a base station (BTS) on an uplink channel;

checking (606) the data to see if it was properly received;

providing (608, 612) the supplementary indicator of data acceptability to the communication device in addition to ACK/NACK information; and

utilizing (610, 614) the supplementary indicator of data acceptability to determine a reliability of the ACK/NACK information.

2. The method of claim 1, wherein the supplementary indicator of data acceptability in the defining step is a New Data Expected (NDE) indicator, and wherein the NDE indicator is sent in a subsequent scheduling assignment message (SAM) from the BTS in the providing step.

3. The method of claim 1, wherein the ACK/NACK information of the providing step is coded into a scheduling assignment message (SAM) from the BTS downlink ACK/NACK code channel.

4. The method of claim 1, wherein the ACK/NACK information of the providing step is provided on a separate downlink ACK/NACK code channel.

5. The method of claim 1, further comprising the step of operating the communication device in soft handoff, and wherein the providing step includes measuring a downlink signal level from each active set BTS for inclusion in the utilizing step to determine reliability.

6. The method of claim 1, further comprising the step of operating the communication device in soft handoff, and wherein the providing step includes providing downlink transmit power control command information for inclusion in the utilizing step to determine reliability.

7. The method of claim 1, further comprising the step of operating the communication device in soft handoff, and wherein the providing step includes determining a channel quality of at least two of the active set of base stations for inclusion in the utilizing step to determine reliability.

8. The method of claim 1, wherein the defining step includes defining a New Data Indicator (NDI), and wherein the sending step includes the communication device sending a NDI coded as at least one bit in the transport format related information (TFRI).

9. The method of claim 1, wherein upon a reliable ACK determination in the utilizing step, further comprising the step of flushing the data in a buffer of the communication device.

10. The method of claim 1, wherein upon a reliable NACK determination in the utilizing step, further comprising the steps of:

waiting a first predetermined time period for a subsequent SAM from the BTS, and

flushing the data in a buffer of the communication device if a subsequent SAM is not received before the first predetermined time period expires.

11. The method of claim 1, wherein upon a reliable NACK determination in the utilizing step, further comprising the steps of:

waiting a second predetermined time period for a subsequent SAM from the BTS, and

resending the data in a buffer of the communication device if a subsequent SAM is not received before the second predetermined time period expires.

12. A method for ACK/NACK determination reliability for a communication device, the method comprising steps of:

defining (602) a New Data Expected (NDE) indicator that indicates whether a base station (BTS) is expecting new data;

sending (604) data from a communication device to the BTS on an uplink channel, the data including a new data indication (NDI) of whether new data is being sent;

checking (606) the data to see if it was properly received;

providing (608, 612) the NDE to the communication device in addition to ACK/NACK information; and

utilizing (610, 614) the NDE to determine a reliability of the ACK/NACK information.

13. The method of claim 12, wherein the ACK/NACK information of the providing step is coded into a scheduling assignment message (SAM) from the BTS downlink ACK/NACK code channel.

14. The method of claim 12, wherein if a NACK is received in the checking step and the NDE indicates that new data is expected, further comprising the step of sending an indication of new data indication along with a new packet of data.

15. The method of claim 12, wherein if an ACK is received in the checking step and the NDE indicates that new data is not expected, further comprising the step of sending an indication of previous data along with resending the previous packet of data.

16. The method of claim 12, further comprising the step of operating the communication device in soft handoff, and wherein the providing step includes providing the NDE and ACK/NACK information from a first, scheduling base station and ACK/NACK information from a second, non-scheduling base station to the communication device, and wherein if the utilizing step indicates a conflict between a received ACK and the NDE from the scheduling base station, and an ACK is received from the non-scheduling base station, then the providing step includes measuring relative levels of a quality of signal (QoS) of the scheduling and non-scheduling base stations for inclusion in the utilizing step to determine reliability, and wherein if the relative levels of the QoS between the scheduling and non-scheduling base stations has changed indicating that the non-scheduling base station now has a better QoS than the scheduling base station further comprising the steps of assigning the second base station as the scheduling base, and sending new packet data to the second base station.

17. The method of claim 12, wherein upon a reliable NACK determination in the utilizing step, further comprising the steps of:

waiting a first predetermined time period for a subsequent SAM from the BTS, and

flushing the data in a buffer of the communication device if a subsequent SAM is not received before the first predetermined time period expires.

18. The method of claim 12, wherein upon a reliable NACK determination in the utilizing step, further comprising the steps of:

waiting second predetermined time period for a subsequent SAM from the BTS, and

resending the data in a buffer of the communication device if a subsequent SAM is not received before the second predetermined time period expires.

19. A method for ACK/NACK determination reliability for a communication device, the method comprising steps of:

defining (602) a New Data Expected (NDE) indicator that indicates whether a base station (BTS) is expecting new data;

sending (604) data from a communication device to the BTS on an uplink channel, the data including a new data indication (NDI) of whether new data is being sent;

checking (606) the data to see if it was properly received;

providing (608, 612) the NDE to the communication device in addition to ACK/NACK information; and

utilizing (610, 614) the NDE to determine a reliability of the ACK/NACK information such that

if a NACK is received in the checking step and the NDE indicates that new data is expected, further comprising the step of sending an indication of new data indication along with a new packet of data, and

if an ACK is received in the checking step and the NDE indicates that new data is not expected, further comprising the step of sending an indication of previous data along with resending the previous packet of data.

20. The method of claim 19, further comprising the step of operating the communication device in soft handoff, and wherein the providing step includes providing the NDE and ACK/NACK information from a first, scheduling base station and ACK/NACK information from a second, non-scheduling base station to the communication device, and wherein if the utilizing step indicates a conflict between a received ACK and the NDE from the scheduling base station, and an ACK is received from the non-scheduling base station, then the providing step includes measuring relative levels of a quality of signal (QoS) of the scheduling and non-scheduling base stations for inclusion in the utilizing step to determine reliability, and wherein if the relative levels of the QoS between the scheduling and non-scheduling base stations has changed indicating that the non-scheduling base station now has a better QoS than the scheduling base station further comprising the steps of assigning the second base station as the scheduling base, and sending new packet data to the second base station.

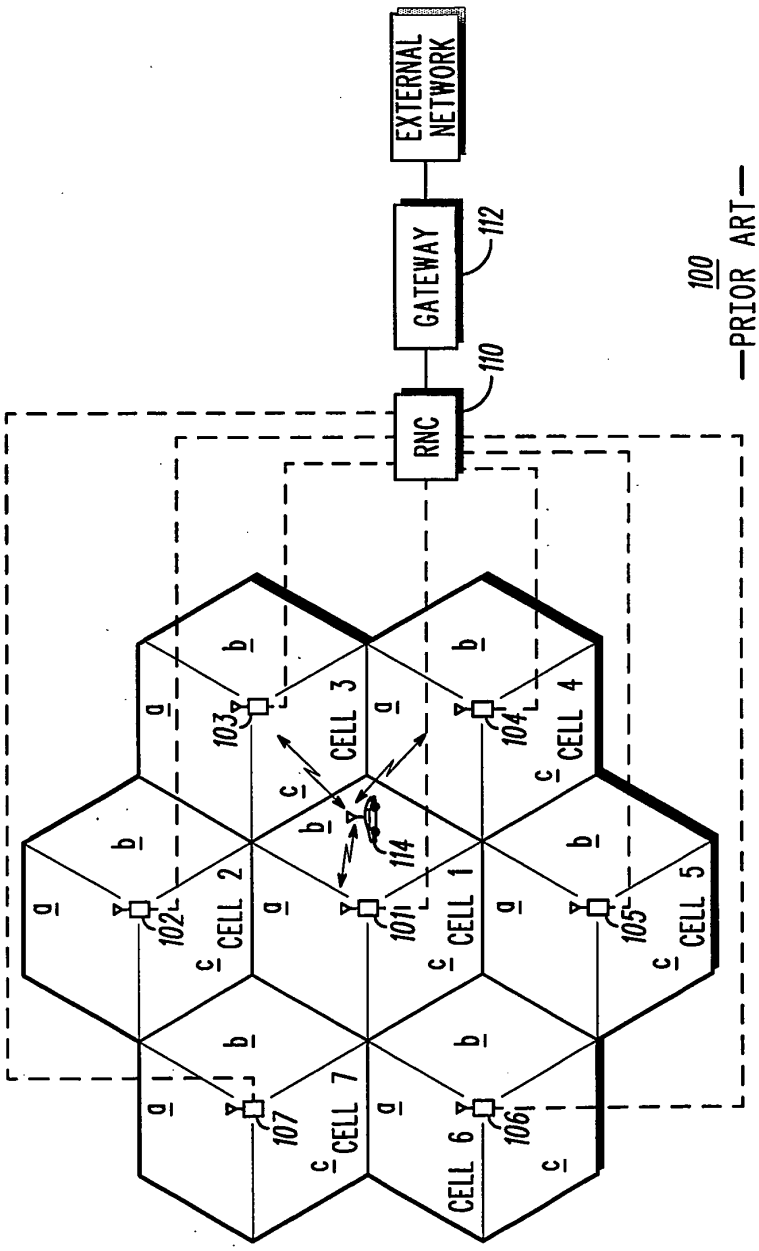

EXTERNAL NETWORK
GATEWAY
112
RNC
110
100
PRIOR ART
CELL 1
CELL 2
CELL 3
CELL 4
CELL 5
CELL 6
CELL 7
101
102
103
104
105
106
107
114
a
b
c

FIG. 1

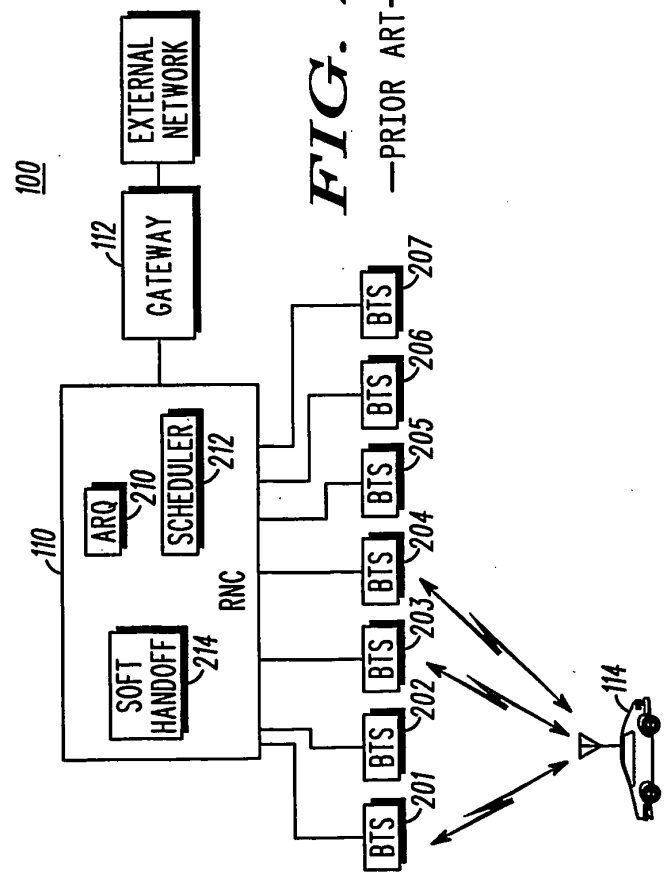


FIG. 2
—PRIOR ART—

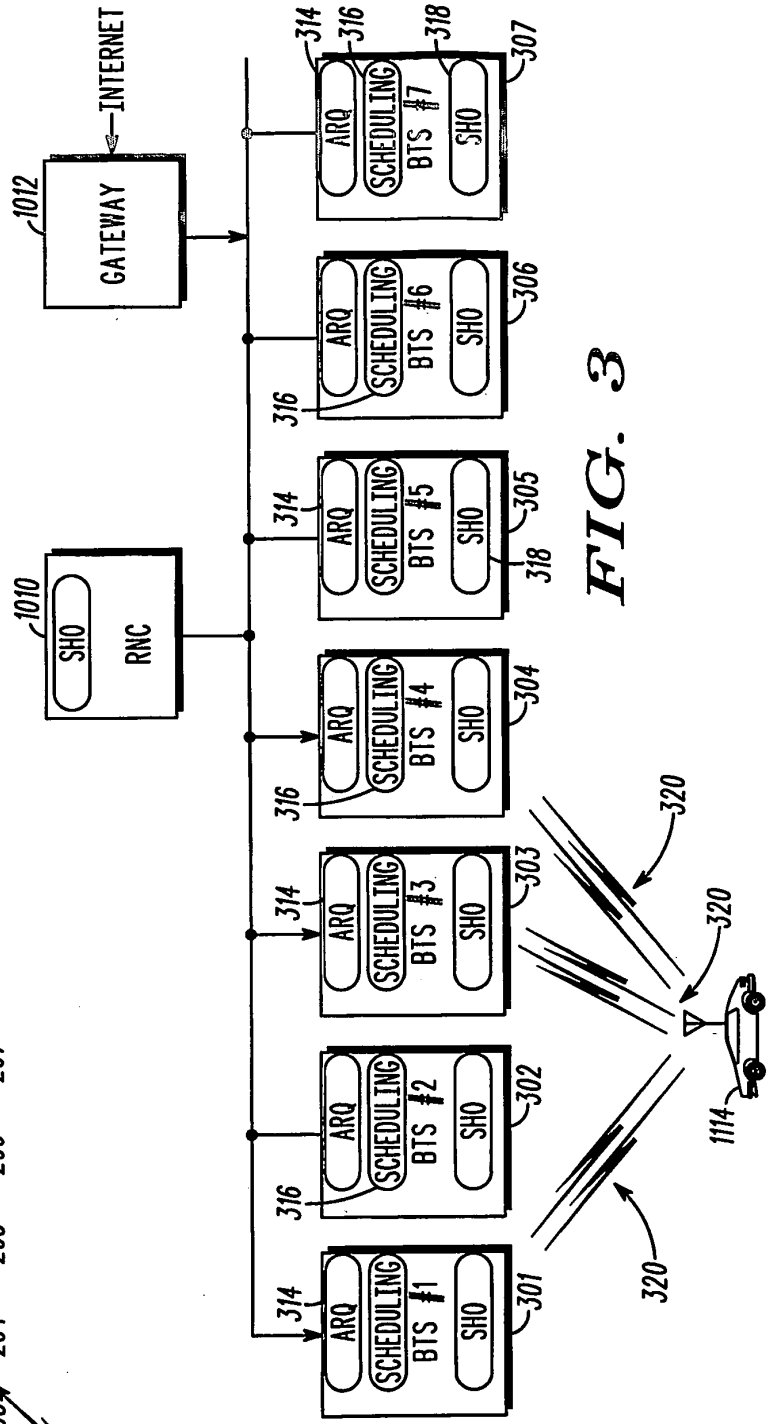


FIG. 3

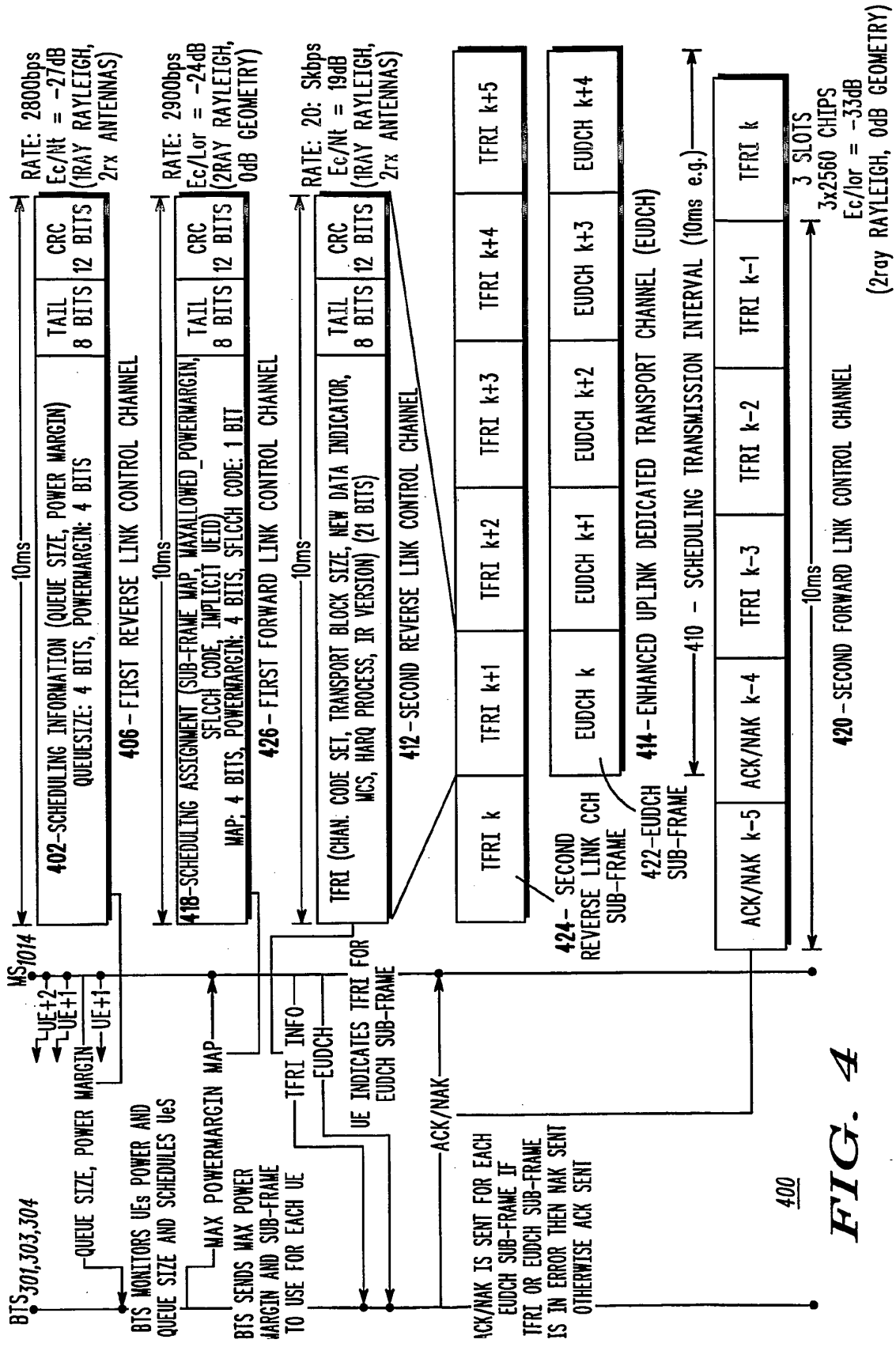

BTS 301,303,304
MS 1014
UE+2
UE+1
UE+1
QUEUE SIZE, POWER MARGIN
BTS MONITORS UEs POWER AND QUEUE SIZE AND SCHEDULES UeS
MAX POWERMARGIN MAP
BTS SENDS MAX POWER MARGIN AND SUB-FRAME TO USE FOR EACH UE
TFRI INFO
EUDCH
UE INDICATES TFRI FOR EUDCH SUB-FRAME
ACK/NAK
ACK/NAK IS SENT FOR EACH EUDCH SUB-FRAME IF TFRI OR EUDCH SUB-FRAME IS IN ERROR THEN NAK SENT OTHERWISE ACK SENT
10ms
402-SCHEDULING INFORMATION (QUEUE SIZE, POWER MARGIN) QUEUESIZE: 4 BITS, POWERMARGIN: 4 BITS
TAIL 8 BITS
CRC 12 BITS
RATE: 2800bps Ec/Nt = -27dB (1RAY RAYLEIGH, 2rx ANTENNAS)
406-FIRST REVERSE LINK CONTROL CHANNEL
10ms
418-SCHEDULING ASSIGNMENT (SUB-FRAME MAP, MAXALLOWED_POWERMARGIN, SFLCCH CODE, IMPLICIT UEID) MAP: 4 BITS, POWERMARGIN: 4 BITS, SFLCCH CODE: 1 BIT
TAIL 8 BITS
CRC 12 BITS
RATE: 2900bps Ec/Ior = -24dB (2RAY RAYLEIGH, 0dB GEOMETRY)
426-FIRST FORWARD LINK CONTROL CHANNEL
10ms
TFRI (CHAN. CODE SET, TRANSPORT BLOCK SIZE, NEW DATA INDICATOR, MCS, HARQ PROCESS, IR VERSION) (21 BITS)
TAIL 8 BITS
CRC 12 BITS
RATE: 20: 5kbps Ec/Nt = 19dB (1RAY RAYLEIGH, 2rx ANTENNAS)
412-SECOND REVERSE LINK CONTROL CHANNEL
TFRI k
TFRI k+1
TFRI k+2
TFRI k+3
TFRI k+4
TFRI k+5
424- SECOND REVERSE LINK CCH SUB-FRAME
EUDCH k
EUDCH k+1
EUDCH k+2
EUDCH k+3
EUDCH k+4
422-EUDCH SUB-FRAME
414-ENHANCED UPLINK DEDICATED TRANSPORT CHANNEL (EUDCH)
410 - SCHEDULING TRANSMISSION INTERVAL (10ms e.g.)
ACK/NAK k-5
ACK/NAK k-4
TFRI k-3
TFRI k-2
TFRI k-1
TFRI k
10ms
3 SLOTS
3x2560 CHIPS
Ec/Ior = -33dB
(2ray RAYLEIGH, 0dB GEOMETRY)
420-SECOND FORWARD LINK CONTROL CHANNEL
400

FIG. 4

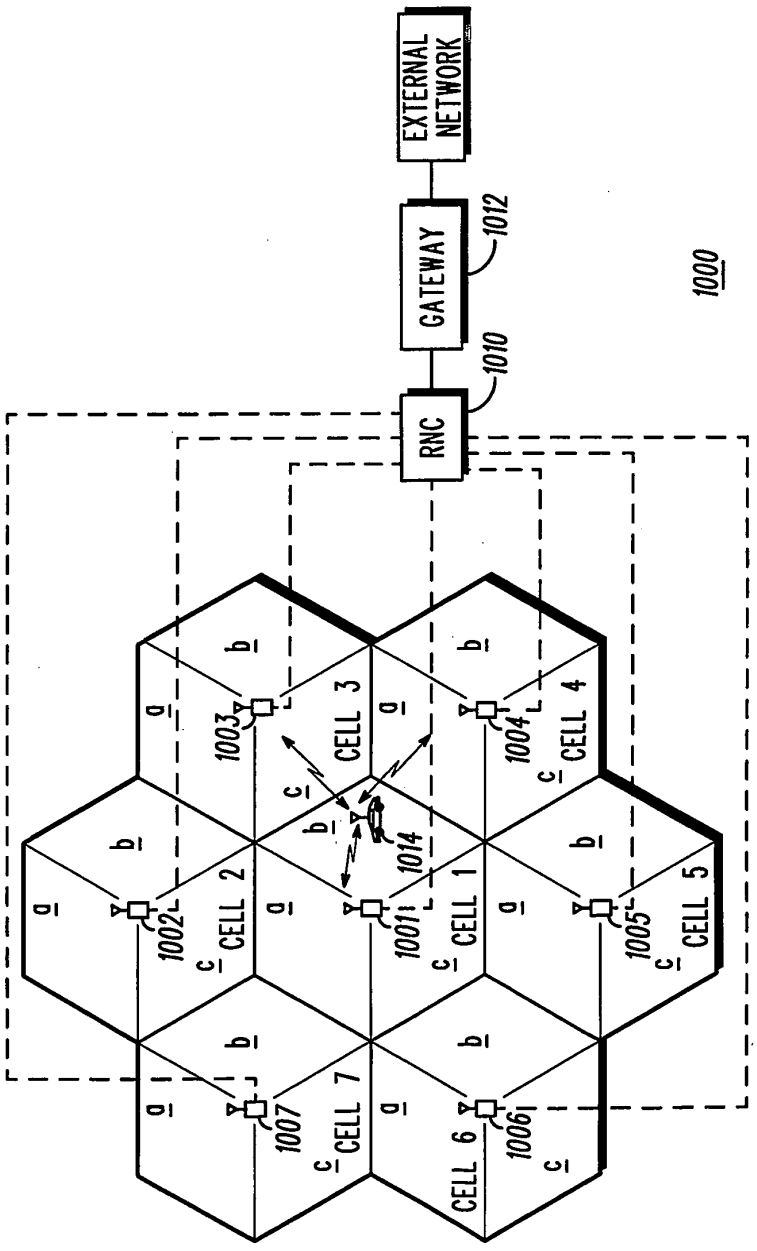
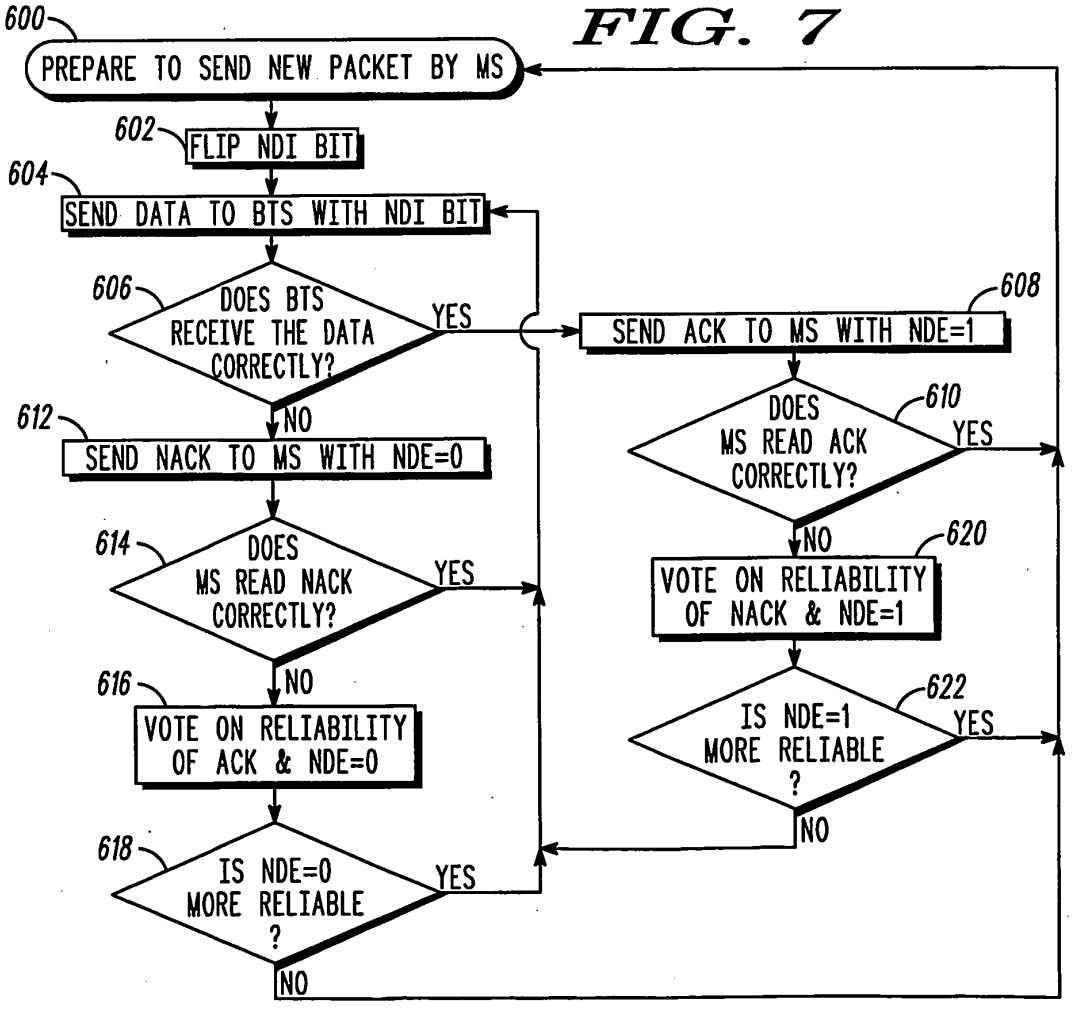

EXTERNAL NETWORK
GATEWAY
1012
RNC
1010
1000
CELL 1
CELL 2
CELL 3
CELL 4
CELL 5
CELL 6
CELL 7
1001
1002
1003
1004
1005
1006
1007
1014
a
b
c

FIG. 5

FIG. 6 —PRIOR ART—

NDI (MS TFRI)	ACK/NACK SENT (BTS)	ACK/NACK RECEIVED (MS)
0 (PREVIOUS PACKET)	ACK	ACK
1 (1st ATTEMPT)	NACK	NACK
1 (2nd ATTEMPT)	ACK	NACK
1 (3rd ATTEMPT)	ACK (2nd)	ACK

FIG. 7



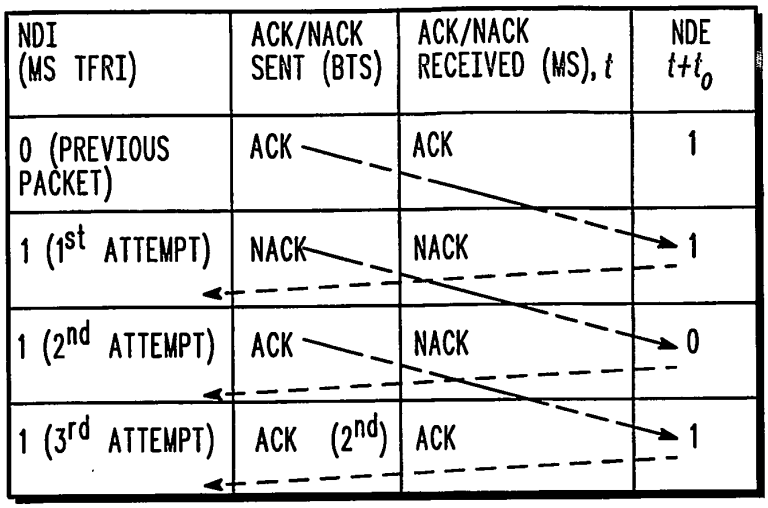


FIG. 8

NDI (MS TFRI)	ACK/NACK SENT (BTS)	ACK/NACK RECEIVED (MS)
0 (PREVIOUS PACKET)	ACK	ACK
1 (1st ATTEMPT)	NACK	NACK
1 (2nd ATTEMPT)	NACK	ACK
0 (1st ATTEMPT)	ERROR: FLUSH	

FIG. 9

— PRIOR ART —

NDI (MS TFRI)	ACK/NACK SENT (BTS)	ACK/NACK RECEIVED (MS)	NDE SENT (BTS)
0 (PREVIOUS PACKET)	ACK	ACK	0
1 (1st ATTEMPT)	NACK	NACK	1
1 (2nd ATTEMPT)	NACK	ACK	0
1 (3rd ATTEMPT)	~~ERROR: FLUSH~~ ACK	ACK	0

FIG. 10

NDI (MS TFRI) (3bits)	ACK/NACK SENT (BTS1)	ACK/NACK SENT (BTS2)	ACK/NACK RECEIVED 1 (MS)	ACK/NACK RECEIVED 2 (MS)	NDE SENT (BTS1)
0 (PREVIOUS PACKET)	ACK	NACK	ACK	NACK	0
1 (1st ATTEMPT)	NACK	NACK	NACK	NACK	1
1 (2nd ATTEMPT)	NACK	ACK (FLUSH)	ACK (ERROR)	ACK (?)	0
1 (3rd ATTEMPT)	ACK	DTX OR ACK	ACK	DTX OR ACK	0

FIG. 11

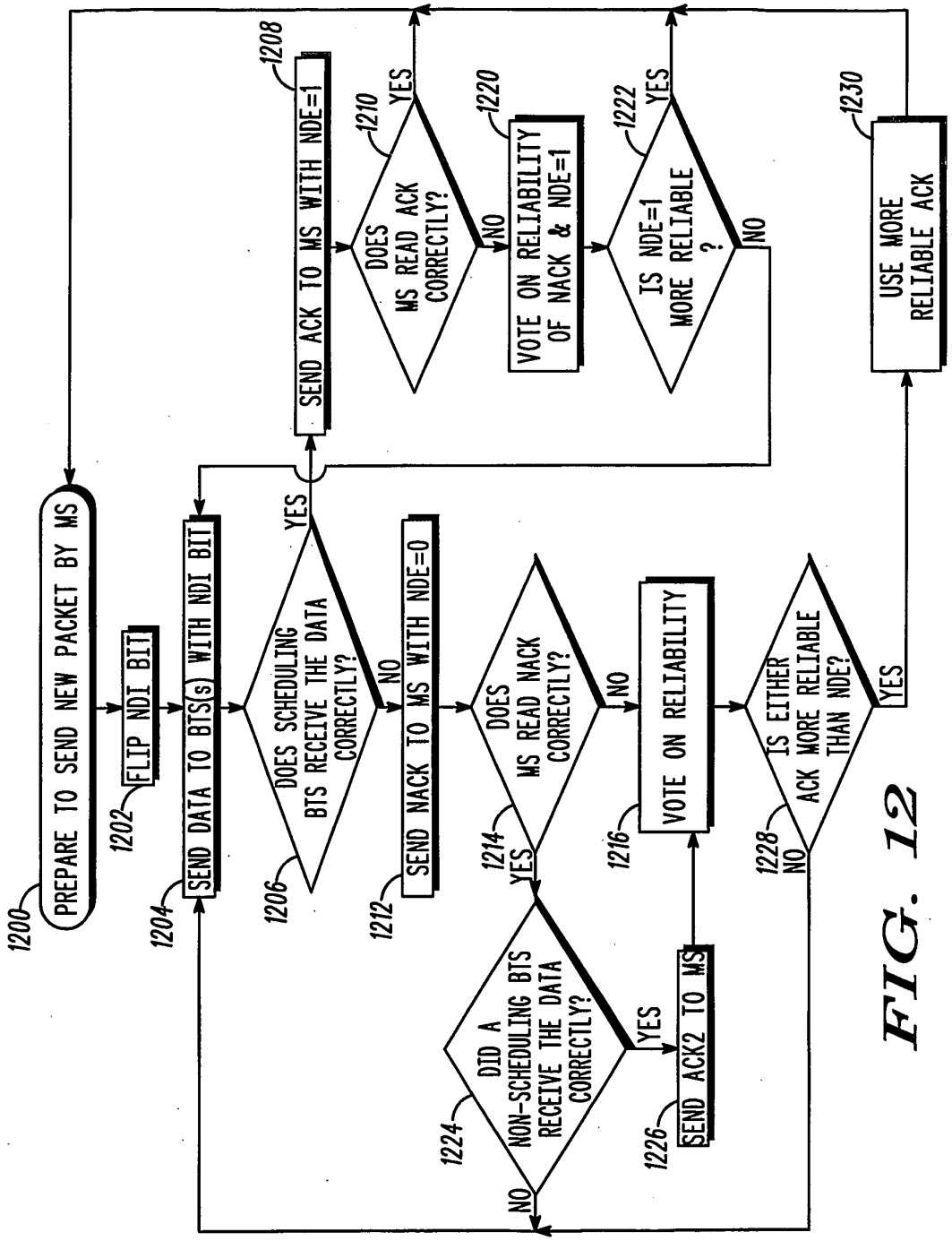

PREPARE TO SEND NEW PACKET BY MS
1200
FLIP NDI BIT
1202
SEND DATA TO BTS(s) WITH NDI BIT
1204
DOES SCHEDULING BTS RECEIVE THE DATA CORRECTLY?
1206
YES
NO
SEND NACK TO MS WITH NDE=0
1212
DOES MS READ NACK CORRECTLY?
1214
YES
NO
DID A NON-SCHEDULING BTS RECEIVE THE DATA CORRECTLY?
1224
YES
NO
SEND ACK2 TO MS
1226
VOTE ON RELIABILITY
1216
IS EITHER ACK MORE RELIABLE THAN NDE?
1228
YES
NO
USE MORE RELIABLE ACK
1230
SEND ACK TO MS WITH NDE=1
1208
DOES MS READ ACK CORRECTLY?
1210
YES
NO
VOTE ON RELIABILITY OF NACK & NDE=1
1220
IS NDE=1 MORE RELIABLE ?
1222
YES
NO

FIG. 12

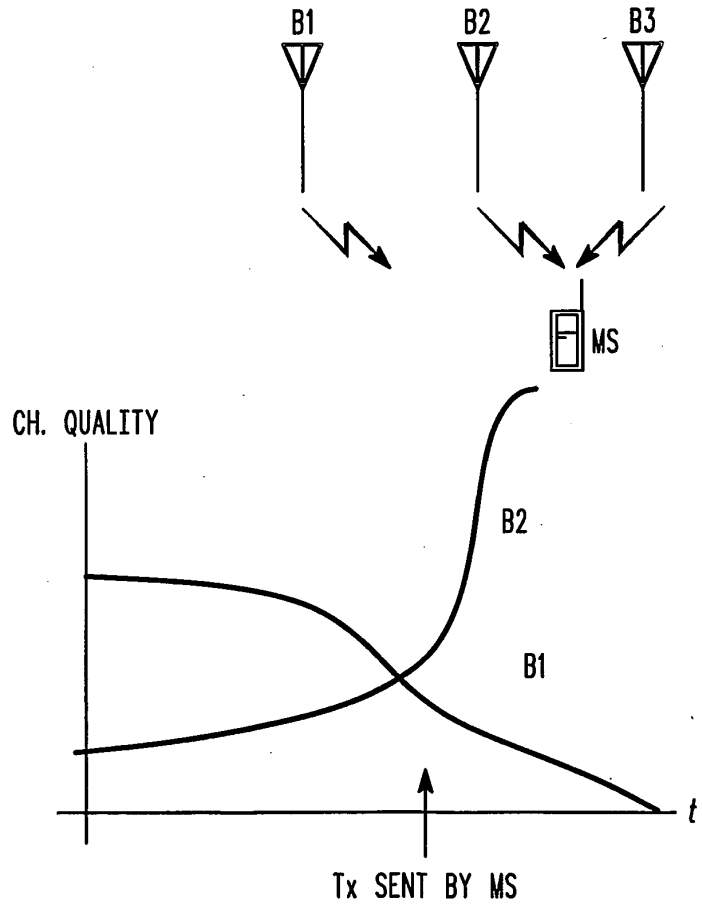


FIG. 13

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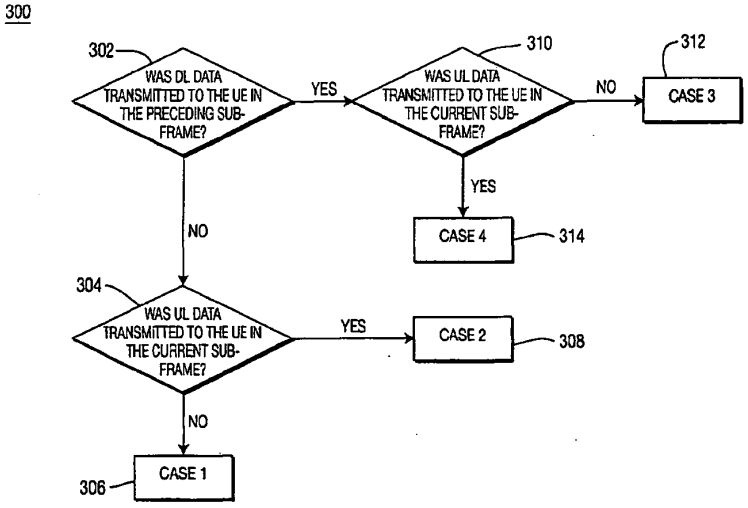
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(54) Title: SCHEDULING CHANNEL QUALITY INDICATOR AND ACKNOWLEDGEMENT/NEGATIVE ACKNOWLEDGEMENT FEEDBACK



(57) Abstract: A method for transmitting feedback by a user equipment in a wireless communication system includes scheduling a non-contention based uplink channel; and transmitting the feedback on the scheduled uplink channel. The feedback can include a channel quality indicator and an acknowledgement/negative acknowledgement for received downlink data. The feedback can be multiplexed is various ways for efficient transmission.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

[0001] SCHEDULING CHANNEL QUALITY INDICATOR AND ACKNOWLEDGEMENT/NEGATIVE ACKNOWLEDGEMENT FEEDBACK

[0002] FIELD OF INVENTION

[0003] The invention relates to wireless communication systems, in particular to scheduling and multiplexing of channel quality indicator (CQI) and acknowledgement/negative acknowledgement (ACK/NACK) feedback in uplink (UL) single carrier frequency division multiple access (SC-FDMA) for evolved universal terrestrial radio access (E-UTRA).

[0004] BACKGROUND

[0005] Both 3GPP and 3GPP2 are currently considering long term evolution projects, in which evolution of the radio interface and the network architecture are necessary. SC-FDMA has been adopted for the uplink of E-UTRA, and orthogonal frequency division multiple access (OFDMA) has been adopted for the downlink.

[0006] Downlink CQI measured by a user equipment (UE) is used by the Node B for scheduling the downlink shared data channel. After decoding the downlink data transmission, the UE needs to send feedback (e.g., an ACK/NACK) to the Node B to inform the Node B whether the corresponding HARQ transmission is successful. Uplink transport format information and HARQ information are called uplink data-associated control information. On the other hand, CQI and ACK/NACK for downlink data transmissions are called uplink data-non-associated control information. One problem that needs to be addressed in the E-UTRA system is how to schedule the reporting of the downlink CQI and the ACK/NACK via a UL channel. For convenience, the UL channel that transmits the CQI is called UL CQICH, and the UL channel that transmits the ACK/NACK is called UL ACKCH.

[0007] In the prior art of High Speed Downlink Packet Access (HSDPA), a dedicated low data rate channel is allocated for the UE to report the CQI together

with the ACK/NACK to the Node B, and the dedicated channel is exclusive for the UE all the time. However, using a dedicated channel to transmit the CQI and the ACK/NACK limits the number of UEs that can be simultaneously supported.

[0008] SUMMARY

[0009] A method for transmitting feedback by a UE in a wireless communication system includes scheduling a non-contention based UL channel; and transmitting the feedback on the scheduled UL channel. The feedback can include a channel quality indicator and an ACK/NACK for received downlink data. The feedback can be multiplexed is various ways for efficient transmission.

[0010] The scheduling procedures can also include scheduling periodic feedback reporting, determining a location of the UL channel to use for the feedback reporting, and signaling the location of the UL channel and the feedback reporting period to the UE.

[0011] The selection of the multiplexing scheme is based on at least one of: whether downlink data was transmitted to a UE in the preceding sub-frame, whether UL data was transmitted to the UE in the current sub-frame, and whether the CQI bits are configured to be transmitted in the current sub-frame. Various multiplexing schemes are disclosed based on combinations of the foregoing determinations. Among those schemes, there can be several options per scheme, with the option being selected by the implementer.

[0012] A system for scheduling and multiplexing feedback reporting in a wireless communication system includes a user equipment (UE) and a Node B. The UE includes a first processor; a first transmitter/receiver in communication with the first processor; a first antenna connected to the first transmitter/receiver; a feedback generator in communication with the first processor and the first multiplexer, the feedback generator for generating feedback based on received downlink data; and a first multiplexer in communication with the first processor, the first multiplexer for multiplexing feedback information from the feedback generator with other uplink data. The Node B includes a second processor; a buffer in communication with the second

processor, the buffer storing data to be sent to the UE; a second transmitter/receiver in communication with the second processor; a second antenna connected to the second transmitter/receiver; a second multiplexer in communication with the second processor; a scheduler in communication with the second processor and the second transmitter/receiver, the scheduler for scheduling an uplink feedback channel; and a mapping device in communication with the scheduler, the mapping device for mapping resource blocks from a downlink communication to an uplink feedback channel location.

[0013] BRIEF DESCRIPTION OF THE DRAWINGS

[0014] A more detailed understanding of the invention may be had from the following description of a preferred embodiment, given by way of example, and to be understood in conjunction with the accompanying drawings, wherein:

[0015] Figure 1 is a flowchart of a method for scheduling CQI reporting;

[0016] Figure 2 is a flowchart of a method for scheduling ACK/NACK reporting;

[0017] Figure 3 is a flowchart of a method for multiplexing when the CQI feedback is sent every sub-frame;

[0018] Figure 4 is a flowchart of a method for multiplexing when the CQI feedback is sent less frequently than every sub-frame; and

[0019] Figure 5 is a block diagram of a system for scheduling and multiplexing CQI reporting and ACK/NACK reporting.

[0020] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] Hereafter, the term "user equipment (UE)" includes, but is not limited to, a wireless transmit/receive unit (WTRU), a mobile station, a fixed or mobile subscriber unit, a pager, cellular telephone, personal digital assistant (PDA), computer, or any other type of device capable of operating in a wireless environment. When referred to hereafter, the term "base station (BS)" includes, but is not limited to, a Node B, a site controller, an access point, or any other type of interfacing device in a wireless environment.

[0022] Scheduling of the UL CQICH

[0023] The present invention uses a shared channel to transmit CQI in uplink SC-FDMA in a non-contention-based manner. A method 100 for scheduling the CQICH is shown in Figure 1. First, a determination is made whether there is any data for a UE in the buffer at the Node B (step 102). If there is no data in the buffer, then the method waits at step 102 until there is data in the buffer. When there is no data for a UE in the buffer at the Node B, no uplink CQICH needs to be scheduled.

[0024] If there is data in the buffer at the Node B, then CQI reporting is scheduled every N sub-frames (step 104). As will be described in greater detail in connection with Figures 3 and 4, the value of N can be any value greater than or equal to one and no more than five or ten, depending on the implementation. The value of N relates to the mobility of the UE; the greater the mobility of the UE, the lower that the value of N should be. The Node B schedules the CQI reporting and the UL CQICH before the first downlink (DL) data transmission for the UE. The UL CQICH is configured to be transmitted once every N sub-frames.

[0025] The UL CQICH location (in terms of time and frequency) should be known for the Node B and the UE. A predefined time and frequency hopping pattern can be applied to the scheduled UL CQICH location (step 106). One example way of knowing the UL CQICH location is that Node B signals the UL CQICH location explicitly to the UE when the Node B schedules the CQI reporting. A pre-defined time and frequency hopping pattern can be applied to the scheduled UL CQICH location to achieve better time and frequency diversity. Since both the Node B and the UE know the UL CQICH location, the UE ID does not need to be transmitted on the UL CQICH.

[0026] There are several possible ways that the CQI bits of the UE can be multiplexed with the ACK/NACK information and/or the UL data-associated control information and user data of the same UE, and/or UL control information and user data of other UEs within one or more resource blocks.

[0027] The receiver (i.e., the Node B) needs UL pilots to decode the UL CQICH. Therefore, the UL pilots used for the UL CQICH need to be allocated with the UL CQICH as well. If frequency division multiplexing (FDM)-based UL pilots are used, then UL pilot locations (in the frequency domain) should be allocated. If code division multiplexing (CDM)-based UL pilots are used, then the UL pilot cyclic shift and frequency domain locations (optional) should be allocated. One example of a CDM-based pilot is the Constant Amplitude Zero Auto Correlation (CAZAC) sequence-based pilot. The information on the UL pilots used for the UL CQICH is signaled explicitly together with the UL CQICH. Alternatively, a pre-defined mapping is used between the UL CQICH locations (in the time and frequency domains) within one or more resource blocks and the UL pilots used for the UL CQICH. Therefore, there is no signaling overhead. The predefined mapping can be reconfigured through a broadcast signal or a control channel for more flexibility.

[0028] After the Node B receives the CQI feedback from the UE, it will start to schedule the DL data transmission on the DL shared data channel. The scheduling mode of DL data transmission for the UE can be changed dynamically. The possible scheduling modes include distributed, localized, MIMO (closed-loop and open-loop), and non-MIMO, and possible combinations of them. Different scheduling modes require different amounts of CQI feedback, such as the average CQI of the whole bandwidth, K best CQIs of chunks, CQIs to support closed-loop or open-loop MIMO, etc. Therefore, different UL CQICH types corresponding to different amounts of CQI feedback should be defined and allocated/scheduled accordingly.

[0029] The UL CQICH can be dynamically reconfigured during the packet call when the Node B switches between different scheduling modes. When reconfiguring the modes for localized, distributed, MIMO, etc., the configuration/reconfiguration, for example, can be set up using a broadcast channel. This is achievable when the common mode is used per cell or users use the same mode in a cell. However, when a hybrid scheme is used, i.e., each UE or connection has a different mode in a cell, then some shared control channel

should be used to dynamically reconfigure the operation or scheduling modes. In this case, the information for the modes (1-3 bits) should be transmitted and carried in the shared control channel. The reconfiguration can be also done via RRC signaling in a slow fashion.

[0030] When hybrid modes are used such that some UEs have distributed modes, some UEs have localized modes, and some UEs have MIMO modes, the scheduling become more challenging. Scheduling algorithms therefore need to be used to efficiently cope with the "hybrid" scenario.

[0031] After the UL CQICH location is communicated to the UE, a determination is then made whether all of the data in the buffer at the Node B has been successfully transmitted to the UE (step 108). If all of the data has not been successfully transmitted, then step 108 is repeated until all of the data has been successfully transmitted. Once all of the data for the UE in the buffer at the Node B has been successfully transmitted, the Node B deallocates the UL CQICH (step 110), and the method 100 repeats by checking to see if there is any data in the buffer at the Node B (step 102).

[0032] Scheduling of the UL ACKCH

[0033] A shared channel is preferably used to transmit the ACK/NACK feedback for DL data transmission in UL SC-FDMA in a non-contention-based manner. A method 200 for scheduling the UL ACKCH is shown in Figure 2. A determination is made whether there is a DL data transmission for the UE (step 202). If there is no DL transmission for the UE, then the method 200 waits at step 202 until there is DL data to be sent to the UE. When there is no DL data transmission for the UE, no UL ACKCH needs to be scheduled.

[0034] If there is DL data to be sent to the UE, then the UL ACKCH is scheduled M frames after the DL data is sent (step 204). A fixed timing (M sub-frames) is required between each DL data transmission scheduled by the Node B and the corresponding ACK/NACK feedback. In a preferred embodiment, M = 1.

[0035] The UL ACKCH location is obtained (step 206), a signal is sent to the UE with the location of the UL ACKCH (step 208), and the method

terminates (step 210). The UL ACKCH location (in time and frequency domains) should be known for both the Node B and the UE. There are two ways to obtain the UL ACKCH location. The first is by explicit signaling, in which case once the UL ACKCH location is obtained it is directly sent by the Node B to the UE for each scheduled DL data transmission (i.e., step 208 immediately follows step 206).

[0036] The second way to obtain the UL ACKCH location is by mapping the resource blocks used by the DL data transmission to the UL ACKCH location (step 212). The mapping should be transmitted to the UE via a broadcast channel (BCH). Optionally, a pre-defined time and frequency hopping pattern is applied to the mapping (step 214; shown in dashed outline). In this way, better time and frequency diversity is achieved for the UL ACKCH.

[0037] If K (for all K greater than one) resource blocks are used by the DL data transmission, there are two possible mappings of the UL ACKCH location:

[0038] 1. The UL ACKCH uses the location mapped by the k^{th} ($1 \leq k \leq K$) resource block used by the DL data transmission.

[0039] 2. The UL ACKCH uses a permutation of the locations mapped by K resource blocks. For example, three resource blocks are used for DL data transmission. For the first transmission, the ACK/NACK is transmitted on the location mapped by the second resource block. For the second (re)transmission, the ACK/NACK is transmitted on the location mapped by the third resource block. For the third (re)transmission, the ACK/NACK is transmitted on location mapped by the first resource block, and so on.

[0040] Since both the Node B and the UE know the UL ACKCH location, then the UE ID does not need to be transmitted on the UL ACKCH.

[0041] There are several possible ways that the ACK/NACK information of a UE can be multiplexed with CQI bits and/or UL data-associated control information and user data of the same UE, and/or UL control information and user data of other UEs within one or more resource blocks. A receiver (i.e., the Node B) needs UL pilots to decode the UL ACKCH. Therefore, the UL pilots used for the UL ACKCH need to be allocated with the UL ACKCH as well. If FDM-

based UL pilots are used, then the UL pilot locations (in the frequency domain) should be allocated. If CDM-based UL pilots (such as CAZAC-based pilots) are used, then the UL pilot cyclic shift and frequency domain locations (optional) should be allocated.

[0042] In a preferred embodiment, a pre-defined mapping between the UL ACKCH location (in the time and frequency domains) within one resource block is used and UL pilots are used for the UL ACKCH. Therefore, there is no signaling overhead.

[0043] Multiplexing of UL Data-Non-Associated Control Information

[0044] The UL CQICH is preferably configured to be transmitted once every N sub-frames, as described above. Depending on whether the value of N is larger than one, a different multiplexing of the UL data-independent control information can be used.

[0045] Multiplexing when the CQI is configured to send feedback every sub-frame

[0046] Figure 3 shows a method 300 for multiplexing when the CQI reporting period, N, equals one sub-frame. A determination is made whether the was any DL data transmitted to the UE in the preceding sub-frame (step 302). If no DL data was transmitted to the UE in the preceding sub-frame, then a determination is made whether UL data was transmitted to the UE in the current sub-frame (step 304).

[0047] If no UL data was transmitted to the UE in the current sub-frame, then multiplexing Case 1 applies (step 306). In Case 1, the CQI bits are transmitted on the pre-defined UL CQICH. The pre-defined UL CQICH can be located at any resource block configured by the Node B, even multiplexed within the resource blocks used for other UE's UL data transmission.

[0048] If there was UL data that was transmitted to the UE in the current sub-frame (step 304), then Case 2 applies (step 308). In Case 2, there are two mutually exclusive choices for multiplexing. In Choice 2A, the CQI bits are

transmitted on the pre-defined UL CQICH. For this choice, no resources are wasted; however, Choice 2A has more pilot overhead compared to Choice 2B.

[0049] In Choice 2B, the CQI bits are transmitted within the resource blocks scheduled for UL shared data transmission of the same UE. In this way, the CQI bits are multiplexed with the UL data-associated control bits and user data of the same UE. Choice 2B has no pilot overhead, as compared to Choice 2A; however, the UL data rate of the UE will be reduced. Since the UL shared data transmission is not always present, the pre-defined UL CQICH still needs to be allocated. The resources of the pre-defined UL CQICH will be wasted unless the Node B allocates other UEs to transmit on those resources, which makes the Node B scheduling complicated. It is optional that the Node B allocates the resources of the pre-defined UL CQICH for other UEs to transmit.

[0050] If there was DL data that was transmitted to the UE in the preceding sub-frame (step 302), then a determination is made whether UL data was transmitted to the UE in the current sub-frame (step 310). If no UL data was transmitted to the UE in the current sub-frame, then Case 3 applies (step 312). In Case 3, there are three mutually exclusive choices.

[0051] In Choice 3A, the ACK/NACK for DL data transmission is transmitted together with the CQI bits on the pre-defined UL CQICH. This choice saves pilot overhead compared to Choice 3C. Since the UL CQICH is always available, there is no need to allocate the UL ACKCH separately. However, the pre-defined UL CQICH has to be configured large enough to transmit the ACK/NACK information. Resources will be wasted when the ACK/NACK is not transmitted.

[0052] In Choice 3B, the CQI information is transmitted together with the ACK/NACK on the UL ACKCH. The UL ACKCH can be located at any resource block configured by the Node B, even multiplexed within the resource blocks used for other UE's UL data transmission. Choice 3B saves pilot overhead compared to Choice 3C. If the DL shared control channel (DL-SCCH) is not decoded correctly, the ACK/NACK will not be transmitted (because the UE does not know that there was a DL data transmission is the preceding sub-frame). In this case, the

Node B thinks that the CQI bits were transmitted with the ACK/NACK on the pre-defined UL ACKCH. However, the ACK/NACK was not transmitted, which will create a problem. However, since the ACKCH is not always available, the pre-defined UL CQICH still needs to be allocated. The resources of the pre-defined UL CQICH will be wasted unless the Node B allocates other UEs to transmit on those resources, which makes the Node B scheduling complicated. It is optional that the Node B allocates the resources of a pre-defined UL CQICH for other UEs to transmit.

[0053] In Choice 3C, the ACK/NACK and the CQI are transmitted separately. That is, the ACK/NACK is transmitted on the UL ACKCH, and the CQI bits are transmitted on the pre-defined UL CQICH. For Choice 3C, no resources are wasted on the UL CQICH; however, there is more pilot overhead as compared to Choices 3A and 3B.

[0054] If there was UL data transmitted to the UE in the current sub-frame (step 310), then Case 4 applies (step 314). In Case 4, there are four mutually exclusive choices for multiplexing. In Choice 4A, the ACK/NACK and the CQI bits are transmitted together within the resource blocks scheduled for UL shared data transmission of the same UE. In this way, the ACK/NACK and the CQI bits are multiplexed with the UL data-associated control bits and user data of the same UE. Choice 4A has no pilot overhead; however, the UL data rate of the UE will be reduced. Since the UL shared data transmission is not always present, the pre-defined UL CQICH (and maybe the UL ACKCH as well) still needs to be allocated. The resources of the pre-defined UL CQICH (and UL ACKCH, if any) will be wasted unless the Node B allocates other UEs to transmit on those resources, which makes the Node B scheduling complicated. It is optional that the Node B allocates the resources of the pre-defined UL CQICH (and UL ACKCH, if any) for other UEs to transmit.

[0055] In Choice 4B, the ACK/NACK for DL data transmission is transmitted together with the CQI bits on the pre-defined UL CQICH. Choice 4B has less pilot overhead compared to Choice 4D, but has more pilot overhead compared to Choice 4A. Since the UL CQICH is always available, there is no

need to allocate the UL ACKCH, and the UL data rate of the UE will not be reduced. However, the pre-defined UL CQICH has to be configured large enough to transmit the ACK/NACK information. Resources will be wasted when the ACK/NACK is not transmitted.

[0056] In Choice 4C, the CQI information is transmitted together with the ACK/NACK information on the pre-defined UL ACKCH. Choice 4C has less overhead compared to Choice 4D, but has more pilot overhead compared to Choice 4A. The UL data rate of the UE will not be reduced. Other disadvantages to Choice 4C are the same as the disadvantages of Choice 3B of Case 3.

[0057] In Choice 4D, the ACK/NACK and the CQI are transmitted separately. That is, the ACK/NACK is transmitted on the pre-defined UL ACKCH, and the CQI bits are transmitted on the pre-defined UL CQICH. For Choice 4D, no resources are wasted in the UL CQICH and the UL ACKCH. The UL data rate of the UE will not be reduced. However, Choice 4D has more pilot overhead compared to Choices 4A, 4B, and 4C.

[0058] Moreover, the UL resources request (called "scheduling information") bits can be transmitted on the UL CQICH or the UL ACKCH of the same UE, or can be transmitted together within the resource blocks scheduled for UL shared data transmission of the same UE. Correspondingly, the UL CQICH or the UL ACKCH needs to be configured large enough to accommodate the UL resource request bits. Or the number of UL resource request bits need to be reserved in the resource blocks scheduled for UL shared data transmission of the same UE.

[0059] Multiplexing when the CQI reporting is less frequent than every sub-frame

[0060] Figure 4 shows a method 400 for multiplexing when the CQI reporting period, N, is larger than one sub-frame. A determination is made whether the was any DL data transmitted to the UE in the preceding sub-frame (step 402). If no DL data was transmitted to the UE in the preceding sub-frame, then a determination is made whether UL data was transmitted to the UE in the

current sub-frame (step 404). If no UL data was transmitted to the UE in the current sub-frame, then a determination is made whether the CQI bits are configured to be transmitted in the current sub-frame (step 406). If the CQI bits are configured to be transmitted in the current sub-frame, then Case 1 applies (step 408). In Case 1, the CQI bits are transmitted on the pre-defined UL CQICH. If the CQI bits are not configured to be transmitted in the current sub-frame (step 406), then no data-non-associated control signaling will be transmitted (step 410).

[0061] If there was UL data transmitted to the UE in the current sub-frame (step 404), then a determination is made whether the CQI bits are configured to be transmitted in the current sub-frame (step 412). If the CQI bits are configured to be transmitted in the current sub-frame, then Case 2 applies (step 414). In Case 2, there are two mutually exclusive choices for multiplexing. In Choice 2A, the CQI bits are transmitted on the pre-defined UL CQICH. Choice 4A has no resources wasted on the UL CQICH; however, it needs more pilot overhead compared to Choice 2B.

[0062] In Choice 2B, the CQI bits are transmitted within the resource blocks scheduled for UL shared data transmission of the same UE. In this way, the CQI bits are multiplexed with the UL data-associated control bits and user data of the same UE. It has less pilot overhead compared to Choice 2A. However, the UL data rate of the UE will be reduced. Since UL shared data transmission is not always present, the pre-defined UL CQICH still needs to be allocated. The resources of the pre-defined UL CQICH will be wasted unless the Node B allocates other UEs to transmit on those resources, which makes the Node B scheduling complicated. It is optional that the Node B allocates the resources of the pre-defined UL CQICH for other UEs to transmit.

[0063] If the CQI bits are not configured to be transmitted in the current sub-frame (step 412), then no data-non-associated control signaling will be transmitted (step 410).

[0064] If there was DL data transmitted to the UE in the preceding sub-frame (step 402), then a determination is made whether UL data was

transmitted to the UE in the current sub-frame (step 416). If no UL data was transmitted to the UE in the current sub-frame, then a determination is made whether the CQI bits are configured to be transmitted in the current sub-frame (step 418). If the CQI bits are not configured to be transmitted in the current sub-frame, then Case 3 applies (step 420). In Case 3, the ACK/NACK for the DL data transmission should be transmitted on the UL ACKCH.

[0065] If the CQI bits are configured to be transmitted in the current sub-frame (step 418), then Case 4 applies (step 422). In Case 4, there are three mutually exclusive choices for multiplexing. In Choice 4A, the ACK/NACK for DL data transmission is transmitted together with the CQI bits on the pre-defined UL CQICH. Choice 4A has a low pilot overhead. However, the pre-defined UL CQICH has to be configured large enough to transmit the ACK/NACK information. Resources will be wasted when the ACK/NACK is not transmitted. Since the UL CQICH is not always available when the ACK/NACK needs to be transmitted, the pre-defined UL ACKCH still needs to be allocated. The resources of the pre-defined UL ACKCH will be wasted unless the Node B allocates other UEs to transmit on those resources, which makes the Node B scheduling complicated. It is optional that the Node B allocates the resources of the pre-defined UL CQICH (and UL ACKCH, if any) for other UEs to transmit.

[0066] In Choice 4B, the CQI information is transmitted together with the ACK/NACK on the pre-defined UL ACKCH. Choice 4B has a low pilot overhead. If the DL-SCCH is not decoded correctly, the ACK/NACK will not be transmitted (because the UE does not know that there was a DL data transmission is the preceding sub-frame). In this case, the Node B thinks that the CQI bits were transmitted with the ACK/NACK on the pre-defined UL ACKCH. However, the ACK/NACK is not transmitted, which will create a problem. Since the ACKCH is not always available, the pre-defined UL CQICH still needs to be allocated. The resources of the pre-defined UL CQICH will be wasted unless the Node B allocates other UEs to transmit on those resources, which makes the Node B scheduling complicated. It is optional that the Node B allocates the resources of the pre-defined UL CQICH for other UEs to transmit.

[0067] In Choice 4C, the ACK/NACK and the CQI are transmitted separately. That is, the ACK/NACK is transmitted on the UL ACKCH, and the CQI bits are transmitted on the pre-defined UL CQICH. Choice 3C has no resources wasted on the UL CQICH or the UL ACKCH; however, it has more pilot overhead compared to Choices 4A and 4B.

[0068] If there was UL data transmitted to the UE in the current sub-frame (step 416), then a determination is made whether the CQI bits are configured to be transmitted in the current sub-frame (step 424). If the CQI bits are configured to be transmitted in the current sub-frame, then Case 5 applies (step 426). In Case 5, there are four mutually exclusive choices for multiplexing.

[0069] In Choice 5A, the ACK/NACK and the CQI bits are transmitted together within the resource blocks scheduled for UL shared data transmission of the same UE. In this way, the ACK/NACK and the CQI bits are multiplexed with UL data-associated control bits and user data of the same UE. Choice 5A has less pilot overhead compared to Choices 5B, 5C, and 5D. However, the UL data rate of the UE will be reduced. Since UL shared data transmission is not always present, the pre-defined UL CQICH (and maybe the UL ACKCH as well) still needs to be allocated. The resources of the pre-defined UL CQICH (and ACKCH, if any) will be wasted unless the Node B allocates other UEs to transmit on those resources, which makes the Node B scheduling complicated. It is optional that the Node B allocates the resources of the pre-defined UL CQICH (and UL ACKCH, if any) for other UEs to transmit.

[0070] In Choice 5B, the ACK/NACK for DL data transmission is transmitted together with the CQI bits on the pre-defined UL CQICH. Choice 5B has less pilot overhead compared to Choice 5D. The UL data rate of the UE will not be reduced. However, the pre-defined UL CQICH has to be configured large enough to transmit the ACK/NACK information. Resources will be wasted when the ACK/NACK is not transmitted on the UL CQICH. Since the UL CQICH is not always available when the ACK/NACK needs to transmitted, the UL ACKCH still needs to be allocated. The resources of the pre-defined UL ACKCH will be wasted unless the Node B allocates other UEs to transmit on those resources,

which makes the Node B scheduling complicated. It is optional that the Node B allocates the resources of the pre-defined UL ACKCH for other UEs to transmit.

[0071] In Choice 5C, the CQI information is transmitted together with the ACK/NACK on the UL ACKCH. Choice 5C saves pilot overhead compared to Choice 5D. The UL data rate of the UE will not be reduced. However, Choice 5C has more pilot overhead compared to Choice 5A. Other disadvantages of Choice 5C are the same as the disadvantages of Choice 4B of Case 4.

[0072] In Choice 5D, the ACK/NACK and the CQI are transmitted separately. That is, the ACK/NACK is transmitted on the pre-defined UL ACKCH, and the CQI bits are transmitted on the pre-defined UL CQICH. For Choice 5D, no resources are wasted for the UL CQICH and the UL ACKCH. The UL data rate of the UE will not be reduced. However, Choice 5D has more pilot overhead compared to Choices 5A, 5B, and 5C.

[0073] If the CQI bits are not configured to be transmitted in the current sub-frame (step 424), then Case 6 applies (step 428). In Case 6, there are two mutually exclusive choices for multiplexing.

[0074] In Choice 6A, the ACK/NACK information is transmitted within the resource blocks scheduled for UL shared data transmission of the same UE. In this way, the ACK/NACK information is multiplexed with UL data-associated control bits and user data of the same UE. Choice 6A has no pilot overhead; however, the UL data rate of the UE will be reduced. Since UL shared data transmission is not always present, the UL ACKCH still needs to be allocated. The resources of the pre-defined UL ACKCH will be wasted unless the Node B allocates other UEs to transmit on those resources, which makes the Node B scheduling complicated. It is optional that the Node B allocates the resources of the pre-defined UL ACKCH for other UEs to transmit.

[0075] In Choice 6B, the ACK/NACK is transmitted on the UL ACKCH. For Choice 6B, the UL data rate of the UE will not be reduced. No resources are wasted for the UL ACKCH; however, Choice 6B has more pilot overhead as compared to Choice 6A.

[0076] Moreover, the UL resources request (called "scheduling information") bits can be transmitted on the UL CQICH or the UL ACKCH of the same UE, or transmitted together within the resource blocks scheduled for UL shared data transmission of the same UE. Correspondingly, the UL CQICH or the UL ACKCH needs to be configured large enough to accommodate UL resource request bits. Or, the number of UL resource request bits need to be reserved in the resource blocks scheduled for UL shared data transmission of the same UE.

[0077] System construction

[0078] Figure 5 is a block diagram of a system 500 for scheduling and multiplexing CQI reporting and ACK/NACK reporting, including a UE 502 and a Node B 504. The UE 502 includes a processor 510, a transmitter/receiver 512 in communication with the processor 510, and an antenna 514 connected to the transmitter/receiver 512. A multiplexer 516 is in communication with the processor 510. A feedback generator 518 is in communication with the processor 510 and the multiplexer 516. The feedback generator 518 can provide a CQI and an ACK/NACK for received DL data.

[0079] The Node B 504 includes a processor 520 and a buffer 522 in communication with the processor 520. The buffer 522 holds data to be sent to the UE 502. A transmitter/receiver 524 is in communication with the processor 520 and an antenna 526 is connected to the transmitter/receiver 524. A multiplexer 528 is in communication with the processor 520. A scheduler 530 is in communication with the processor 520 and the transmitter/receiver 524. The scheduler 530 is used to schedule CQI reporting and ACK/NACK reporting to the UE 502. A mapping device 532 is in communication with the scheduler 530, and is used to map resource blocks used by a DL data transmission to an UL channel location.

[0080] Although the features and elements of the present invention are described in the preferred embodiments in particular combinations, each feature or element can be used alone without the other features and elements of the preferred embodiments or in various combinations with or without other features

and elements of the present invention. The methods or flow charts provided in the present invention may be implemented in a computer program, software, or firmware tangibly embodied in a computer-readable storage medium for execution by a general purpose computer or a processor. Examples of computer-readable storage mediums include a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs).

[0081] Suitable processors include, by way of example, a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any integrated circuit, and/or a state machine.

[0082] A processor in association with software may be used to implement a radio frequency transceiver for in use in a wireless transmit receive unit (WTRU), user equipment, terminal, base station, radio network controller, or any host computer. The WTRU may be used in conjunction with modules, implemented in hardware and/or software, such as a camera, a video camera module, a videophone, a speakerphone, a vibration device, a speaker, a microphone, a television transceiver, a hands-free headset, a keyboard, a Bluetooth module, a frequency modulated (FM) radio unit, a liquid crystal display (LCD) display unit, an organic light-emitting diode (OLED) display unit, a digital music player, a media player, a video game player module, an Internet browser, and/or any wireless local area network (WLAN) module.

[0083] Embodiments

[0084] 1. A method for transmitting channel quality indicator (CQI) feedback by a user equipment (UE) in a wireless communication system,

including the steps of: scheduling a non-contention based uplink channel; and transmitting the CQI on the scheduled uplink channel.

[0085] 2. The method according to embodiment 1, wherein the scheduling step includes: scheduling periodic CQI reporting; determining a location of the uplink channel to use for reporting the CQI; and signaling the location of the uplink channel and the CQI reporting period to the UE.

[0086] 3. The method according to embodiments 1 or 2, further including the step of deallocating the uplink channel.

[0087] 4. The method according to embodiment 3, wherein the deallocating step includes: examining a buffer at a Node B that holds data to be sent to the UE; and deallocating the uplink channel when the buffer at the Node B is empty.

[0088] 5. The method according to one of embodiments 1-4, wherein the transmitting step includes multiplexing the CQI with at least one item selected from the group consisting of: acknowledgement/negative acknowledgement information, uplink data-associated control information of the UE, user data of the UE, uplink control information of another UE, and user data of another UE.

[0089] 6. The method according to one of embodiments 1-5, further including the step of scheduling a downlink data transmission from a Node B to the UE, wherein a scheduling mode for the downlink data transmission is based on the CQI feedback transmitted by the UE.

[0090] 7. The method according to embodiment 6, further including the step of dynamically reconfiguring the uplink channel based on the scheduling mode used by the Node B for the downlink data transmission.

[0091] 8. A method for transmitting acknowledgement (ACK)/negative acknowledgement (NACK) feedback by a user equipment (UE) in a wireless communication system, including the steps of: scheduling a non-contention based uplink channel; and transmitting the ACK/NACK on the scheduled uplink channel.

[0092] 9. The method according to embodiment 8, wherein the scheduling step includes: scheduling periodic ACK/NACK reporting; determining

a location of the uplink channel to use for reporting the ACK/NACK; and signaling the location of the uplink channel and the ACK/NACK reporting period to the UE.

[0093] 10. The method according to embodiment 9, wherein the determining step includes explicitly signaling the location of the uplink channel from a Node B to the UE.

[0094] 11. The method according to embodiment 9, wherein the determining step includes mapping resource blocks used by a downlink data transmission to the uplink channel location.

[0095] 12. The method according to embodiment 11, wherein the mapping step includes using a location mapped by a predetermined resource block used by the downlink data transmission.

[0096] 13. The method according to embodiment 11, wherein the mapping step includes using a permutation of the location mapped by a number of resource blocks.

[0097] 14. The method according to one of embodiments 8-13, wherein the transmitting step includes multiplexing the ACK/NACK with at least one item selected from the group consisting of: channel quality indicator information, uplink data-associated control information of the UE, user data of the UE, uplink control information of another UE, and user data of another UE.

[0098] 15. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; and transmitting the CQI on a predetermined uplink channel if there was no downlink data transmitted to the UE in the preceding sub-frame.

[0099] 16. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink

data was transmitted to the UE in the current sub-frame; and transmitting the CQI within resource blocks scheduled for uplink shared data transmission of the UE if there was no downlink data transmitted to the UE in the preceding sub-frame; and there was uplink data was transmitted to the UE in the current sub-frame.

[0100] 17. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; and transmitting the CQI with an acknowledgement/negative acknowledgement for downlink data on a predetermined uplink channel if there was downlink data transmitted to the UE in the preceding sub-frame; and there was no uplink data was transmitted to the UE in the current sub-frame.

[0101] 18. The method according to embodiment 17, wherein the uplink channel is used for CQI transmission.

[0102] 19. The method according to embodiment 17, wherein the uplink channel is used for acknowledgement/negative acknowledgement transmission.

[0103] 20. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; and transmitting the CQI on a predetermined uplink channel for CQI transmission and transmitting an acknowledgement/negative acknowledgement (ACK/NACK) for downlink data on a predetermined uplink channel for ACK/NACK transmission.

[0104] 21. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; and transmitting the

CQI with an acknowledgement/negative acknowledgement for downlink data within resource blocks scheduled for uplink shared data transmission of the UE if there was downlink data transmitted to the UE in the preceding sub-frame; and there was uplink data was transmitted to the UE in the current sub-frame.

[0105] 22. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; and transmitting the CQI with an acknowledgement/negative acknowledgement for downlink data on a predetermined uplink channel for CQI transmission if there was downlink data transmitted to the UE in the preceding sub-frame; and there was uplink data was transmitted to the UE in the current sub-frame.

[0106] 23. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; and transmitting the CQI with an acknowledgement/negative acknowledgement (ACK/NACK) for downlink data on a predetermined uplink channel for ACK/NACK transmission if there was downlink data transmitted to the UE in the preceding sub-frame; and there was uplink data was transmitted to the UE in the current sub-frame.

[0107] 24. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; determining whether the CQI bits are configured to be transmitted in the current sub-frame; and transmitting the CQI bits on a predetermined uplink channel if there was no downlink data transmitted to the UE in the preceding sub-frame; there was no uplink data was transmitted to the

UE in the current sub-frame; and the CQI bits were not configured to be transmitted in the current sub-frame.

[0108] 25. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; determining whether the CQI bits are configured to be transmitted in the current sub-frame; and transmitting the CQI bits on a predetermined uplink channel if there was no downlink data transmitted to the UE in the preceding sub-frame; there was uplink data was transmitted to the UE in the current sub-frame; and the CQI bits were configured to be transmitted in the current sub-frame.

[0109] 26. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; determining whether the CQI bits are configured to be transmitted in the current sub-frame; and transmitting the CQI within resource blocks scheduled for uplink shared data transmission of the UE if there was no downlink data transmitted to the UE in the preceding sub-frame; there was uplink data was transmitted to the UE in the current sub-frame; and the CQI bits were configured to be transmitted in the current sub-frame.

[0110] 27. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; determining whether the CQI bits are configured to be transmitted in the current sub-frame; and transmitting an

acknowledgement/negative acknowledgement for downlink data transmitted on a predetermined uplink channel if there was downlink data transmitted to the UE in the preceding sub-frame; there was no uplink data was transmitted to the UE in the current sub-frame; and the CQI bits were not configured to be transmitted in the current sub-frame.

[0111] 28. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; determining whether the CQI bits are configured to be transmitted in the current sub-frame; and transmitting the CQI with an acknowledgement/negative acknowledgement for downlink data on a predetermined uplink channel if there was downlink data transmitted to the UE in the preceding sub-frame; there was no uplink data was transmitted to the UE in the current sub-frame; and the CQI bits were configured to be transmitted in the current sub-frame.

[0112] 29. The method according to embodiment 28, wherein the uplink channel is used for CQI transmission.

[0113] 30. The method according to embodiment 28, wherein the uplink channel is used for acknowledgement/negative acknowledgement transmission.

[0114] 31. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; determining whether the CQI bits are configured to be transmitted in the current sub-frame; and transmitting the CQI on a predetermined uplink channel for CQI transmission and transmitting an acknowledgement/negative acknowledgement (ACK/NACK) for downlink data on a predetermined uplink channel for ACK/NACK transmission if there was

downlink data transmitted to the UE in the preceding sub-frame; there was no uplink data was transmitted to the UE in the current sub-frame; and the CQI bits were configured to be transmitted in the current sub-frame.

[0115] 32. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; determining whether the CQI bits are configured to be transmitted in the current sub-frame; and transmitting the CQI with an acknowledgement/negative acknowledgement for downlink data within resource blocks scheduled for uplink shared data transmission of the UE if there was downlink data transmitted to the UE in the preceding sub-frame; there was uplink data was transmitted to the UE in the current sub-frame; and the CQI bits were configured to be transmitted in the current sub-frame.

[0116] 33. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, comprising the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; determining whether the CQI bits are configured to be transmitted in the current sub-frame; and transmitting the CQI with an acknowledgement/negative acknowledgement for downlink data on a predetermined uplink channel if there was downlink data transmitted to the UE in the preceding sub-frame; there was uplink data was transmitted to the UE in the current sub-frame; and the CQI bits were configured to be transmitted in the current sub-frame.

[0117] 34. The method according to embodiment 33, wherein the uplink channel is used for CQI transmission.

[0118] 35. The method according to embodiment 33, wherein the uplink channel is used for acknowledgement/negative acknowledgement transmission.

[0119] 36. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; determining whether the CQI bits are configured to be transmitted in the current sub-frame; and transmitting the CQI on a predetermined uplink channel for CQI transmission and transmitting an acknowledgement/negative acknowledgement (ACK/NACK) for downlink data on a predetermined uplink channel for ACK/NACK transmission if there was downlink data transmitted to the UE in the preceding sub-frame; there was uplink data was transmitted to the UE in the current sub-frame; and the CQI bits were configured to be transmitted in the current sub-frame.

[0120] 37. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; determining whether the CQI bits are configured to be transmitted in the current sub-frame; and transmitting an acknowledgement/negative acknowledgement within resource blocks scheduled for uplink shared data transmission of the UE if there was downlink data transmitted to the UE in the preceding sub-frame; there was uplink data was transmitted to the UE in the current sub-frame; and the CQI bits were not configured to be transmitted in the current sub-frame.

[0121] 38. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, including the steps of: determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame; determining whether uplink data was transmitted to the UE in the current sub-frame; determining whether the CQI bits are configured to be

transmitted in the current sub-frame; and transmitting an acknowledgement/negative acknowledgement on a predetermined uplink channel if there was downlink data transmitted to the UE in the preceding sub-frame; there was uplink data was transmitted to the UE in the current sub-frame; and the CQI bits were not configured to be transmitted in the current sub-frame.

* * *

CLAIMS

What is claimed is:

1. A method for transmitting channel quality indicator (CQI) feedback by a user equipment (UE) in a wireless communication system, comprising the steps of:

scheduling a non-contention based uplink channel; and

transmitting the CQI on the scheduled uplink channel.

2. The method according to claim 1, wherein the scheduling step includes:

scheduling periodic CQI reporting;

determining a location of the uplink channel to use for reporting the CQI; and

signaling the location of the uplink channel and the CQI reporting period to the UE.

3. The method according to claim 1, further comprising the step of:

deallocating the uplink channel.

4. The method according to claim 3, wherein the deallocating step includes:

examining a buffer at a Node B that holds data to be sent to the UE; and

deallocating the uplink channel when the buffer at the Node B is empty.

5. The method according to claim 1, wherein the transmitting step includes:

multiplexing the CQI with at least one item selected from the group consisting of: acknowledgement/negative acknowledgement information, uplink data-associated control information of the UE, user data of the UE, uplink control information of another UE, and user data of another UE.

6. The method according to claim 1, further comprising the step of:

scheduling a downlink data transmission from a Node B to the UE, wherein a scheduling mode for the downlink data transmission is based on the CQI feedback transmitted by the UE.

7. The method according to claim 6, further comprising the step of:

dynamically reconfiguring the uplink channel based on the scheduling mode used by the Node B for the downlink data transmission.

8. A method for transmitting acknowledgement (ACK)/negative acknowledgement (NACK) feedback by a user equipment (UE) in a wireless communication system, comprising the steps of:

scheduling a non-contention based uplink channel; and

transmitting the ACK/NACK on the scheduled uplink channel.

9. The method according to claim 8, wherein the scheduling step includes:

scheduling periodic ACK/NACK reporting;

determining a location of the uplink channel to use for reporting the ACK/NACK; and

signaling the location of the uplink channel and the ACK/NACK reporting period to the UE.

10. The method according to claim 9, wherein the determining step includes:

explicitly signaling the location of the uplink channel from a Node B to the UE.

11. The method according to claim 9, wherein the determining step includes:

mapping resource blocks used by a downlink data transmission to the uplink channel location.

12. The method according to claim 11, wherein the mapping step includes:

using a location mapped by a predetermined resource block used by the downlink data transmission.

13. The method according to claim 11, wherein the mapping step includes:

using a permutation of the location mapped by a number of resource blocks.

14. The method according to claim 8, wherein the transmitting step includes:

multiplexing the ACK/NACK with at least one item selected from the group consisting of: channel quality indicator information, uplink data-associated control information of the UE, user data of the UE, uplink control information of another UE, and user data of another UE.

15. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame; and

transmitting the CQI on a predetermined uplink channel if there was no downlink data transmitted to the UE in the preceding sub-frame.

16. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame; and

transmitting the CQI within resource blocks scheduled for uplink shared data transmission of the UE if

there was no downlink data transmitted to the UE in the preceding sub-frame; and

there was uplink data was transmitted to the UE in the current sub-frame.

17. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame; and

transmitting the CQI with an acknowledgement/negative acknowledgement for downlink data on a predetermined uplink channel if

there was downlink data transmitted to the UE in the preceding sub-frame; and

there was no uplink data was transmitted to the UE in the current sub-frame.

18. The method according to claim 17, wherein the uplink channel is used for CQI transmission.

19. The method according to claim 17, wherein the uplink channel is used for acknowledgement/negative acknowledgement transmission.

20. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame; and

transmitting the CQI on a predetermined uplink channel for CQI transmission and transmitting an acknowledgement/negative acknowledgement (ACK/NACK) for downlink data on a predetermined uplink channel for ACK/NACK transmission.

21. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame; and

transmitting the CQI with an acknowledgement/negative acknowledgement for downlink data within resource blocks scheduled for uplink shared data transmission of the UE if

there was downlink data transmitted to the UE in the preceding sub-frame; and

there was uplink data was transmitted to the UE in the current sub-frame.

22. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame; and

transmitting the CQI with an acknowledgement/negative acknowledgement for downlink data on a predetermined uplink channel for CQI transmission if

there was downlink data transmitted to the UE in the preceding sub-frame; and

there was uplink data was transmitted to the UE in the current sub-frame.

23. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame; and

transmitting the CQI with an acknowledgement/negative acknowledgement (ACK/NACK) for downlink data on a predetermined uplink channel for ACK/NACK transmission if

there was downlink data transmitted to the UE in the preceding sub-frame; and

there was uplink data was transmitted to the UE in the current sub-frame.

24. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame;

determining whether the CQI bits are configured to be transmitted in the current sub-frame; and

transmitting the CQI bits on a predetermined uplink channel if

there was no downlink data transmitted to the UE in the preceding sub-frame;

there was no uplink data was transmitted to the UE in the current sub-frame; and

the CQI bits were not configured to be transmitted in the current sub-frame.

25. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame;

determining whether the CQI bits are configured to be transmitted in the current sub-frame; and

transmitting the CQI bits on a predetermined uplink channel if

there was no downlink data transmitted to the UE in the preceding sub-frame;

there was uplink data was transmitted to the UE in the current sub-frame; and

the CQI bits were configured to be transmitted in the current sub-frame.

26. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame;

determining whether the CQI bits are configured to be transmitted in the current sub-frame; and

transmitting the CQI within resource blocks scheduled for uplink shared data transmission of the UE if

there was no downlink data transmitted to the UE in the preceding sub-frame;

there was uplink data was transmitted to the UE in the current sub-frame; and

the CQI bits were configured to be transmitted in the current sub-frame.

27. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame;

determining whether the CQI bits are configured to be transmitted in the current sub-frame; and

transmitting an acknowledgement/negative acknowledgement for downlink data transmitted on a predetermined uplink channel if

there was downlink data transmitted to the UE in the preceding sub-frame;

there was no uplink data was transmitted to the UE in the current sub-frame; and

the CQI bits were not configured to be transmitted in the current sub-frame.

28. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame;

determining whether the CQI bits are configured to be transmitted in the current sub-frame; and

transmitting the CQI with an acknowledgement/negative acknowledgement for downlink data on a predetermined uplink channel if

there was downlink data transmitted to the UE in the preceding sub-frame;

there was no uplink data was transmitted to the UE in the current sub-frame; and

the CQI bits were configured to be transmitted in the current sub-frame.

29. The method according to claim 28, wherein the uplink channel is used for CQI transmission.

30. The method according to claim 28, wherein the uplink channel is used for acknowledgement/negative acknowledgement transmission.

31. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame;

determining whether the CQI bits are configured to be transmitted in the current sub-frame; and

transmitting the CQI on a predetermined uplink channel for CQI transmission and transmitting an acknowledgement/negative acknowledgement (ACK/NACK) for downlink data on a predetermined uplink channel for ACK/NACK transmission if

there was downlink data transmitted to the UE in the preceding sub-frame;

there was no uplink data was transmitted to the UE in the current sub-frame; and

the CQI bits were configured to be transmitted in the current sub-frame.

32. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame;

determining whether the CQI bits are configured to be transmitted in the current sub-frame; and

transmitting the CQI with an acknowledgement/negative acknowledgement for downlink data within resource blocks scheduled for uplink shared data transmission of the UE if

there was downlink data transmitted to the UE in the preceding sub-frame;

there was uplink data was transmitted to the UE in the current sub-frame; and

the CQI bits were configured to be transmitted in the current sub-frame.

33. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame;

determining whether the CQI bits are configured to be transmitted in the current sub-frame; and

transmitting the CQI with an acknowledgement/negative acknowledgement for downlink data on a predetermined uplink channel if

there was downlink data transmitted to the UE in the preceding sub-frame;

there was uplink data was transmitted to the UE in the current sub-frame; and

the CQI bits were configured to be transmitted in the current sub-frame.

34. The method according to claim 33, wherein the uplink channel is used for CQI transmission.

35. The method according to claim 33, wherein the uplink channel is used for acknowledgement/negative acknowledgement transmission.

36. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame;

determining whether the CQI bits are configured to be transmitted in the current sub-frame; and

transmitting the CQI on a predetermined uplink channel for CQI transmission and transmitting an acknowledgement/negative acknowledgement (ACK/NACK) for downlink data on a predetermined uplink channel for ACK/NACK transmission if

there was downlink data transmitted to the UE in the preceding sub-frame;

there was uplink data was transmitted to the UE in the current sub-frame; and

the CQI bits were configured to be transmitted in the current sub-frame.

37. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame;

determining whether the CQI bits are configured to be transmitted in the current sub-frame; and

transmitting an acknowledgement/negative acknowledgement within resource blocks scheduled for uplink shared data transmission of the UE if

there was downlink data transmitted to the UE in the preceding sub-frame;

there was uplink data was transmitted to the UE in the current sub-frame; and

the CQI bits were not configured to be transmitted in the current sub-frame.

38. A method for multiplexing feedback information when a channel quality indicator (CQI) is configured to be sent at an interval less frequent than every sub-frame, comprising the steps of:

determining whether downlink data was transmitted to a user equipment (UE) in the preceding sub-frame;

determining whether uplink data was transmitted to the UE in the current sub-frame;

determining whether the CQI bits are configured to be transmitted in the current sub-frame; and

transmitting an acknowledgement/negative acknowledgement on a predetermined uplink channel if

there was downlink data transmitted to the UE in the preceding sub-frame;

there was uplink data was transmitted to the UE in the current sub-frame; and

the CQI bits were not configured to be transmitted in the current sub-frame.

39. A system for scheduling and multiplexing feedback reporting in a wireless communication system, comprising:

a user equipment, comprising:

a first processor;

a first transmitter/receiver in communication with said first processor;

a first antenna connected to said first transmitter/receiver;

a feedback generator in communication with said first processor and said first multiplexer, said feedback generator for generating feedback based on received downlink data; and

a first multiplexer in communication with said first processor, said first multiplexer for multiplexing feedback information from said feedback generator with other uplink data; and

a Node B, comprising:

a second processor;

a buffer in communication with said second processor, said buffer storing data to be sent to said user equipment;

a second transmitter/receiver in communication with said second processor;

a second antenna connected to said second transmitter/receiver;

a second multiplexer in communication with said second processor;

a scheduler in communication with said second processor and said second transmitter/receiver, said scheduler for scheduling an uplink feedback channel; and

a mapping device in communication with said scheduler, said mapping device for mapping resource blocks from a downlink communication to an uplink feedback channel location.

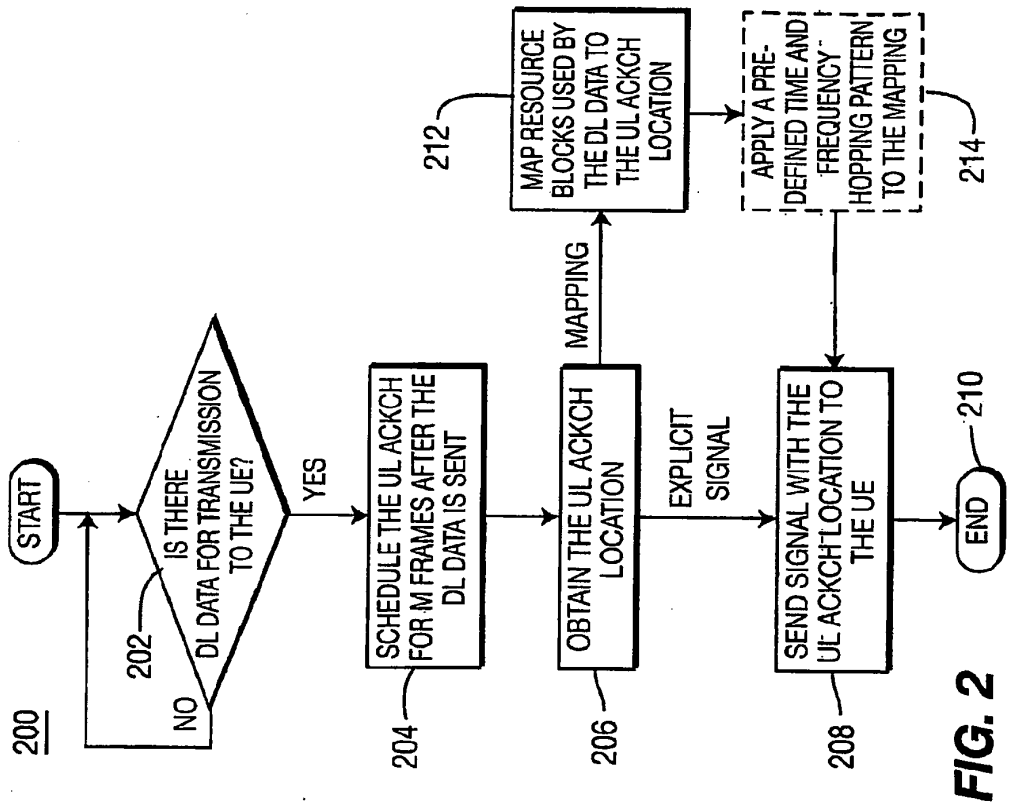

200
START
IS THERE DL DATA FOR TRANSMISSION TO THE UE?
202
NO
YES
SCHEDULE THE UL ACKCH FOR M FRAMES AFTER THE DL DATA IS SENT
204
OBTAIN THE UL ACKCH LOCATION
206
MAPPING
EXPLICIT SIGNAL
MAP RESOURCE BLOCKS USED BY THE DL DATA TO THE UL ACKCH LOCATION
212
APPLY A PRE-DEFINED TIME AND FREQUENCY HOPPING PATTERN TO THE MAPPING
214
SEND SIGNAL WITH THE UL ACKCH LOCATION TO THE UE
208
END
210

FIG. 2

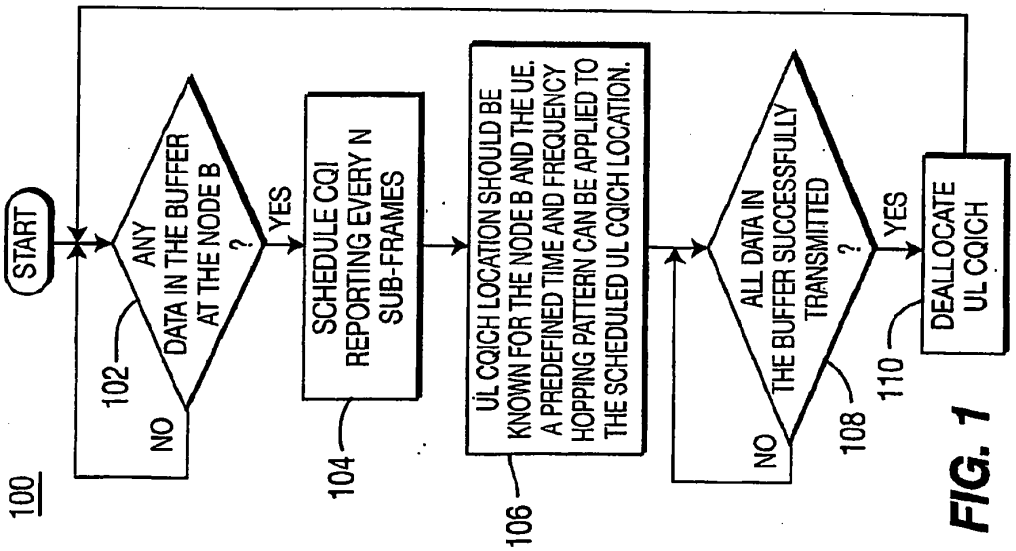

100
START
ANY DATA IN THE BUFFER AT THE NODE B ?
102
NO
YES
SCHEDULE CQI REPORTING EVERY N SUB-FRAMES
104
UL CQICH LOCATION SHOULD BE KNOWN FOR THE NODE B AND THE UE. A PREDEFINED TIME AND FREQUENCY HOPPING PATTERN CAN BE APPLIED TO THE SCHEDULED UL CQICH LOCATION.
106
ALL DATA IN THE BUFFER SUCCESSFULLY TRANSMITTED ?
108
NO
YES
DEALLOCATE UL CQICH
110

FIG. 1

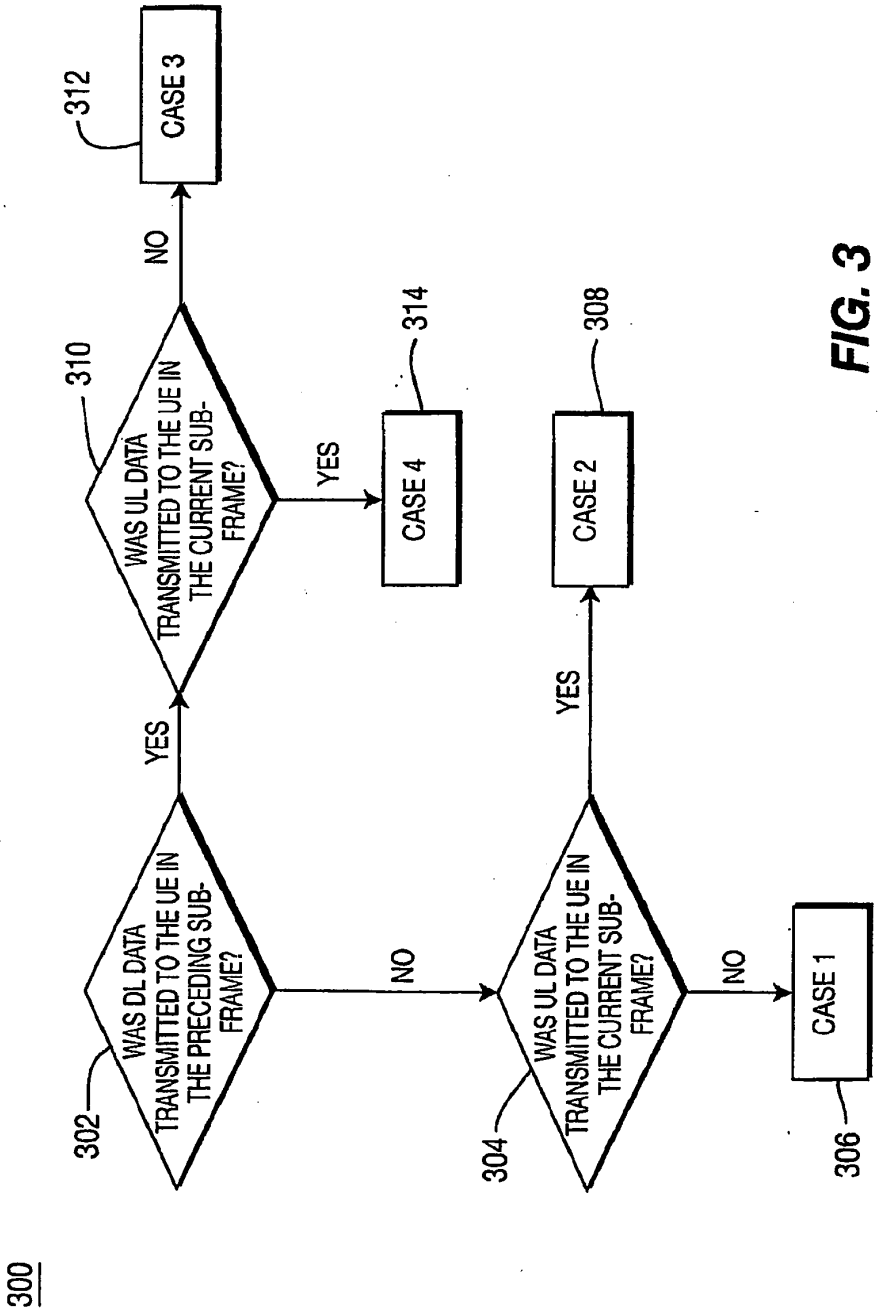

300
302
WAS DL DATA TRANSMITTED TO THE UE IN THE PRECEDING SUB-FRAME?
YES
NO
304
WAS UL DATA TRANSMITTED TO THE UE IN THE CURRENT SUB-FRAME?
YES
NO
306
CASE 1
308
CASE 2
310
WAS UL DATA TRANSMITTED TO THE UE IN THE CURRENT SUB-FRAME?
YES
NO
312
CASE 3
314
CASE 4

FIG. 3

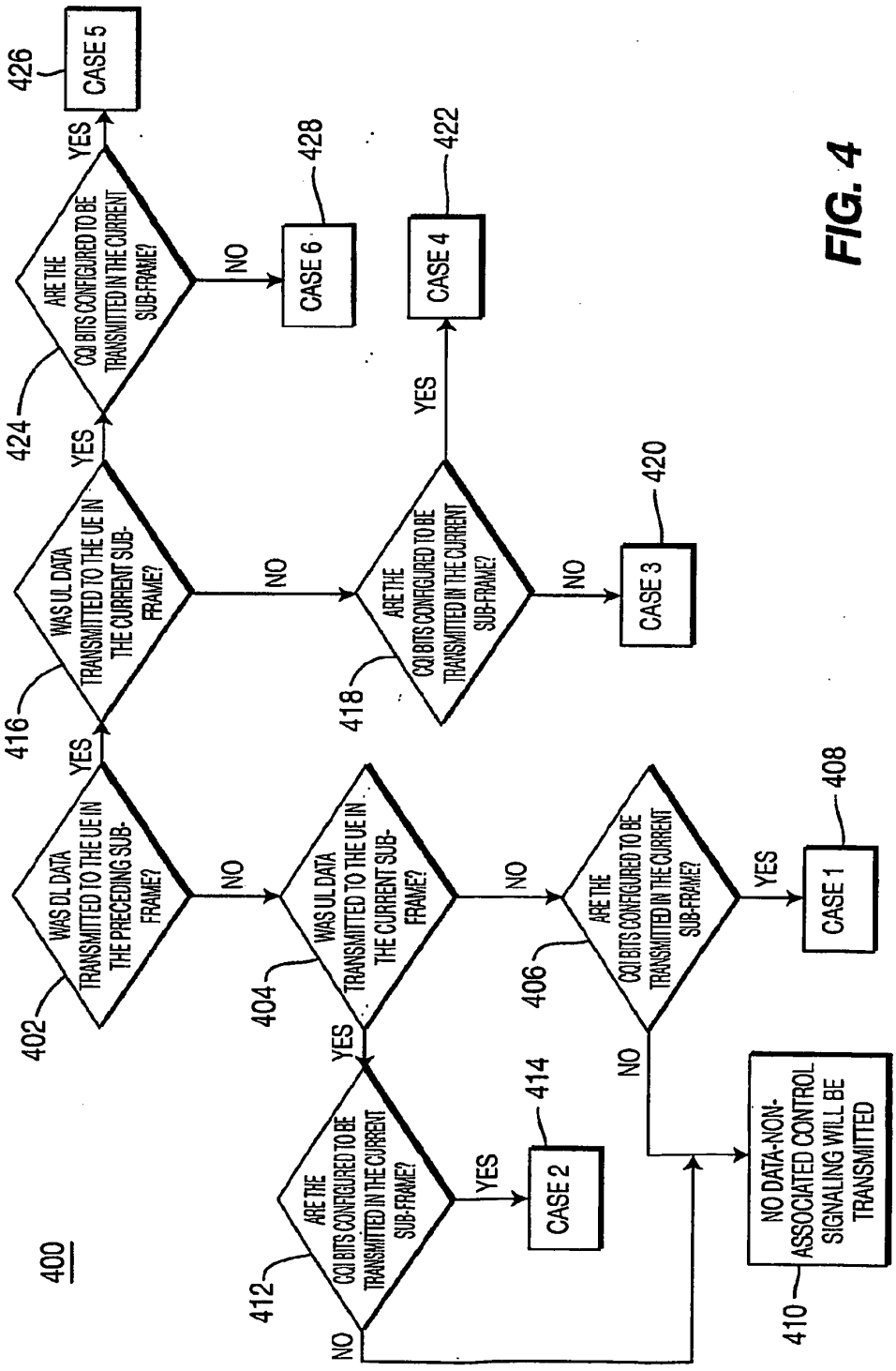

400
WAS DL DATA TRANSMITTED TO THE UE IN THE PRECEDING SUB-FRAME?
402
YES
NO
WAS UL DATA TRANSMITTED TO THE UE IN THE CURRENT SUB-FRAME?
404
YES
NO
ARE THE CQI BITS CONFIGURED TO BE TRANSMITTED IN THE CURRENT SUB-FRAME?
406
YES
NO
CASE 1
408
NO DATA-NON-ASSOCIATED CONTROL SIGNALING WILL BE TRANSMITTED
410
ARE THE CQI BITS CONFIGURED TO BE TRANSMITTED IN THE CURRENT SUB-FRAME?
412
YES
NO
CASE 2
414
WAS UL DATA TRANSMITTED TO THE UE IN THE CURRENT SUB-FRAME?
416
YES
NO
ARE THE CQI BITS CONFIGURED TO BE TRANSMITTED IN THE CURRENT SUB-FRAME?
418
YES
NO
CASE 3
420
CASE 4
422
ARE THE CQI BITS CONFIGURED TO BE TRANSMITTED IN THE CURRENT SUB-FRAME?
424
YES
NO
CASE 5
426
CASE 6
428

FIG. 4

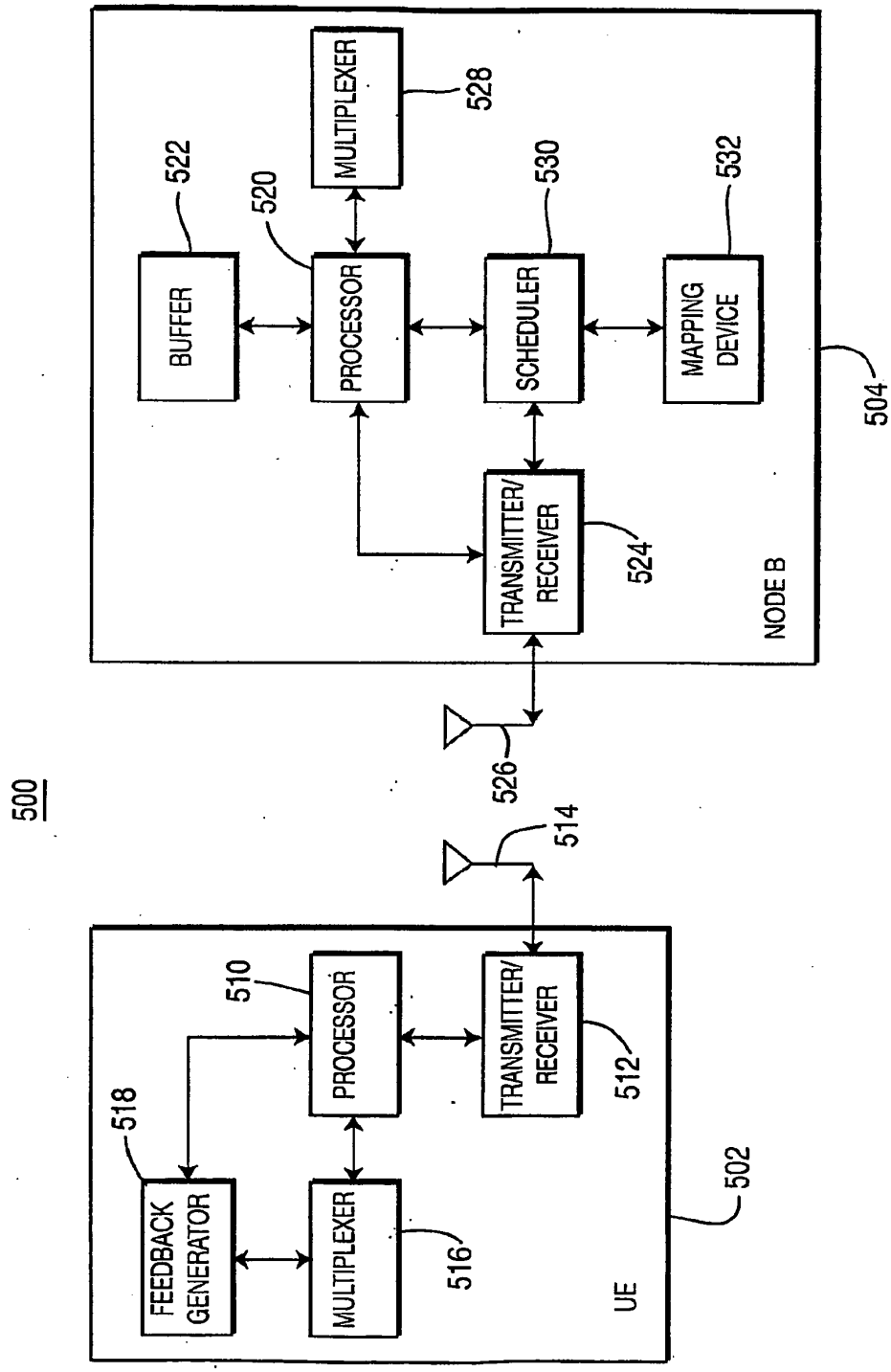

500
NODE B
504
BUFFER
522
PROCESSOR
520
MULTIPLEXER
528
SCHEDULER
530
MAPPING DEVICE
532
TRANSMITTER/ RECEIVER
524
526
514
UE
502
FEEDBACK GENERATOR
518
PROCESSOR
510
MULTIPLEXER
516
TRANSMITTER/ RECEIVER
512

FIG. 5

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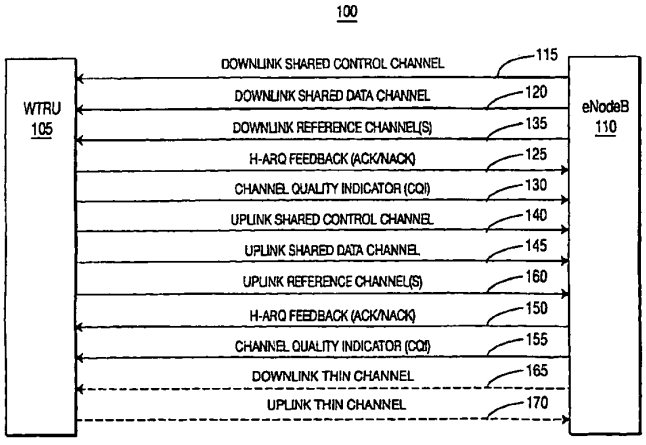
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(54) Title: RADIO LINK FAILURE DETECTION PROCEDURES IN LONG TERM EVOLUTION UPLINK AND DOWNLINK AND APPARATUS THEREFOR



(57) Abstract: A method and apparatus for detecting a radio link (RL) failure for uplink (UL) and downlink (DL) in a long term evolution (LTE) wireless communication system including at least one wireless transmit/receive unit (WTRU) and at least one evolved Node-B (eNodeB) are disclosed. A determination is made as to whether an RL has an in-synchronization status or an out-of-synchronization status. An RL failure is declared if an out-of-synchronization status is detected.

WO 2007/130324 A2

[0001] # RADIO LINK FAILURE DETECTION PROCEDURES IN LONG TERM EVOLUTION UPLINK AND DOWNLINK AND APPARATUS THEREFOR

FIELD OF INVENTION

[0002]

[0003] The present invention is related to wireless communication methods and apparatus having a medium access control (MAC) layer specifically designed for wireless communication systems such as long term evolution (LTE) systems. More particularly, the present invention is related to criteria and procedures in LTE MAC for detecting radio link (RL) failure in both uplink (UL) and downlink (DL) directions when there is no existing dedicated channel in the LTE system.

BACKGROUND

[0004]

[0005] An objective of Evolved Universal Terrestrial Radio Access (E-UTRA) and Universal Terrestrial Radio Access Network (UTRAN) is to provide a radio access network featuring a high-data-rate, low-latency, packet-optimized system with improved system capacity and coverage. In order to achieve this, the inventors have observed that evolution of the radio interface as well as the radio network architecture is needed. For example, instead of using code division multiple access (CDMA), which is currently used in third generation partnership project (3GPP), orthogonal frequency division multiple access (OFDMA) and frequency division multiple access (FDMA) are proposed air interface technologies to be used in the DL and UL transmissions, respectively, for E-UTRA UTRAN.

[0006] Signaling radio bearers (SRB) are used to maintain the connection between a wireless transmit/receive unit (WTRU) and a network by transmitting important information, such as a handover message from the network, e.g., transmitting such information in a dedicated channel (DCH) cell level (Cell_DCH) state in 3GPP. In current 3GPP standards, the SRBs are mapped to dedicated transport channels (TrCHs), (i.e., DCHs), which are then mapped to dedicated physical channels. The dedicated physical channels are comprised of

dedicated physical control channels (DPCCHs) and dedicated physical data channels (DPDCHs).

[0007] In order to detect the failure of the SRBs, and to take necessary measures following the failure, certain criteria and procedures need to be designed. This is known as radio link (RL) failure detection. In 3GPP, there are two quantities to be estimated for reporting in-synchronization status and out-of-synchronization status. One quantity is a DPCCH quality, and the other quantity is a cyclic redundancy check (CRC) results on the received transport blocks to which the SRBs are mapped.

[0008] A Node-B or WTRU should estimate the DPCCH quantities and calculate the CRC in parallel in order to check if the certain criteria are fulfilled for reporting either the in-synchronization status or the out-of-synchronization status. The criteria identified may be only applicable when SRBs are mapped to shared channels, and their associated control channels are identified for RL failure conditions.

[0009] Dedicated physical channel availability is indicated by the physical layer to higher layers with a physical channel in-synchronization status indicator or a physical channel out-of-synchronization status indicator. A RL is said to be in synchronization, (in-sync), if it is available to successfully receive data. Otherwise, the RL is said to be in failure, i.e. when it is out of synchronization (out-of-sync). In the current 3GPP standard, it is the responsibility of physical layer to monitor the dedicated physical channels, determine the in-sync and out-of-sync status of every radio frame, and report the results to the radio resource control (RRC) layer using the primitives physical layer control message in-synchronization indicator (CPHY-in-sync-IND) and physical layer control message out-of-synchronization indicator (CPHY-out-of-sync-IND). The RRC layer will declare the physical channel establishment or failure, or RL failure, whenever appropriate based on these indications and associated timers and counters.

[0010] In 3GPP, high speed DL packet access (HSDPA) and high speed UL packet access (HSUPA) protocols utilize high speed shared channels primarily for

services that do not require continuous channel allocations. Such channels utilize fast physical and MAC layer signaling between Node-Bs and WTRUs for channel assignment and hybrid automatic repeat request (H-ARQ) for efficient and fast recovery of failed transmissions.

[0011] When the service supported by a cellular system is mapped to shared channels, the inventors have recognized that the use of dedicated channels to support SRBs is inefficient. This is because the traffic may not be continuous. Thus, it would be desirable to use shared channels to support the SRBs in HSDPA and HSUPA.

[0012] SUMMARY

[0013] The present invention relates to methods and apparatus for implementing new criteria and procedures for radio link (RL) failure detection in wireless communication systems (e.g., LTE systems). Preferably the invention is implemented for both UL and DL directions by exploiting a new channel structure and characteristics for LTE. Preferably, a shared channel is used to transmit bursty SRBs.

[0014] BRIEF DESCRIPTION OF THE DRAWINGS

[0015] A more detailed understanding of the invention may be had from the following description of a preferred embodiment, given by way of example and to be understood in conjunction with the accompanying drawings.

[0016] Figure 1 is a block diagram of an LTE configured in accordance with the present invention.

[0017] Figure 2A is a signaling diagram depicting a DL RL failure detection procedure in accordance with the present invention.

[0018] Figure 2B is a flow diagram of a method for detecting DL RL failure.

[0019] Figure 3A is a signaling diagram depicting a UL RL failure detection procedure in accordance with the present invention.

[0020] Figure 3B is a flow diagram of a method for detecting UL RL failure.

[0021] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] When referred to hereafter, the terminology "wireless transmit/receive unit (WTRU)" includes but is not limited to a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a computer, or any other type of user device capable of operating in a wireless environment. When referred to hereafter, the terminology "evolved Node-B (eNodeB)" includes but is not limited to a base station, a site controller, an access point (AP), or any other type of interfacing device capable of operating in a wireless environment.

[0023] When referred to hereafter, the terminology "thin channel" is a non-contention-based channel that is periodically and/or temporarily allocated to a particular WTRU. A thin channel may be dynamically allocated, (i.e., switched on an off), when needed to maintain radio link status and provide other control signaling. The other control signaling may include synchronization bursts for maintaining timing advance, scheduling requests, scheduling allocations, or any other channel associated control signaling.

[0024] In an LTE system, only shared physical channels are used for transmission for both DL and UL. Thus, in addition to data traffic, both real time, (i.e., voice over Internet Protocol (VoIP)), and non-real time, (i.e., web browsing), a control message mapped to SRBs is transmitted through a shared physical channel. This is a distinction from systems that transmit control messages in a dedicated channel (DCH).

[0025] Ensuring WTRU and UTRAN detection of SRB loss and recovery with respect to a shared channel presents a problem which is different than when a dedicated channel is used. In the absence of a dedicated channel, burstiness in offered traffic load may cause an undetected SRB failure. This problem exists for both DL and UL.

[0026] An LTE system 100 including a WTRU 105 and an evolved Node-B (eNodeB) 110 which addresses this problem in accordance with the present invention is illustrated in Figure 1. The WTRU 105 and the evolved Node-B (eNodeB) 110 are preferably configured with a hierarchy of processing

components including a physical layer component, a MAC layer component and higher layer components. The physical layer component is preferably configured to physically transmit and receive wireless signals. The MAC layer component is preferably configured to provide control functions for the physical layer, and to act as a conduit for data and other signaling from higher layers for formatting and transmission by the physical layer, and to pass data and other signaling received by the physical layer to the higher layer components.

[0027] RL Failure Detection in DL - Procedures at the WTRU

[0028] As shown in Figure 1, for DL transmission, scheduling information is transmitted on a DL shared control channel 115 from the eNodeB 110 to the WTRU 105. From the control signaling received on the DL shared control channel 115, the WTRU 105 receives information as to the physical resources that are allocated. A DL shared data channel 120 is used to transmit data from the eNodeB 110 that is received by the WTRU 105 via allocated physical resources. The WTRU 105 then transmits H-ARQ feedback 125 to the eNodeB 110, (i.e., positive acknowledgement (ACK)/negative acknowledgement (NACK)). The WTRU 105 also transmits a channel quality indication (CQI) 130 to the eNodeB 110 based on the measurement and estimation of at least one DL reference channel 135 that is transmitted from the eNodeB 110 and received by the WTRU 105.

[0029] The WTRU 105 continuously determines whether an in-synchronization status or an out-of-synchronization status is detected, and reports the results through a signaling message. A higher layer component is configured to preferably declare an RL failure based on appropriate criteria and associated timers and counters, only when an out-of synchronization status is detected. Preferably, the MAC layer component of the WTRU 105 is configured to determine whether an in-synchronization status or an out-of-synchronization status is detected. Quantities used for estimation for the DL RL failure detection are discussed below and are preferably based on the characteristics of the LTE DL channel structure.

[0030] To address resource sharing and allocation to the WTRU 105 in terms of availability of the traffic, new procedures have been devised based on new criteria. By exploiting various shared channels and the information contained therein, the following preferred options of criteria are used to declare DL RL failure at the WTRU 105. Preferably, a combination of one or more criteria is selected from the following five preferred categories for this purpose.

[0031] 1) DL Channel Quality (sliding window average):

1a) whether CQI measured from a DL reference channel, e.g. from a pilot or from a broadcast channel, and reported to the eNodeB is below a specified threshold Q_{DL_CQI} within a certain period (timer T_{DL_CQI});

1b) whether CQI from the eNodeB measured on UL reference channels transmitted from WTRU is below a specified threshold Q_{UL_CQI} within a certain period (timer T_{UL_CQI}) or cannot be received on a regular basis; and

1c) a combination of CQI for both UL and DL.

[0032] 2) DL Shared Control Channel

2a) whether quality of DL common shared control physical channel, e.g. signal to interference ratio (SIR), energy per bit per noise power spectral density (EbNo), CRC/block error rate (BLER) ($Q_{SC_DL_SIR}$, $Q_{SC_DL_BLER}$), is below a certain threshold over a specified time period (timers $T_{SC_DL_SIR}$, $T_{SC_DL_BLER}$); and

2b) whether quality of DL dedicated shared control physical channel, e.g. SIR, EbNo, CRC/BLER, and the like ($Q_{DC_DL_SIR}$, $Q_{DC_DL_BLER}$), is below certain threshold over a specified time period ($T_{DC_DL_SIR}$, $T_{DC_DL_BLER}$).

[0033] 3) DL Shared Data Channel

3a) whether quality of DL data shared physical channel, e.g. SIR, EbNo, CRC/BLER, and the like ($Q_{SD_DL_SIR}$, $Q_{SD_DL_BLER}$), is below certain threshold over a specified time period (timers $T_{D_DL_SIR}$, $T_{D_DL_BLER}$);

3b) whether an ACK/NACK ratio generated at WTRU and fed back in UL for the DL data packets is below a specified threshold ($Q_{SD_DL_ACK}$);

3c) whether an ACK/NACK ratio fed back from the eNodeB for UL data packets is below a specified threshold ($Q_{SD_UL_ACK}$); and

3d) a combination of items 3b) and 3c).

[0034] 4) UL Resource Grant

4a) whether allocated UL resource cannot guarantee the SRB bit rate;

4b) whether there is a timeout following no response to single/multiple resource requests ($C_{UL_Request}$) sent over a uplink dedicated physical channel; and

4c) whether there is a timeout following no response to single or multiple resource requests ($R_{UL_Request}$) sent over a random access channel (RACH) in Active state.

[0035] 5) A periodic DL Channel for DL Dedicated transmission

5a) whether quality of DL data shared physical channel, e.g. SIR, EbNo, CRC/BLER, and the like, is below a certain threshold over a specified time period (timers $T_{D_DL_SIR}$, $T_{D_DL_BLER}$);

5b) whether an ACK/NACK ratio generated at WTRU for DL data packets is below a specified threshold ($Q_{DL_Dedi_ACK}$);

5c) whether an ACK/NACK ratio provided as feedback from eNodeB for UL data packets is below a specified threshold ($Q_{UL_Dedi_ACK}$);

5d) where a UL thin channel is used to probe, (i.e., "ping"), for RL failure based on criteria similar to those used to determine DL RL failure; and

5e) a combination of items 5b) and 5c)

[0036] The eNodeB 110 preferably selects a combination of the above quantities and parameters and the corresponding thresholds, timers, counters to be used for RL status detection and then transmits a selected configuration to the WTRU 105. The configuration signals to support the DL RL failure detection preferably include:

1) A combination of estimation quantities and parameters for RL failure detection;

2) Specific timer duration for each quantity and parameter where the RL failure timer configuration is preferably based on the WTRU sensitivity; and

3) Specific counters for each quantity and parameter.

[0037] Once the WTRU 105 is configured with this information, it can begin the RL detection process. The signaling for DL RL failure detection preferably uses a DL RL failure indication. A high level procedure can be implemented, preferably in an embodiment dealing with a "Keep Alive" (using thin channel) case or an embodiment dealing with a "Non-Keep Alive" (without using thin channel) case.

[0038] Figure 2A is a signaling diagram depicting a DL RL failure detection procedure in a wireless communication including a WTRU 105 and an eNodeB 110 in accordance with the present invention. As shown in Figure 2A, a CQI is measured from a DL reference channel and is provided to the WTRU 105 as feedback from the eNodeB 110. The DL RL failure detection may detect the failure of a DL shared control channel, a DL shared data channel, a UL resource grant or a DL thin channel.

[0039] Generally, in accordance with the present invention, a high level DL RL detection procedure is preferably implemented with the following steps:

1) A combination of estimation quantities are selected to serve as the criteria for DL RL failure detection. The estimation quantities are preferably a combination of criteria as described above. Preferably, associated thresholds and timers are included as described in above paragraphs individually along with the estimation quantities. Preferably the configuration is determined by the eNodeB 110 and signaled to the WTRU 105.

2) The WTRU 105 is preferably configured with the selected combination of quantities and parameters before the start of the detection procedure. Preferably, the MAC component of the WTRU 105 is provided with the ability to be selectively configurable for this purpose.

3) The WTRU 105, preferably via its MAC component, then

monitors the selected combination of quantities and parameters. When the configured estimation quantities do not meet selected thresholds within a pre-configured time period, a DL RL failure is detected and declared.

4) The WTRU 105 then signals the failure status to the eNodeB 110.

5) Actions for DL RL recovery are then taken, and the timers and counters are reset for a new detection.

[0040] In accordance with a first embodiment of the present invention, a high level DL RL detection procedure for a keep alive channel scenario of SRBs a pre-allocated DL thin channel is maintained. Where there is a pre-allocated DL thin channel maintained for SRB, the channel quality is measured on a DL thin channel is preferably selected as a main quantity to estimate the quality for DL SRB transmission. Other estimation quantities are selected to serve as a complimentary approach to assist the DL RL failure detection is selecting the combination of estimation quantities with which to configure the WTRU.

[0041] In accordance with a second embodiment of the present invention, a high level DL RL detection procedure for a non-keep alive channel scenario of SRBs is implemented. In this case, there is no pre-allocated DL thin channel for SRB service. Although there are other periodic DL receptions, such as DL reference channels, that are not directly related to the DL SRB transmission. Accordingly, such other periodic DL receptions are preferably only used in combination with other quantities which preferably includes the shared data channel transmitting the DL SRBs.

[0042] Figure 2B is a flow diagram of a method 200 for detecting DL RL failure. In step 205, the channel quality of a DL thin channel is measured if there is a pre-allocated DL thin channel maintained for an SRB to estimate the quality for DL SRB transmission. In step 210, quantities and parameters are configured for performing DL RL failure detection which is then conducted in step 215. If a DL RL failure is detected and declared in step 215, a WTRU signals DL RL failure status to an eNodeB in step 220. The WTRU then

performs necessary actions for DL RL recovery in step 225 and the WTRU resets timers and counters for new RL failure detection in step 230.

[0043] **RL Failure Detection in UL - Procedures at the eNodeB**

[0044] As shown in Figure 1, for UL transmission, the scheduling information is also transmitted on the DL shared control channel 115 from the eNodeB 110 to the WTRU 105. The UL shared control channel 140 is used to send control information from WTRU 105 to the eNodeB 110. From the control signaling received on the DL shared control channel 115, the WTRU 105 receives information as to the physical resources that are allocated. A UL shared data channel 145 is used to transmit data from the WTRU 105 to the eNodeB 110. After receiving UL packets from the WTRU 105, the eNodeB 110 then transmits H-ARQ feedback (ACK/NACK) 150 to the WTRU 105. Furthermore, the eNodeB 110 transmits a CQI 155 to the WTRU 105 based on the measurement and estimation of at least one UL reference channel 160 that is transmitted from the WTRU 105 and received by the eNodeB 110.

[0045] The eNodeB 110 continuously determines whether an in-synchronization status or an out-of-synchronization status is detected, and reports the results through a signaling message. A higher layer component is configured to preferably declare an RL failure based on appropriate criteria and associated timers and counters only when an out-of synchronization status is detected. Preferably, the MAC layer component of the MAC layer component of the eNodeB 110 is configured to determine whether an in-synchronization status or an out-of-synchronization status is detected. Quantities used for estimation for the UL RL failure detection are discussed below and are preferably based on the characteristics of the LTE UL channel structure.

[0046] Due to the new characteristics of LTE UL channel structure, some new quantities have to be used for estimation for the UL RL failure detection. These quantities may not be exactly the same as those used for DL RL failure detection.

[0047] At the eNodeB 110, the information contained in the UL shared control and data channels is used as the estimation quantities of the UL RL

failure detection. Specifically, the UL thin channel is used to provide a periodic and/or temporarily allocated link in UL. Thus, the new criteria and parameters for UL RL failure detection may include one or more of the following:

[0048] 1) whether a reported CQI is below a certain threshold Q_{UL_CQI} within a specified period T_{UL_CQI} sliding window average).

1a) whether a CQI to be reported to WTRU (measured from UL reference channel) is below a specified threshold Q_{UL_CQI} within certain period T_{UL_CQI};

1b) whether a CQI from feedback from WTRU (measured on the DL reference channels transmitted from the eNodeB) is below a specified threshold Q_{DL_CQI} within a certain period T_{DL_CQI}; and

1c) a combination of CQI for both UL and DL.

[0049] 2) Rate Request reception - whether a predefined periodic or polled UL timing synchronization signal is not received for a specified period T_{UL_Thin}.

[0050] 3) UL Data Reception

3a) whether no response to the scheduling grants are received for a specified period $T_{UL_Resp_ULGrant}$; and

3b) whether ACK/NACK ratio and/or discarded DL transmissions is below a specified threshold R_{UL_ACK}.

[0051] 4) UL Data BLER - calculated by ACK/NACK ratio on final data transmission attempt from the WTRU's UL shared data channel.

[0052] 5) UL Resource Grant

Allocated UL resources cannot guarantee the SRB bit rate, and timeout following no response to multiple resource requests.

[0053] 6) UL Control Reception- whether the quality of a UL shared physical channel is below certain threshold Q_{UL_SIR}, Q_{UL_BLER} (SIR, EbNo, CRC/BLER, and the like) over a specified time period T_{UL_SIR}, T_{UL_BLER}.

[0054] A higher layer should determine the subset of the above quantities and what the appropriate thresholds, timers, counters and parameters (as

described above) to be used for UL RL status detection should be. The following parameters should be configured to support the UL RL failure:

1) Estimation quantities and parameters to be used for UL RL failure detection;

2) Specific timer duration for each quantity and special parameter; and

3) Specific counters for each quantity and special parameter. The signaling for UL RL failure detection can be the UL RL failure indication.

[0055] The eNodeB can begin the UL RL detection process once the eNodeB is configured with above information. Similar to described above for WTRU, the high level procedure can be proposed in two embodiments dealing with the Keep Alive (using thin channel) and Non-Keep Alive (without using thin channel) cases.

[0056] Figure 3A is a signaling diagram depicting a UL RL failure detection procedure in a wireless communication including a WTRU 105 and an eNodeB 110 in accordance with the present invention. As shown in Figure 3A, a CQI is measured from a UL reference channel and is reported by the WTRU 105. The UL RL failure detection may detect the failure of a UL rate request, (a thin UL channel or a non-synchronous random access channel (RACH)), a UL shared control channel, a UL shared data channel or a UL resource grant.

[0057] In accordance with a third embodiment of the present invention, a keep alive channel scenario of SRBs is implemented as follows:

[0058] 1) Since there is a pre-defined UL thin channel maintained for SRB in this scenario, it is proposed to measure the channel quality on UL thin channel as a main factor to estimate the quality for UL SRB transmission. The DL thin channel may be used to probe, (i.e., "ping"), for RL failure. It may probe based on criteria similar to those used to determine UL RL failure.

[0059] 2) Other estimation quantities can be used as a complimentary approach to assist the UL RL failure detection. Exact quantities and parameters should be configured before the start of the detection procedure.

[0060] 3) If the configured estimation quantities are not meeting certain thresholds within a pre-configured time period, then UL RL failure is detected and it should be declared, then:

a) The eNodeB should signal the failure status to WTRU;

b) The eNodeB should take the necessary actions for UL RL recovery; and

c) The eNodeB should reset the timers and counters for new detection.

[0061] In accordance with a fourth embodiment of the present invention, a high level UL RL detection procedure for a non-keep alive channel scenario of SRBs is implemented.

[0062] 1) In this case, there is no pre-allocated UL thin channel for SRB service. Although there are other periodic UL receptions, such as a UL reference channel, these are not directly related to the UL SRB transmission, so they can only be used by combining with other quantities, especially the shared data channel transmitting the UL SRBs.

[0063] 2) The following procedures are similar as described in step 3) of the third embodiment.

[0064] Estimation quantities described above can be used to assist the UL RL failure detection. Exact quantities and parameters (part of or all of them) should be configured before the start of the detection procedure.

[0065] If the configured estimation quantities are not meeting certain thresholds within a pre-configured time period, then UL RL failure is detected and it should be declared, then:

a) The eNodeB should signal the failure status to WTRU;

b) The eNodeB should take the necessary actions for UL RL recovery; and

c) The Node-B should reset the timers and counters for new detection. The gap due to discontinuous reception (DRX)/discontinuous transmission (DTX) should be handled properly while setting the timer or measurements.

[0066] Figure 3B is a flow diagram of a method 300 for detecting uplink radio link failure. In step 305, the channel quality of a UL thin channel is measured if there is a pre-allocated UL thin channel maintained for an SRB to estimate the quality for UL SRB transmission. In step 310, quantities and parameters are configured for performing UL RL failure detection. If an UL RL failure is detected and declared in step 315, an eNodeB signals UL RL failure status to a WTRU in step 320. The eNodeB then performs necessary actions for UL RL recovery in step 325 and the eNodeB resets timers and counters for new RL failure detection in step 330.

[0067] Embodiments

1. A method of detecting radio link (RL) failure in a wireless communication system including at least one wireless transmit/receive unit (WTRU) and at least one Node-B, the method comprising:

detecting whether an RL has an in-synchronization status or an out-of-synchronization status; and

declaring an RL failure if an out-of-synchronization status is detected.

2. The method of embodiment 1 wherein the RL failure is declared if a channel quality indicator (CQI) measured from a downlink (DL) reference channel is reported to the Node-B and the CQI is below a threshold within a certain period.

3. The method as in any one of embodiments 1 and 2 wherein the RL failure is declared if a channel quality indicator (CQI) measured on uplink (UL) reference channels transmitted by the WTRU is below a threshold within a certain period.

4. The method as in any one of embodiments 1-3 wherein the RL failure is declared if the quality of a downlink (DL) data shared physical channel is below a certain threshold over a specified time period.

5. The method as in any one of embodiments 1-4 wherein the RL failure is declared if a positive acknowledgement (ACK)/negative acknowledgement (NACK) ratio below a specified ratio is generated at the WTRU.

6. The method as in any one of embodiments 1-5 wherein the wireless communication system is a long term evolution (LTE) system and the Node-B is an evolved Node-B (eNodeB).

7. The method of embodiment 6 further comprising:

the eNodeB selecting a subset of quantities and appropriate thresholds, timers, counters and parameters to be used for RL status detection; and

the eNodeB signaling the selected subset to the WTRU.

8. A method of detecting radio link (RL) failure in a long term evolution (LTE) wireless communication system including at least one wireless transmit/receive unit (WTRU) and at least one evolved Node-B (eNodeB), the method comprising:

measuring channel quality of a downlink thin channel if there is a pre-allocated downlink thin channel maintained for a signaling radio bearer (SRB) to estimate the quality for downlink SRB transmission;

configuring quantities and parameters for performing a downlink RL failure; and

the WTRU signaling a downlink RL failure status to the eNodeB if a downlink RL failure is detected.

9. The method of embodiment 8 wherein the downlink thin channel is a non-contention-based channel that is periodically and/or temporarily allocated to a particular WTRU.

10. The method as in any one of embodiments 8 and 9 further comprising:

the WTRU taking necessary actions to initiate downlink RL recovery; and

the WTRU resetting timers and counters for performing a new RL failure detection.

11. The method as in any one of embodiments 8-10 wherein the RL failure is declared if a channel quality indicator (CQI) measured from a downlink (DL) reference channel is reported to the eNodeB and the CQI is below a threshold within a certain period.

12. The method as in any one of embodiments 8-11 wherein the RL failure is declared if a channel quality indicator (CQI) measured on uplink (UL) reference channels transmitted by the WTRU is below a threshold within a certain period.

13. The method as in any one of embodiments 8-12 wherein the RL failure is declared if the quality of a downlink (DL) data shared physical channel is below a certain threshold over a specified time period.

14. The method as in any one of embodiments 8-13 wherein the RL failure is declared if a positive acknowledgement (ACK)/negative acknowledgement (NACK) ratio below a specified ratio is generated at the WTRU.

15. A method of detecting radio link (RL) failure in a long term evolution (LTE) wireless communication system including at least one wireless transmit/receive unit (WTRU) and at least one evolved Node-B (eNodeB), the method comprising:

measuring channel quality of an uplink thin channel if there is a pre-allocated uplink thin channel maintained for a signaling radio bearer (SRB) to estimate the quality for uplink SRB transmission;

configuring quantities and parameters for performing a uplink RL failure; and

the eNodeB signaling an uplink RL failure status to the WTRU if an uplink RL failure is detected.

16. The method of embodiment 15 wherein the uplink thin channel is a non-contention-based channel that is periodically and/or temporarily allocated to a particular WTRU.

17. The method as in any one of embodiments 15 and 16 further comprising:

the eNodeB taking necessary actions to initiate uplink RL recovery; and

the eNodeB resetting timers and counters for performing a new RL failure detection.

18. The method as in any one of embodiments 15-17 wherein the RL failure is declared if a channel quality indicator (CQI) measured from an uplink (UL) reference channel is reported to the eNodeB and the CQI is below a threshold within a certain period.

19. The method as in any one of embodiments 15-18 wherein the RL failure is declared if a channel quality indicator (CQI) measured on downlink (DL) reference channels transmitted by the eNodeB is below a threshold within a certain period.

20. The method as in any one of embodiments 15-19 wherein the RL failure is declared if the quality of an uplink (UL) data shared physical channel is below a certain threshold over a specified time period.

21. The method as in any one of embodiments 15-20 wherein the RL failure is declared if a positive acknowledgement (ACK)/negative acknowledgement (NACK) ratio below a specified ratio is generated at the eNodeB.

22. The method as in any one of embodiments 15-21 wherein the RL failure is declared if a predefined periodic or polled UL timing synchronization signal is not received for a specified period.

23. The method as in any one of embodiments 15-22 wherein the RL failure is declared if there is no response to scheduling grants for a specified period.

24. A long term evolution (LTE) wireless communication system for detecting a radio link (RL) failure, the system comprising:

at least one wireless transmit/receive unit (WTRU); and

at least one evolved Node-B (eNodeB) wherein an RL failure is declared if an out-of-synchronization status is detected.

25. The LTE wireless communication system of embodiment 24 further comprising:

a downlink shared control channel established between the eNodeB and the WTRU;

a downlink shared data channel established between the eNodeB and the WTRU;

at least one downlink reference channel established between the eNodeB and the WTRU; and

a downlink thin channel established between the eNodeB and the WTRU.

26. The system as in any one of embodiments 24 and 25 wherein the downlink thin channel is a non-contention-based channel that is periodically and/or temporarily allocated to a particular WTRU.

27. The LTE wireless communication system as in any one of embodiments 24-26 further comprising:

an uplink shared control channel established between the eNodeB and the WTRU;

an uplink shared data channel established between the eNodeB and the WTRU;

at least one uplink reference channel established between the eNodeB and the WTRU; and

an uplink thin channel established between the eNodeB and the WTRU.

28. The system of embodiment 27 wherein the uplink thin channel is a non-contention-based channel that is periodically and/or temporarily allocated to a particular WTRU.

29. A wireless transmit/receive unit (WTRU) configured for wireless communication in a long term evolution (LTE) wireless communication system, the WTRU comprising:

a processing component selectively configurable based on radio link (RL) failure detection configuration data received from a base station to conduct downlink (DL) RL failure detection such that when the processing component receives RL failure detection configuration data from a base station, the processing component monitors criteria specified by the received RL failure detection configuration data to detect DL RL failure; and

the processing component being further configured to generate a DL RL failure indication when a DL RL failure is detected.

30. The WTRU of embodiment 29 wherein the WTRU is configured with a hierarchy of processing layers including a physical (PHY) layer, a medium access control (MAC) layer and higher layers, wherein the processing component is a MAC layer component.

31. The WTRU as in any one of embodiments 29 and 30 wherein the WTRU is configured to transmit a DL RL failure indication to the base station when a DL RL failure indication is generated.

32. The WTRU as in any one of embodiments 29-31 wherein the WTRU is configured to perform DL RL recovery actions when a DL RL failure indication is generated.

33. The WTRU as in any one of embodiments 29-32 wherein the base station is an evolved Node-B (eNodeB).

34. The WTRU as in any one of embodiments 29-33 wherein the processing component is configured to monitor a selected combination of criteria based on received configuration data where the criteria include one or more of the following:

whether a channel quality indicator (CQI) measured from a DL reference channel, such as a pilot or a broadcast channel, and reported to the base station is below a specified threshold within a certain period;

whether a CQI reported by the WTRU is measured on uplink (UL) reference channels transmitted from the WTRU is below a specified threshold within a certain period or cannot be received on a regular basis;

a combination of CQI for both UL and DL;

whether quality of a DL common shared control physical channel, such as signal to interference ratio (SIR), energy per bit per noise power spectral density (EbNo) or cyclic redundancy check (CRC) to block error rate (BLER) ratio (CRC/BLER), is below a certain threshold over a specified time period;

whether quality of a DL dedicated shared control physical channel, such as SIR, EbNo, or CRC/BLER, is below certain threshold over a specified time period;

whether quality of a DL data shared physical channel, such as SIR, EbNo, or CRC/BLER, is below certain threshold over a specified time period;

whether a positive acknowledgement to negative acknowledgement (ACK/NACK) ratio generated at the WTRU and fed back in UL for the DL data packets is below a specified threshold;

whether an ACK/NACK ratio fed back from the base station for UL data packets is below a specified threshold;

a combination of whether a ACK/NACK ratio generated at the WTRU and fed back in UL for the DL data packets is below a specified threshold and of whether an ACK/NACK ratio fed back from the base station for UL data packets is below a specified threshold;

whether an allocated UL resource cannot guarantee a signaling radio bearer (SRB) bit rate;

whether there is a timeout following no response to single/multiple resource requests sent over an uplink dedicated physical channel;

whether there is a timeout following no response to single or multiple resource requests sent over a random access channel (RACH) in an active state;

whether quality of DL data shared physical channel, such as SIR, EbNo or CRC/BLER, is below a certain threshold over a specified time period;

whether an ACK/NACK ratio generated at the WTRU for DL data packets is below a specified threshold;

whether an ACK/NACK ratio provided as feedback from the base station for UL data packets is below a specified threshold; and

a combination of whether an ACK/NACK ratio generated at the WTRU for DL data packets is below a specified threshold and of whether an ACK/NACK ratio provided as feedback from the base station for UL data packets is below a specified threshold.

35. An evolved Node-B (eNodeB) configured for wireless communication in a long term evolution (LTE) wireless communication system, the eNodeB comprising:

a processing component selectively configurable based on radio link (RL) failure detection configuration data received from a base station to conduct uplink (UL) RL failure detection such that when the processing component receives RL failure detection configuration data from a wireless transmit/receive unit (WTRU), the processing component monitors criteria specified by the received RL failure detection configuration data to detect UL RL failure; and

the processing component being further configured to generate a UL RL failure indication when a UL RL failure is detected.

36. The eNodeB of embodiment 35 wherein the eNodeB is configured with a hierarchy of processing layers including a physical (PHY) layer, a medium access control (MAC) layer and higher layers, wherein the processing component is a MAC layer component.

37. The eNodeB as in any one of embodiments 35 and 36 wherein the eNodeB is configured to transmit a UL RL failure indication to the WTRU when a UL RL failure indication is generated.

38. The eNodeB as in any one of embodiments 35-37 wherein the eNodeB is configured to perform UL RL recovery actions when a UL RL failure indication is generated.

39. The eNodeB as in any one of embodiments 35-38 wherein the processing component is configured to monitor a selected combination of criteria based on received configuration data where the criteria include one or more of the following:

whether a channel quality indicator (CQI) measured from a UL reference channel is below a specified threshold within a certain period; and

whether a CQI from feedback from the WTRU and measured on downlink (DL) reference channels transmitted from the eNodeB is below a specified threshold within a certain period.

[0068] The present invention may be implemented in any type of wireless communication system, as desired. By way of example, the present invention may be implemented in any type of LTE, OFDM-MIMO or any other type of wireless communication system. The present invention may also be implemented in software, DSP, or on an integrated circuit, such as an application specific integrated circuit (ASIC), multiple integrated circuits, logical programmable gate array (LPGA), multiple LPGAs, discrete components, or a combination of integrated circuit(s), LPGA(s), and discrete component(s).

[0069] Although the features and elements of the present invention are described in the preferred embodiments in particular combinations, each feature or element can be used alone without the other features and elements of the preferred embodiments or in various combinations with or without other features and elements of the present invention. The methods or flow charts provided in the present invention may be implemented in a computer program, software, or firmware tangibly embodied in a computer-readable storage medium for execution by a general purpose computer or a processor. Examples of computer-readable storage mediums include a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs).

[0070] Suitable processors include, by way of example, a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), and/or a state machine.

[0071] A processor in association with software may be used to implement a radio frequency transceiver for use in a wireless transmit receive unit (WTRU), user equipment (UE), terminal, base station, radio network controller (RNC), or any host computer. The WTRU may be used in conjunction with modules,

implemented in hardware and/or software, such as a camera, a video camera module, a videophone, a speakerphone, a vibration device, a speaker, a microphone, a television transceiver, a hands free headset, a keyboard, a Bluetooth® module, a frequency modulated (FM) radio unit, a liquid crystal display (LCD) display unit, an organic light-emitting diode (OLED) display unit, a digital music player, a media player, a video game player module, an Internet browser, and/or any wireless local area network (WLAN) module.

* * *

CLAIMS

What is claimed is:

1. A method of detecting radio link (RL) failure in a long term evolution (LTE) wireless communication system including at least one wireless transmit/receive unit (WTRU) and at least one evolved Node-B (eNodeB), the method comprising:

detecting whether an RL has an in-synchronization status or an out-of-synchronization status; and

declaring an RL failure if an out-of-synchronization status is detected.

2. The method of claim 1 wherein the RL failure is declared if a channel quality indicator (CQI) measured from a downlink (DL) reference channel is reported to the eNodeB and the CQI is below a threshold within a certain period.

3. The method of claim 1 wherein the RL failure is declared if a channel quality indicator (CQI) measured on uplink (UL) reference channels transmitted by the WTRU is below a threshold within a certain period.

4. The method of claim 1 wherein the RL failure is declared if the quality of a downlink (DL) data shared physical channel is below a certain threshold over a specified time period.

5. The method of claim 1 wherein the RL failure is declared if a positive acknowledgement (ACK)/negative acknowledgement (NACK) ratio below a specified ratio is generated at the WTRU.

6. The method of claim 1 further comprising:

the eNodeB selecting a subset of quantities and appropriate thresholds, timers, counters and parameters to be used for RL status detection; and

the eNodeB signaling the selected subset to the WTRU.

7. A method of detecting radio link (RL) failure in a long term evolution (LTE) wireless communication system including at least one wireless transmit/receive unit (WTRU) and at least one evolved Node-B (eNodeB), the method comprising:

measuring channel quality of a downlink thin channel if there is a pre-allocated downlink thin channel maintained for a signaling radio bearer (SRB) to estimate the quality for downlink SRB transmission;

configuring quantities and parameters for performing a downlink RL failure; and

the WTRU signaling a downlink RL failure status to the eNodeB if a downlink RL failure is detected.

8. The method of claim 7 wherein the downlink thin channel is a non-contention-based channel that is periodically and/or temporarily allocated to a particular WTRU.

9. The method of claim 7 further comprising:

the WTRU taking necessary actions to initiate downlink RL recovery; and

the WTRU resetting timers and counters for performing a new RL failure detection.

10. The method of claim 7 wherein the RL failure is declared if a channel quality indicator (CQI) measured from a downlink (DL) reference channel is reported to the eNodeB and the CQI is below a threshold within a certain period.

11. The method of claim 7 wherein the RL failure is declared if a channel quality indicator (CQI) measured on uplink (UL) reference channels transmitted by the WTRU is below a threshold within a certain period.

12. The method of claim 7 wherein the RL failure is declared if the quality of a downlink (DL) data shared physical channel is below a certain threshold over a specified time period.

13. The method of claim 7 wherein the RL failure is declared if a positive acknowledgement (ACK)/negative acknowledgement (NACK) ratio below a specified ratio is generated at the WTRU.

14. A method of detecting radio link (RL) failure in a long term evolution (LTE) wireless communication system including at least one wireless transmit/receive unit (WTRU) and at least one evolved Node-B (eNodeB), the method comprising:

measuring channel quality of an uplink thin channel if there is a pre-allocated uplink thin channel maintained for a signaling radio bearer (SRB) to estimate the quality for uplink SRB transmission;

configuring quantities and parameters for performing a uplink RL failure; and

the eNodeB signaling an uplink RL failure status to the WTRU if an uplink RL failure is detected.

15. The method of claim 14 wherein the uplink thin channel is a non-contention-based channel that is periodically and/or temporarily allocated to a particular WTRU.

16. The method of claim 14 further comprising:

the eNodeB taking necessary actions to initiate uplink RL recovery; and

the eNodeB resetting timers and counters for performing a new RL failure detection.

17. The method of claim 14 wherein the RL failure is declared if a channel quality indicator (CQI) measured from an uplink (UL) reference channel is reported to the eNodeB and the CQI is below a threshold within a certain period.

18. The method of claim 14 wherein the RL failure is declared if a channel quality indicator (CQI) measured on downlink (DL) reference channels transmitted by the eNodeB is below a threshold within a certain period.

19. The method of claim 14 wherein the RL failure is declared if the quality of an uplink (UL) data shared physical channel is below a certain threshold over a specified time period.

20. The method of claim 14 wherein the RL failure is declared if a positive acknowledgement (ACK)/negative acknowledgement (NACK) ratio below a specified ratio is generated at the eNodeB.

21. The method of claim 14 wherein the RL failure is declared if a predefined periodic or polled UL timing synchronization signal is not received for a specified period.

22. The method of claim 14 wherein the RL failure is declared if there is no response to scheduling grants for a specified period.

23. A long term evolution (LTE) wireless communication system for detecting a radio link (RL) failure, the system comprising:

at least one wireless transmit/receive unit (WTRU); and

at least one evolved Node-B (eNodeB) wherein an RL failure is declared if an out-of-synchronization status is detected.

24. The LTE wireless communication system of claim 23 further comprising:

a downlink shared control channel established between the eNodeB and the WTRU;

a downlink shared data channel established between the eNodeB and the WTRU;

at least one downlink reference channel established between the eNodeB and the WTRU; and

a downlink thin channel established between the eNodeB and the WTRU.

25. The system of claim 23 wherein the downlink thin channel is a non-contention-based channel that is periodically and/or temporarily allocated to a particular WTRU.

26. The LTE wireless communication system of claim 23 further comprising:

an uplink shared control channel established between the eNodeB and the WTRU;

an uplink shared data channel established between the eNodeB and the WTRU;

at least one uplink reference channel established between the eNodeB and the WTRU; and

an uplink thin channel established between the eNodeB and the WTRU.

27. The system of claim 26 wherein the uplink thin channel is a non-contention-based channel that is periodically and/or temporarily allocated to a particular WTRU.

28. A wireless transmit/receive unit (WTRU) configured for wireless communication in a long term evolution (LTE) wireless communication system, the WTRU comprising:

a processing component selectively configurable based on radio link (RL) failure detection configuration data received from a base station to conduct downlink (DL) RL failure detection such that when the processing component receives RL failure detection configuration data from a base station, the processing component monitors criteria specified by the received RL failure detection configuration data to detect DL RL failure; and

the processing component being further configured to generate a DL RL failure indication when a DL RL failure is detected.

29. The WTRU of claim 28 wherein the WTRU is configured with a hierarchy of processing layers including a physical (PHY) layer, a medium access control (MAC) layer and higher layers, wherein the processing component is a MAC layer component.

30. The WTRU of claim 28 wherein the WTRU is configured to transmit a DL RL failure indication to the base station when a DL RL failure indication is generated.

31. The WTRU of claim 28 wherein the WTRU is configured to perform DL RL recovery actions when a DL RL failure indication is generated.

32. The WTRU of claim 28 wherein the base station is an evolved Node-B (eNodeB).

33. The WTRU of claim 28 wherein the processing component is configured to monitor a selected combination of criteria based on received configuration data where the criteria include one or more of the following:

whether a channel quality indicator (CQI) measured from a DL reference channel, such as a pilot or a broadcast channel, and reported to the base station is below a specified threshold within a certain period;

whether a CQI reported by the WTRU is measured on uplink (UL) reference channels transmitted from the WTRU is below a specified threshold within a certain period or cannot be received on a regular basis;

a combination of CQI for both UL and DL;

whether quality of a DL common shared control physical channel, such as signal to interference ratio (SIR), energy per bit per noise power spectral density (EbNo) or cyclic redundancy check (CRC) to block error rate (BLER) ratio (CRC/BLER), is below a certain threshold over a specified time period;

whether quality of a DL dedicated shared control physical channel, such as SIR, EbNo, or CRC/BLER, is below certain threshold over a specified time period;

whether quality of a DL data shared physical channel, such as SIR, EbNo, or CRC/BLER, is below certain threshold over a specified time period;

whether a positive acknowledgement to negative acknowledgement (ACK/NACK) ratio generated at the WTRU and fed back in UL for the DL data packets is below a specified threshold;

whether an ACK/NACK ratio fed back from the base station for UL data packets is below a specified threshold;

a combination of whether a ACK/NACK ratio generated at the WTRU and fed back in UL for the DL data packets is below a specified threshold and of whether an ACK/NACK ratio fed back from the base station for UL data packets is below a specified threshold;

whether an allocated UL resource cannot guarantee a signaling radio bearer (SRB) bit rate;

whether there is a timeout following no response to single/multiple resource requests sent over an uplink dedicated physical channel;

whether there is a timeout following no response to single or multiple resource requests sent over a random access channel (RACH) in an active state;

whether quality of DL data shared physical channel, such as SIR, EbNo or CRC/BLER, is below a certain threshold over a specified time period;

whether an ACK/NACK ratio generated at the WTRU for DL data packets is below a specified threshold;

whether an ACK/NACK ratio provided as feedback from the base station for UL data packets is below a specified threshold; and

a combination of whether an ACK/NACK ratio generated at the WTRU for DL data packets is below a specified threshold and of whether an ACK/NACK ratio provided as feedback from the base station for UL data packets is below a specified threshold.

34. An evolved Node-B (eNodeB) configured for wireless communication in a long term evolution (LTE) wireless communication system, the eNodeB comprising:

a processing component selectively configurable based on radio link (RL) failure detection configuration data received from a base station to conduct uplink (UL) RL failure detection such that when the processing component receives RL failure detection configuration data from a wireless transmit/receive unit (WTRU), the processing component monitors criteria specified by the received RL failure detection configuration data to detect UL RL failure; and

the processing component being further configured to generate a UL RL failure indication when a UL RL failure is detected.

35. The eNodeB of claim 34 wherein the eNodeB is configured with a hierarchy of processing layers including a physical (PHY) layer, a medium access control (MAC) layer and higher layers, wherein the processing component is a MAC layer component.

36. The eNodeB of claim 34 wherein the eNodeB is configured to transmit a UL RL failure indication to the WTRU when a UL RL failure indication is generated.

37. The eNodeB of claim 34 wherein the eNodeB is configured to perform UL RL recovery actions when a UL RL failure indication is generated.

38. The eNodeB of claim 34 wherein the processing component is configured to monitor a selected combination of criteria based on received configuration data where the criteria include one or more of the following:

whether a channel quality indicator (CQI) measured from a UL reference channel is below a specified threshold within a certain period; and

whether a CQI from feedback from the WTRU and measured on downlink (DL) reference channels transmitted from the eNodeB is below a specified threshold within a certain period.

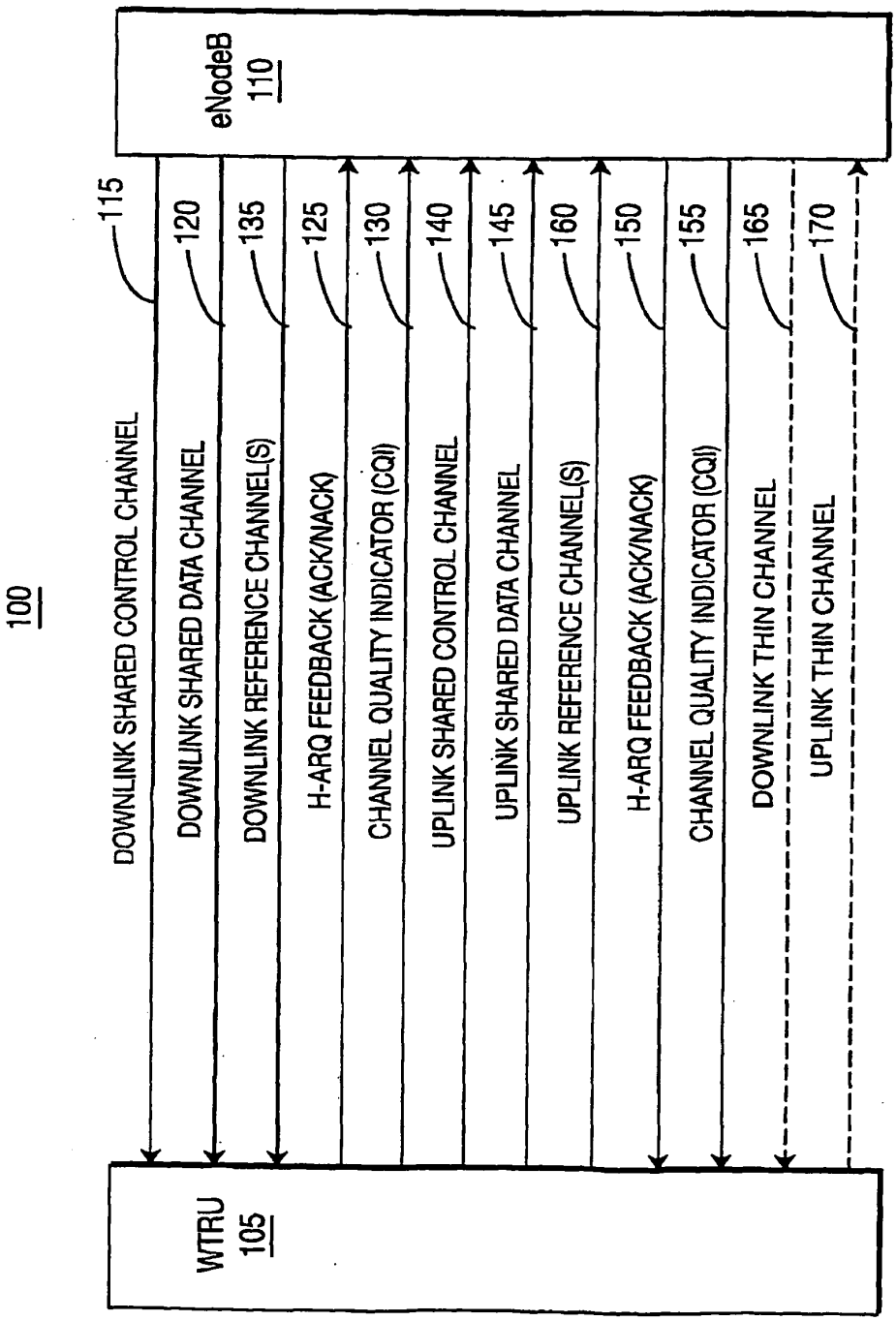

100
eNodeB
110
WTRU
105
DOWNLINK SHARED CONTROL CHANNEL
115
DOWNLINK SHARED DATA CHANNEL
120
DOWNLINK REFERENCE CHANNEL(S)
135
H-ARQ FEEDBACK (ACK/NACK)
125
CHANNEL QUALITY INDICATOR (CQI)
130
UPLINK SHARED CONTROL CHANNEL
140
UPLINK SHARED DATA CHANNEL
145
UPLINK REFERENCE CHANNEL(S)
160
H-ARQ FEEDBACK (ACK/NACK)
150
CHANNEL QUALITY INDICATOR (CQI)
155
DOWNLINK THIN CHANNEL
165
UPLINK THIN CHANNEL
170

FIG. 1

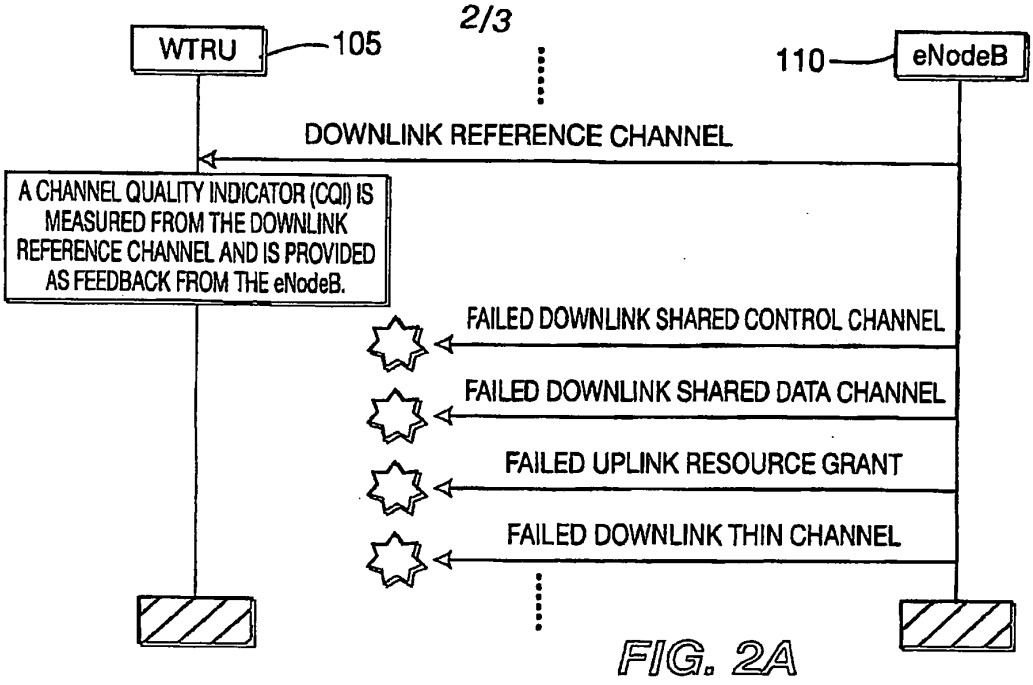

WTRU
105
110
eNodeB
DOWNLINK REFERENCE CHANNEL
A CHANNEL QUALITY INDICATOR (CQI) IS MEASURED FROM THE DOWNLINK REFERENCE CHANNEL AND IS PROVIDED AS FEEDBACK FROM THE eNodeB.
FAILED DOWNLINK SHARED CONTROL CHANNEL
FAILED DOWNLINK SHARED DATA CHANNEL
FAILED UPLINK RESOURCE GRANT
FAILED DOWNLINK THIN CHANNEL

FIG. 2A

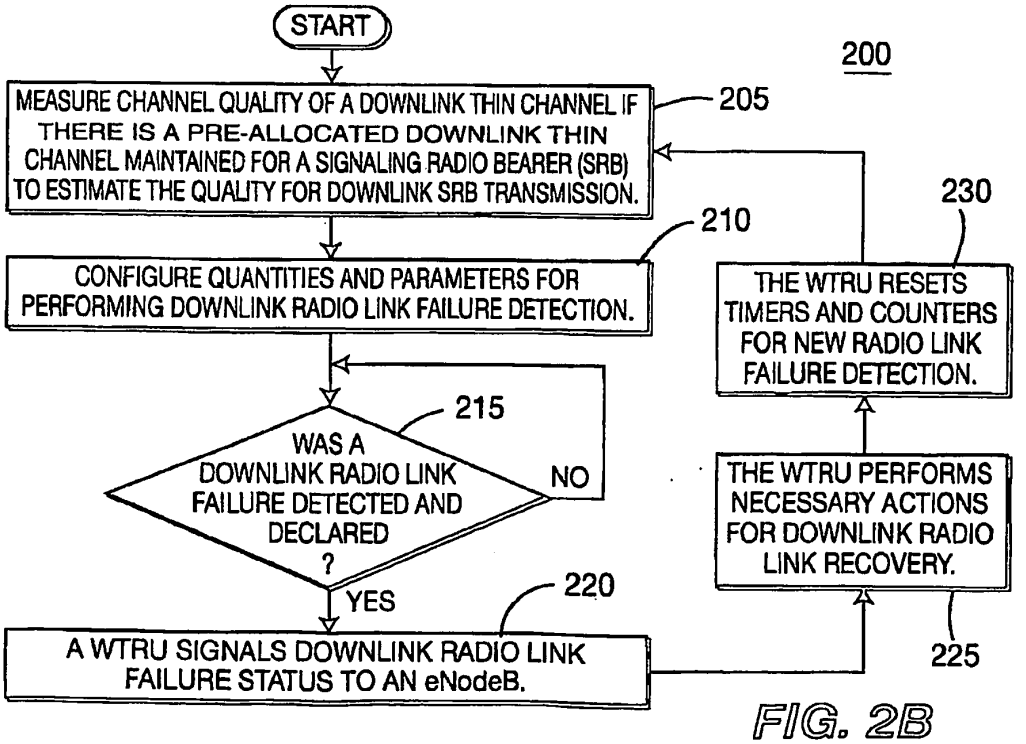

START
200
MEASURE CHANNEL QUALITY OF A DOWNLINK THIN CHANNEL IF THERE IS A PRE-ALLOCATED DOWNLINK THIN CHANNEL MAINTAINED FOR A SIGNALING RADIO BEARER (SRB) TO ESTIMATE THE QUALITY FOR DOWNLINK SRB TRANSMISSION.
205
CONFIGURE QUANTITIES AND PARAMETERS FOR PERFORMING DOWNLINK RADIO LINK FAILURE DETECTION.
210
WAS A DOWNLINK RADIO LINK FAILURE DETECTED AND DECLARED ?
215
NO
YES
A WTRU SIGNALS DOWNLINK RADIO LINK FAILURE STATUS TO AN eNodeB.
220
THE WTRU PERFORMS NECESSARY ACTIONS FOR DOWNLINK RADIO LINK RECOVERY.
225
THE WTRU RESETS TIMERS AND COUNTERS FOR NEW RADIO LINK FAILURE DETECTION.
230

FIG. 2B

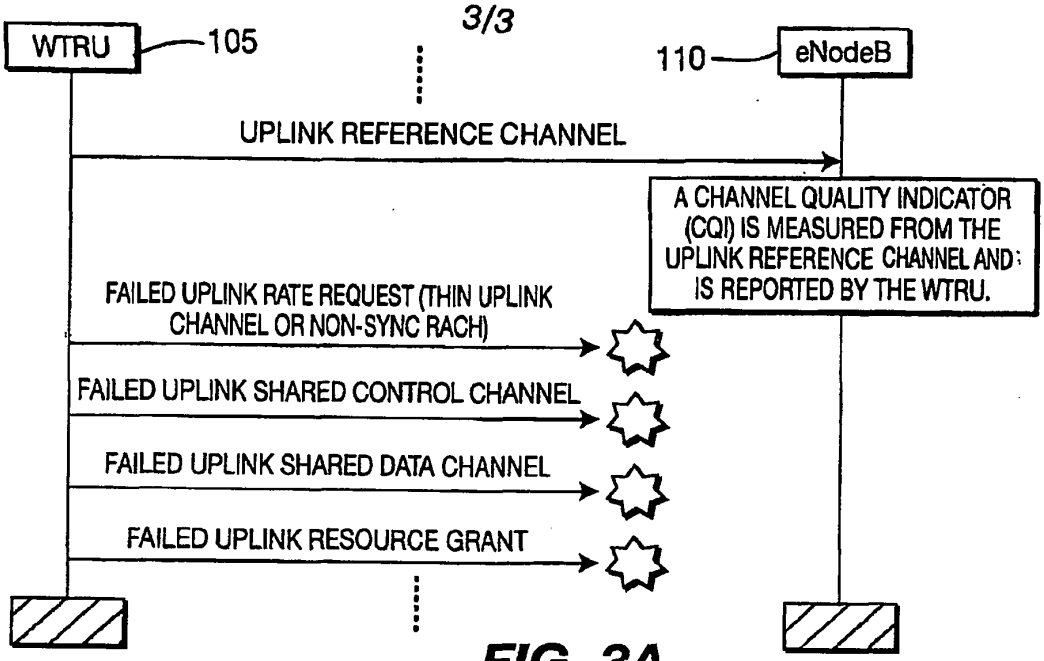

WTRU
105
110
eNodeB
UPLINK REFERENCE CHANNEL
A CHANNEL QUALITY INDICATOR (CQI) IS MEASURED FROM THE UPLINK REFERENCE CHANNEL AND IS REPORTED BY THE WTRU.
FAILED UPLINK RATE REQUEST (THIN UPLINK CHANNEL OR NON-SYNC RACH)
FAILED UPLINK SHARED CONTROL CHANNEL
FAILED UPLINK SHARED DATA CHANNEL
FAILED UPLINK RESOURCE GRANT

FIG. 3A

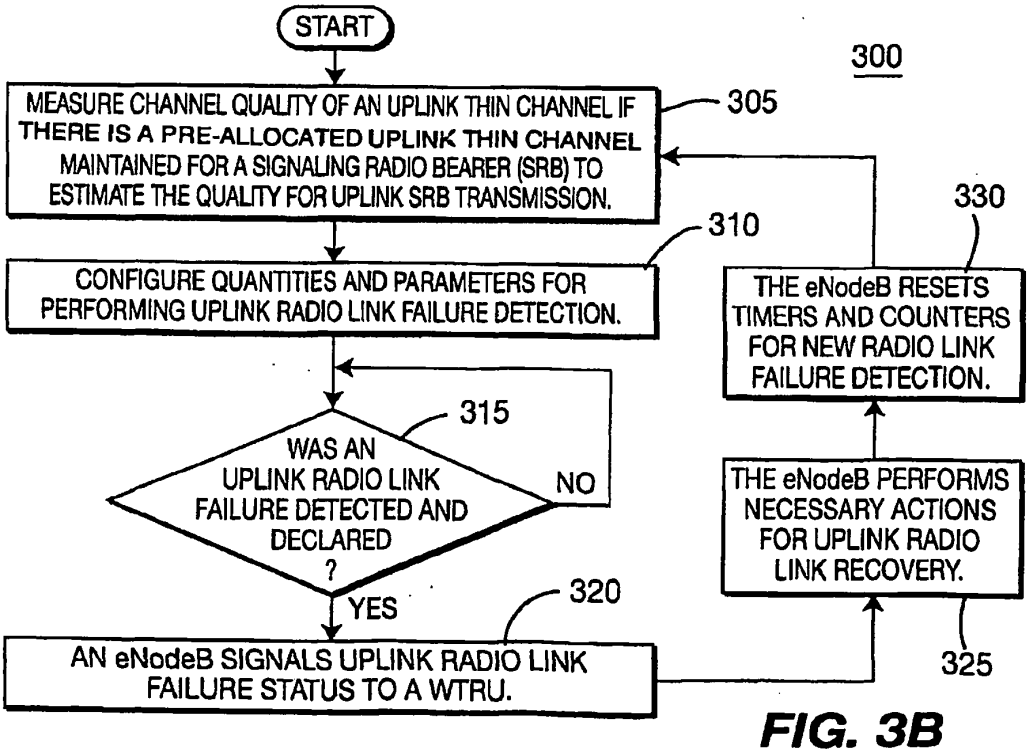

START
300
MEASURE CHANNEL QUALITY OF AN UPLINK THIN CHANNEL IF THERE IS A PRE-ALLOCATED UPLINK THIN CHANNEL MAINTAINED FOR A SIGNALING RADIO BEARER (SRB) TO ESTIMATE THE QUALITY FOR UPLINK SRB TRANSMISSION.
305
CONFIGURE QUANTITIES AND PARAMETERS FOR PERFORMING UPLINK RADIO LINK FAILURE DETECTION.
310
WAS AN UPLINK RADIO LINK FAILURE DETECTED AND DECLARED ?
315
NO
YES
AN eNodeB SIGNALS UPLINK RADIO LINK FAILURE STATUS TO A WTRU.
320
THE eNodeB PERFORMS NECESSARY ACTIONS FOR UPLINK RADIO LINK RECOVERY.
325
THE eNodeB RESETS TIMERS AND COUNTERS FOR NEW RADIO LINK FAILURE DETECTION.
330

FIG. 3B

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(26) Publication Language: English

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60/798,119 5 May 2006 (05.05.2006) US

(71) Applicant *(for all designated States except US)*: **INTERDIGITAL TECHNOLOGY CORPORATION** [US/US]; 3411 Silverside Road, Concord Plaza, Suite 105, Hagley Building, Wilmington, DE 19810 (US).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **WANG, Jin** [CN/US]; Apt. 26, Coventry Lane, Central Islip, NY 11722 (US). **TERRY, Stephen, E.** [US/US]; 15 Summit Avenue, Northport, NY 11768 (US). **CHANDRA, Arty** [IN/US]; 31 Jeffrey Place, Manhasset Hills, NY 11040 (US). **CHEN, John, S.** [US/US]; 102 Bassatt Drive, Downingtown, PA 19335 (US).

(74) Agent: **WOLINSKY, Scott**; United Plaza, Suite 1600, 30 S. 17th Street, Philadelphia, PA 19103 (US).

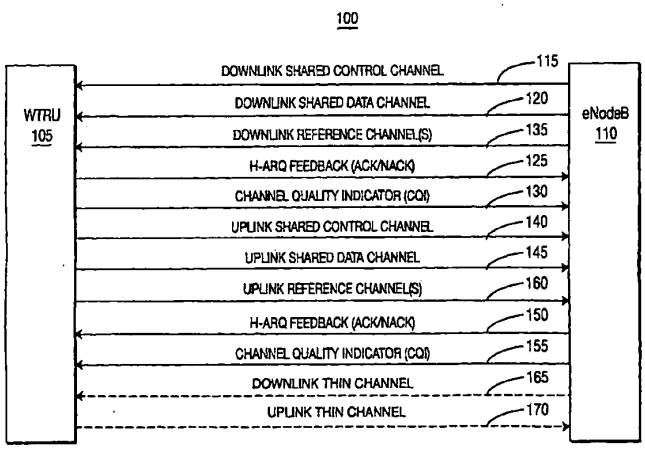
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

(88) Date of publication of the international search report:
29 May 2008

(54) Title: RADIO LINK FAILURE DETECTION PROCEDURES IN LONG TERM EVOLUTION UPLINK AND DOWNLINK AND APPARATUS THEREFOR



(57) Abstract: A method and apparatus for detecting a radio link (RL) failure for uplink (UL) and downlink (DL) in a long term evolution (LTE) wireless communication system including at least one wireless transmit/receive unit (WTRU) and at least one evolved Node-B (eNodeB) are disclosed. A determination is made as to whether an RL has an in-synchronization status or an out-of-synchronization status. An RL failure is declared if an out-of-synchronization status is detected.

WO 2007/130324 A3

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/010394

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L12/28 H04L12/56

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	A. BRANDT: "Answer to liaison statement on out-of-synch and DTX" TSG-RAN WORKING GROUP 1 MEETING NO.11, 28 January 2000 (2000-01-28), pages 1-3, XP002457129 Gothenburg the whole document	1,23
A	EP 1 408 658 A (ASUSTEK COMP INC [TW]) 14 April 2004 (2004-04-14) paragraph [0004] - paragraph [0006] paragraph [0011]	1,23

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 February 2008	04/03/2008

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Larcinese, Annamaria

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/010394

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 2006/086359 A (INTERDIGITAL TECH CORP [US]; TERRY STEPHEN E [US]) 17 August 2006 (2006-08-17) paragraph [0013] - paragraph [0014] paragraph [0035] - paragraph [0039] paragraph [0048] - paragraph [0057]	7,14,28
X	WO 93/16562 A (ERICSSON TELEFON AB L M [SE]) 19 August 1993 (1993-08-19) page 5, line 30 - page 6, line 2 page 7, line 18 - page 8, line 2	34
A		7,14,28
E	EP 1 881 657 A (SAMSUNG ELECTRONICS CO LTD [KR]) 23 January 2008 (2008-01-23) the whole document	1-38

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2007/010394

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of Item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers allsearchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search reportcovers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-6,23-27

A method of detecting radio link failure comprising detecting whether an RL has an in synchronisation status or an out-of-synchronisation status and declaring an RL failure if an out-of-synch status is detected and related system.

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2. claims: 7-22,28-38

Method of detecting a downlink radio link failure comprising measuring channel quality of a downlink thin channel, configuring parameters and quantities and signalling a downlink RL failure and related transmit/receive unit.

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3. claims: 34-38

A node-B configured to detect uplink radio link failure detection.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2007/010394

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		US 5487071 A	23-01-1996
EP 1881657 A	23-01-2008	US 2008019279 A1	24-01-2008

Form PCT/ISA/210 (patent family annex) (April 2005)

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(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
19 February 2009 (19.02.2009)

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(22) International Filing Date: 14 August 2008 (14.08.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

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10-2008-0009193	29 January 2008 (29.01.2008)	KR

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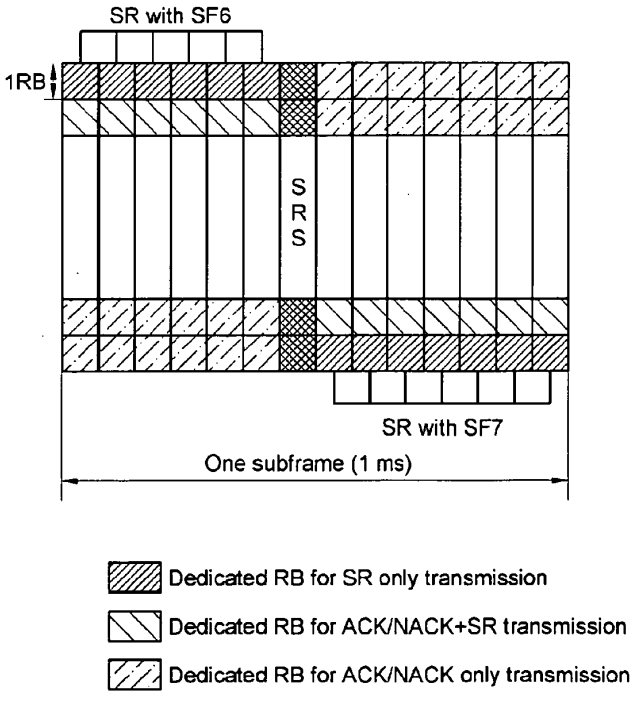
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[Continued on next page]

(54) Title: METHOD OF TRANSMITTING SCHEDULING REQUEST SIGNAL

[Fig. 24]



(57) Abstract: A method of transmitting a scheduling request signal, wherein the scheduling request signal is used to request a radio resource for uplink transmission in a wireless communication system is provided. The method includes configuring a physical uplink control channel (PUCCH) for transmission of a scheduling request signal in a subframe, the subframe comprising two consecutive slots, a slot comprising a plurality of single carrier-frequency division multiple access (SC-FDMA) symbols, the scheduling request signal being carried by a presence or absence of transmission of the PUCCH, wherein at least one SC-FDMA symbol is assigned for transmission of a sounding reference signal, and transmitting the scheduling request signal and the sounding reference signal in the subframe. Scheduling request signal can be transmitted without interference with other control signals such as sounding reference signal that are transmitted on the same control channel with the scheduling request signal.

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Description

METHOD OF TRANSMITTING SCHEDULING REQUEST SIGNAL

Technical Field

[1] The present invention relates to a wireless communication, and more specifically, to a method of transmitting a scheduling request signal for requesting uplink radio resource allocation.

Background Art

[2] One of the systems being considered after the third generation is an Orthogonal Frequency Division Multiplexing (OFDM) system that can diminish inter-symbol interference effect owing to low complexity. OFDM converts serial input data into N parallel data and transmits the parallel data on N orthogonal subcarriers. The subcarriers maintain orthogonality in frequency dimension. Orthogonal Frequency Division Multiple Access (OFDMA) is a multiple access method that realizes multiple access by independently providing each user with some of available subcarriers in a system using OFDM as a modulation scheme.

[3] One of major problems of the OFDM/OFDMA system is that PAPR (Peak-to-Average Power Ratio) can be very high. A problem of PAPR is that peak amplitude of a transmission signal is much higher than average amplitude, which is due to the fact that an OFDM symbol is overlap of N sinusoidal signals on different subcarriers. PAPR is particularly related to capacity of a battery and causes a problem in a user equipment that is sensitive to power consumption. In order to reduce power consumption, the PAPR needs to be lowered.

[4] One of systems proposed to lower PAPR is Single Carrier-Frequency Division Multiple Access (SC-FDMA). SC-FDMA is a form that combines Single Carrier-Frequency Division Equalization (SC-FDE) scheme and Frequency Division Multiple Access (FDMA) scheme. SC-FDMA has a characteristic similar to that of OFDMA in that it modulates and demodulates data in time and frequency domains using Discrete Fourier Transform (DFT). However, since PAPR of a transmission signal is low, SC-FDMA is advantageous for saving transmission power. Particularly, in relation to use of battery, SC-FDMA is advantageous to uplink through a user equipment sensitive to transmission power communicates with the base station.

[5] An important point when the user equipment transmits data to the base station is a wide coverage, in which bandwidth of data is not so wide, but power can be concentrated. An SC-FDMA system lowers variance of a signal and thus has a coverage further wider that those of other systems when using the same power amplifier.

[6] In order to implement a variety of transmit or receive techniques for transmitting high-speed packet, transmission of control signals in time, space, and frequency domains is an indispensable element. A channel that transmits control signals is referred to as a control channel. There may be various kinds of uplink control signals, such as a scheduling request signal transmitted by a user equipment to the base station to allocate uplink radio resources, an Acknowledgement (ACK)/Negative-Acknowledgement (NAK) that is a response to uplink data transmission, Channel Quality Indicator (CQI) for indicating channel quality of downlink, Precoding Matrix Index (PMI), Rank Indicator (RI), and the like.

[7] The scheduling request signal is carried by a presence or asence of transmission(or on/off keying) of a control channel, which is used for a user equipment to request a base station to perform scheduling for the user equipment. So when the user equipment needs to transmit uplink data to the base station, the scheduling request signal should be preliminarily transmitted. In most cases where the transmission interval of the scheduling request signal is not overlapped with those of an ACK/NACK signal and CQI, the scheduling request signal is independently transmitted using a dedicated resource. Accordingly, an occasion where a user should simultaneously transmit the scheduling request signal and ACK/NACK signal does not frequently occur. However, particularly, in the case where downlink data is frequently transmitted and no uplink data is transmitted, if uplink data transmission is urgently needed, probability of occurring such an occasion is further higher. This will invite a problem in transmission of an uplink control channel and give a negative affect to downlink and uplink throughputs. In such a situation, there are largely two methods for requesting scheduling.

[8] First, there is a method of requesting uplink scheduling in a contention-free scheme using a scheduling request signal channel. Such a method is referred to as a multi-code transmission method or a multi-sequence transmission method. That is, it refers to a method of simultaneously transmitting a plurality of independent signals using one or more sequences by a user. However, although scheduling request signals are simultaneously transmitted using a separated scheduling request signal channel, if a plurality of ACK/NACK signals is transmitted to uplink, characteristics of an uplink single carrier are damaged, and thus PAPR is increased as a result.

[9] Second, there is a method of requesting scheduling by performing Time Division Multiplexing (TDM) or joint coding on an ACK/NACK signal and a scheduling request signal in the unit of a symbol or slot. However, when two or more signals having different error requirements are simultaneously coded and transmitted, all signals ultimately should follow a power setting value of a signal that has the strictest requirement, and thus there may be a problem of wasting power. Although such a

power wasting problem can be solved in a variety of methods, a plurality of signals should be transmitted in one subframe, and thus it is certain that power consumption increases compared with a case where one signal is transmitted in one subframe.

[10] Accordingly, it is required to transmit a scheduling request signal efficiently using an ACK/NACK channel and CQI channel, which are existing control channels. In order to operate the scheduling request signal on an existing control channel, compatibility of the control channel with other control signals should be considered. In addition, capacity of a user equipment capable of transmitting a scheduling request signal should be also considered.

[11] Accordingly, an efficient control channel structure is needed to transmit a scheduling request signal.

Disclosure of Invention

Technical Problem

[12] The present invention provides a method of transmitting scheduling request signal, wherein the scheduling request signal is transmitted on the same uplink control channel as other control signals without interference.

Technical Solution

[13] According to an embodiment of the present invention, a method of transmitting a scheduling request signal, wherein the scheduling request signal is used to request a radio resource for uplink transmission in a wireless communication system is provided. The method includes configuring a physical uplink control channel (PUCCH) for transmission of a scheduling request signal in a subframe, the subframe comprising two consecutive slots, a slot comprising a plurality of single carrier-frequency division multiple access (SC-FDMA) symbols, the scheduling request signal being carried by a presence or absence of transmission of the PUCCH, wherein at least one SC-FDMA symbol is assigned for transmission of a sounding reference signal, and transmitting the scheduling request signal and the sounding reference signal in the subframe.

[14] According to another embodiment of the present invention a method of transmitting a scheduling request signal, the method includes generating a physical uplink control channel (PUCCH) carrying a scheduling request signal in form of presence or absence in a subframe, the subframe comprising a first slot and a second slot, a slot comprising a plurality of SC-FDMA symbols, the scheduling request signal spreaded by a first orthogonal covering sequence in the first slot and a second orthogonal covering sequence in the second slot, wherein the length of the first orthogonal covering sequence is shorter than that of the second orthogonal covering sequence, and transmitting the scheduling request signal on the PUCCH and a sounding reference signal using a SC-FDMA symbol of the first slot.

[15]

Advantageous Effects

[16] Scheduling request signal can be transmitted without interference with other control signals such as sounding reference signal that are transmitted on the same control channel with the scheduling request signal.

Brief Description of the Drawings

[17] FIG. 1 is a block diagram showing a wireless communication system.

[18] FIG. 2 shows an exemplary structure of a radio frame.

[19] FIG. 3 shows an example of a subframe.

[20] FIG. 4 shows an exemplary structure of a control channel applied with two-dimensional spreading.

[21] FIG. 5 shows the structure of an ACK/NACK channel.

[22] FIG. 6 shows the structure of a CQI channel.

[23] FIG. 7 shows an example of a method of allocating a sequence to CQI.

[24] FIG. 8 shows a method of transmitting a scheduling request signal based on a selection rule on an ACK/NACK channel according to an embodiment of the present invention.

[25] FIG. 9 shows a method of transmitting a scheduling request signal based on a selection rule on an ACK/NACK channel according to another embodiment of the present invention.

[26] FIG. 10 shows a method of transmitting a scheduling request signal based on a priority on an ACK/NACK channel according to another embodiment of the present invention.

[27] FIG. 11 shows a method of transmitting a scheduling request signal together with an ACK/NACK signal according to still another embodiment of the present invention.

[28] FIG. 12 shows a method of transmitting a scheduling request signal together with an ACK/NACK signal according to still another embodiment of the present invention.

[29] FIG. 13 shows an example of occurrence of transmission contention between CQI and scheduling request signal in a CQI channel.

[30] FIG. 14 shows a method of transmitting a scheduling request signal on a CQI channel according to an embodiment of the present invention.

[31] FIG. 15 shows a method of transmitting a scheduling request signal on a CQI channel according to another embodiment of the present invention.

[32] FIG. 16 shows a method of transmitting a scheduling request signal based on a selection rule on a CQI channel according to an embodiment of the present invention.

[33] FIG. 17 shows a method of transmitting a scheduling request signal based on a selection rule on a CQI channel according to another embodiment of the present

invention.

[34] FIG. 18 shows an example of transmitting only a scheduling request signal on a control channel.

[35] FIG. 19 shows a method of transmitting a scheduling request signal on the same physical channel structure with ACK/NACK channel according to an embodiment of the present invention.

[36] FIG. 20 shows a method of transmitting a scheduling request signal on the same physical channel structure with ACK/NACK channel according to another embodiment of the present invention.

[37] FIG. 21 shows a method of transmitting a scheduling request signal on the same physical channel structure with ACK/NACK channel according to still another embodiment of the present invention.

[38] FIG. 22 shows a method of transmitting a scheduling request signal in one subframe according to an embodiment of the present invention.

[39] FIG. 23 shows orthogonal code indexes that can be allocated in a resource block for a scheduling request signal according to an embodiment of the present invention.

[40] FIG. 24 shows resource blocks for a scheduling request signal according to an embodiment of the present invention.

[41] FIG. 25 shows orthogonal code indexes that can be allocated in a resource block for a scheduling request signal according to another embodiment of the present invention.

[42] FIG. 26 shows a method of transmitting a scheduling request signal in one subframe according to another embodiment of the present invention.

[43] FIG. 27 shows a method of transmitting a scheduling request signal in one subframe according to still another embodiment of the present invention.

Mode for the Invention

[44] Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings so that this disclosure can be thorough and complete, and will fully convey the concept of the invention to those skilled in the art.

[45] FIG. 1 shows a wireless communication system. The wireless communication system can be widely deployed to provide a variety of communication services, such as voices, packet data, etc.

[46] Referring to FIG. 1, the wireless communication system includes a base station (BS) 20 and at least one user equipment (UE) 10. The BS 20 is generally a fixed station that communicates with the UE 10 and may be referred to as another terminology, such as a node-B, a base transceiver system (BTS), an access point, etc. There are one or more cells within the coverage of the BS 20. The UE 10 may be fixed or mobile, and may be

referred to as another terminology, such as a mobile station (MS), a user terminal (UT), a subscriber station (SS), a wireless device, etc.

[47] A downlink represents a communication link from the BS 20 to the UE 10, and an uplink represents a communication link from the UE 10 to the BS 20. In the downlink, a transmitter may be a part of the BS 20, and a receiver may be a part of the UE 10. In the uplink, the transmitter may be a part of the UE 10, and the receiver may be a part of the BS 20.

[48] Downlink and uplink transmissions can be made using different multiple access schemes. For example, orthogonal frequency division multiple access (OFDMA) may be used for downlink transmission, and single carrier-frequency division multiple access (SC-FDMA) may be used for uplink transmission.

[49] There is no restriction on the multiple access scheme used in the wireless communication system. The multiple access scheme may be based on code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), single-carrier FDMA (SC-FDMA), orthogonal frequency division multiple access (OFDMA), or other well-known modulation schemes. In these modulation schemes, signals received from multiple users are demodulated to increase capacity of the communication system.

[50] FIG. 2 shows an exemplary structure of a radio frame.

[51] Referring to FIG. 2, the radio frame includes 10 subframes. One subframe includes two slots. The subframe is a basic unit of data transmission. Downlink or uplink scheduling is performed in a subframe unit. One slot may include a plurality of OFDM symbols in a time domain and at least one subcarrier in a frequency domain. One slot may include 7 or 6 OFDM symbols.

[52] The radio frame structure is shown for exemplary purposes only. Thus, the number of subframes included in the radio frame, the number of slots included in the subframe, and the number of OFDM symbols and subcarriers included in the slot can change variously.

[53] FIG. 3 shows an example of a subframe. This may be an uplink subframe.

[54] Referring to FIG. 3, a subframe can be divided into a control channel and a data region. The control channel is a region for transmitting only control signals, which is generally allocated to a control channel. The data region is a region for transmitting data, which is generally allocated to a data channel. The control channel may be referred to as physical uplink control channel (PUCCH), and the data channel may be referred to as physical uplink shared channel (PUSCH). The control channel and the data channel can be configured as a subframe. The control signal is a signal that is not user data, and there may be various kinds of control signals such as an ACK (Acknowledgement)/NACK (Negative-Acknowledgement) signal, CQI (Channel

Quality Indicator), PMI (Precoding Matrix Index), RI (Rank Indicator), scheduling request signal, and the like.

[55] Although only control signals are loaded on the control region, user data can be loaded on the data region together with control signals. That is, when a user equipment transmits only control signals, the user equipment is allocated with a control channel and transmits the control signals, and when the user equipment transmits data together with control signals, the user equipment may be allocated with a data region and transmit the data and control signals. Exceptionally, although the user equipment transmits only control signals, if the amount of the control signals is large or the control signals are inappropriate to be transmitted on a control channel, the user equipment can be allocated with radio resources on the data region and transmit the control signals.

[56] Since the control channel and the data region use frequency bands different from each other, they are multiplexed in Frequency Division Multiplexing (FDM). However, this is merely an example, and allocation of the control channel and data region on a subframe is not a restriction.

[57] From the view point of a user equipment, each slot in a subframe can be divided into two portions in the frequency domain. When a first subframe is divided into a first slot and a second slot, the first slot is divided into a first region and a second region in the frequency domain, and the second slot also can be divided into a first region and a second region in the frequency domain. When it is assumed that the first region transmits control signals and the second region transmits user data in the first slot, the first region may transmit user data and the second region may transmit control signals in the second slot. If there are many terminals, although both of the first and second regions may transmit control signals in the first slot, a user does not simultaneously use both of the shared resource regions.

[58] A slot allocated to each user equipment may be frequency hoped on a subframe. That is, the frequency band of one side is allocated for one of two slots in one subframe, and the frequency band of the other side may be allocated to the other slot. Frequency diversity gain can be obtained by transmitting a control channel for a user equipment on slots allocated to frequency bands different from each other.

[59] Two-dimensional spreading of frequency spreading and time-domain covering can be applied to the structure of an uplink control channel. A reference signal can be defines for coherent detection.

[60] To clarify the explanation, hereinafter, one slot is configured with seven OFDM symbols, and one subframe including two slots includes total fourteen OFDM symbols. The number of OFDM symbols included in one subframe or the number of OFDM symbols included in one slot is merely an example, and the technical spirit of the

present invention is not limited to this.

[61] FIG. 4 shows an exemplary structure of a control channel applied with two-dimensional spreading.

[62] Referring to FIG. 4, {s0, s1, ..., s13} represents a sequence of control signals corresponding to respective OFDM symbols, and {x0, x1, .., x13} represents time domain spreading codes corresponding to respective OFDM symbols. A well-known orthogonal code such as a Walsh code can be used as the time domain spreading code for time domain spreading. {c0, c1, ..., c11} is frequency domain spreading codes, and a Zadoff-Chu (ZC) CAZAC (Constant Amplitude Zero Auto-Correlation) sequence can be used.

[63] The ZC CAZAC sequence is a kind of CAZAC sequence, and when N is the length of a CAZAC sequence of a positive integer, and M is a prime number relative to N (M is a natural number less than N, which is a prime number relative to N), the k-th element of the M-th CAZAC sequence can be expressed as shown in Equation 1.

[64] MathFigure 1

[Math.1]

$$c(k;N,M)=\exp\left\{-\frac{j\pi Mk(k+1)}{N}\right\} \quad \textit{where } N \textit{ is an odd vmber}$$

[65]

$$c(k;N,M)=\exp\left\{-\frac{j\pi Mk^{2}}{N}\right\} \quad \textit{where } N \textit{ is an even vmber}$$

[66] This is merely an example, and other sequences having a superior correlation characteristic can be applied. Between different user equipments, ZC CAZAC sequences having different circular shift values are applied to distinguish a channel.

[67] In a frequency domain spreading code, circular shift hopping can be applied to every OFDM symbol. That is, although FIG. 5 shows that the same frequency domain spreading code is applied to every OFDM symbol, the frequency domain spreading code can be circular shifted at every OFDM symbol. This is called as circular shift hopping. When the circular shift hopping is performed, characteristics of a control channel can be prevented from being abruptly deteriorated at a specific circular shift value due to a high correlation.

[68] FIG. 5 shows the structure of an ACK/NACK channel. The ACK/NACK channel is a control channel for transmitting ACK/NACK signals. The ACK/NACK signal a transmit and/or receive confirmation signal for downlink data. When a control signal is transmitted within a previously allocated band, frequency domain spreading and time domain spreading are simultaneously applied in order to increase the number of user equipments or control channels that can be multiplexed.

[69] Referring to FIG. 5, a reference signal (RS) is carried on three OFDM symbols in the middle portion of seven OFDM symbols in one slot, and an ACK/NACK signal is loaded on the other four OFDM symbols in the one slot. The reference signal is loaded on three contiguous OFDM symbols in the middle of the slot. At this time, the number and positions of symbols used for the reference signal can be changed, and the number and positions of symbols used for the ACK/NACK signal related thereto also can be changed depending thereon.

[70] A frequency domain spreading code is used to spread the ACK/NACK signal in the frequency domain. The ZC CAZAC sequence described above can be used as the frequency domain spreading code. Each user equipment can be distinguished by applying ZC CAZAC sequences having circular shift values different from each other. Depending on delay spread of a channel, the number of available circular shifts may be changed.

[71] After IFFT is performed on the ACK/NACK signal which is spread in the frequency domain, the ACK/NACK signal is spread again in the time domain using a time domain spreading code. The ACK/NACK signal is spread using a time domain spreading code of length four w0, w1, w2, w3 for four OFDM symbols. In addition, the ACK/NACK signal can be spread by a spreading code of length three for a reference signal.

[72] Performing time domain spreading after performing frequency domain spreading is merely an example, and the order of performing the time domain spreading and frequency domain spreading is not restricted. The frequency domain spreading can be performed after the time domain spreading, or the time domain spreading and frequency domain spreading can be simultaneously performed using a sequence of one combined form.

[73] FIG. 6 shows the structure of a CQI channel. The CQI channel is a control channel for transmitting CQI. The CQI does not use time domain spreading in order to secure sufficient symbol space.

[74] Referring to FIG. 6, a reference signal is loaded on two OFDM symbols apart from each other by three OFDM symbols among seven symbols included in one slot, and CQI is loaded on the other five OFDM symbols. The proposed values are merely an example, and the number and positions of the OFDM symbols used for the reference signal and the number and positions of the OFDM symbols used for CQI can be changed. Since a CQI value of two bits can be loaded when Quadrature Phase Shift Keying (QPSK) mapping is used for one OFDM symbol, a CQI value of ten bits can be loaded on one slot. A CQI value of maximum twenty bits can be loaded for one subframe. A modulation scheme other than QPSK, such as 16-QAM or the like, can be applied as a modulation scheme used for CQI.

[75] A frequency domain spreading code is used to spread CQI in the frequency domain. A ZC CAZAC sequence can be used as a frequency domain spreading code. Unlike applying two-dimensional spreading in an ACK/NACK channel, a CQI channel applies only one-dimensional spreading, and thus transmission capacity of CQI is increased.

[76] A channel can be allocated as a scheduling request channel by reserving circular shift. This is the same as the example of the ACK/NACK channel except that the number of OFDM symbols for a reference signal is different. Unlike an ACK/NACK channel, there are many cases where less OFDM symbols are allocated to a reference signal in a CQI channel. It is since that a user is identified only by distinguishing a sequence on the frequency axis and thus spreading is not needed on the time axis. Accordingly, minimum one OFDM symbol can function as a reference signal. Although about two OFDM symbols can be allocated as a reference signal if a Doppler effect is high, it is difficult to apply time domain spreading.

[77] However, a time domain spreading code can be defined in order to define a scheduling request channel. When coherent detection is supported, about three OFDM symbols are allocated as a reference signal like the ACK/NACK channel structure, and a control signal portion can be transmitted separately from a reference signal portion. When non-coherent detection is supported, the time domain spreading code can be defined using a long sequence including the entire length of one slot. Even in this case, like the ACK/NACK channel, a set of sequences orthogonal to each other (a set of sequences having a low cross-correlation between each other) such as a circular shift of a ZC CAZAC sequence is defined and used as a time domain spreading code.

[78] FIG. 7 shows an example of a method of allocating a sequence to CQI.

[79] Referring to FIG. 7, UE1 uses a sequence allocated for transmitting CQI at every transmission interval and releases allocation of the sequence when it does not transmit CQI so that other users may use the sequence to transmit CQI. Of course, UE1 may reserve a sequence allocated for CQI transmission in advance and continue to occupy the sequence even when it does not transmit CQI.

[80] Hereinafter, a method of creating a scheduling request channel for transmitting a scheduling request signal will be described.

[81] A scheduling request signal is a signal for requesting, by a user equipment, the base station to allocate uplink radio resources. When the user equipment transmits uplink data to the base station, a scheduling request signal should be transmitted. If the user equipment requests scheduling through the scheduling request signal, the base station allocated radio resources for transmitting uplink data and informs the user equipment of the radio resource allocation. A control channel for transmitting the scheduling request signal is referred to as a scheduling request channel.

[82] As a method for creating a scheduling request channel, there may be a method of allocating a dedicate channel as a scheduling request channel and a method of reserving a channel that transmits other control signals, such as an ACK/NACK channel or CQI channel, as a scheduling request channel. The former is a method of allocating new time-frequency resources for transmitting scheduling request signals. In the latter case, the scheduling request channel is created together with other control channels and is compatible with other control channels. That is, although the scheduling request signal shares the same time-frequency resources with other control signals, the scheduling request signal is distinguished by using a difference sequence.

[83] In the former case, when a plurality ACK/NACK signals is transmitted on uplink as described above, characteristics of the uplink single carrier are deteriorated, and thus PAPR increases as a result. Hereinafter, a method of efficiently transmitting a scheduling request signal in the latter case will be described.

[84] When a scheduling request signal is transmitted using an ACK/NACK or CQI channel, the following three cases can be occurred. A method of transmitting a scheduling request signal in each case is described. Hereinafter, a case where a scheduling request signal and other signals are simultaneously transmitted is referred to as a transmission contention.

[85] First, there may be a case where a scheduling request signal and an ACK/NACK signal should be simultaneously transmitted in an ACK/NACK channel (transmission contention between the scheduling request signal and the ACK/NACK signal). Second, there may be a case where a scheduling request signal and CQI should be simultaneously transmitted in a CQI channel (transmission contention between the scheduling request signal and the CQI). Third, there may be a case where only a scheduling request signal is transmitted without contention between the scheduling request signal and other control signals.

[86] A method of multiplexing a scheduling request signal and other control signal and a method of operating each control channel will be described in each of the cases where the scheduling request signal competes with other control signal for transmission. However, the present invention is not limited to the ACK/NACK or CQI channel, but is widely applied to a structure that configures a control channel to transmit a second control signal (e.g., a scheduling request signal) on a control channel that transmits a first control signal (e.g., an ACK/NACK signal, CQI, or the like).

[87] First, described is a method of transmitting a scheduling request signal on an ACK/NACK channel when transmission contention occurs between an ACK/NACK signal and the scheduling request signal in the ACK/NACK channel.

[88] In an embodiment, a user equipment selects only a signal based on a predetermined selection rule and transmits the selected signal. It is the principle of the selection rule

to preferentially transmit an ACK/NACK signal and then transmit a scheduling request signal after delaying the scheduling request signal for a predetermined time period. Exceptionally, the scheduling request signal is transmitted prior to the ACK/NACK signal although transmission contention occurs only if the number of delays of the scheduling request signal (hereinafter, referred to as a delay count) caused by transmission contention is equal to a critical delay count. In this exceptional case, the user equipment retransmits the ACK/NACK signal.

[89] FIG. 8 shows a method of transmitting a scheduling request signal based on a selection rule on an ACK/NACK channel according to an embodiment of the present invention. An ACK/NACK signal may be periodically transmitted at regular transmission intervals, or non-periodically transmitted without being restricted to a transmission interval. When the ACK/NACK signal is transmitted at regular intervals, each of a first to fourth transmission periods corresponds to a transmission interval. The transmission period may be referred to as a transmission timing.

[90] Referring to FIG. 8, UE1 having a critical delay count of 2 transmits an ACK/NACK signal in the first transmission period. At this time, the delay count is 0. When UE1 transmits a scheduling request signal in the second transmission period, transmission contention with the ACK/NACK signal occurs. Since the delay count is 0, it is smaller than the critical delay count of 2. Accordingly, UE1 delays transmission of the scheduling request signal and transmits the ACK/NACK signal. At this time, the delay count becomes 1.

[91] When UE1 transmits a scheduling request signal again in the third transmission period, transmission contention with the ACK/NACK signal occurs. Since the delay count is 1, it is still smaller than the critical delay count of 2. Accordingly, UE1 delays transmission of the scheduling request signal again and transmits the ACK/NACK signal. At this time, the delay count becomes 2.

[92] When UE1 transmits a scheduling request signal again in the fourth transmission period, transmission contention with the ACK/NACK signal occurs. Since the delay count is 2, it is equal to the critical delay count of 2. Therefore, UE1 delays transmission of the ACK/NACK signal and transmits the scheduling request signal at last. Since UE1 transmits the scheduling request signal, the delay count becomes 0 again.

[93] The critical delay count of the selection rule can be differently determined depending on system status, importance or urgency of the scheduling request signal, or importance of the ACK/NACK signal. This is to distinguish the sequence of the scheduling request signal from the sequences allocated to ACK/NACK signals for other UEs.

[94] Like an ACK/NACK signal, a common sequence is a sequence of a case where a pre-

determined set of sequences is previously reserved and a sequence allocated to an ACK/NACK signal is changed in every subframe depending on the position of a control signal used for downlink data transmission. Although the common sequence is allocated without a collision among ACK/NACK channels, a sequence once allocated may not be consistently allocated to one ACK/NACK channel. That is, changes of a sequence index may occur at any time for each UE.

[95] On the other hand, a dedicated sequence is a sequence of a case where a sequence to be used for each user or scheduling request channel is previously allocated regardless of downlink data transmission. That is, a sequence allocated to a corresponding scheduling request channel is used at a time when a scheduling request signal is transmitted. The sequence does not change frequently unlike an ACK/NACK channel, and a sequence once allocated is exclusively used for a predetermined time period at a predetermined time point. That is, there is no changed in the sequence index.

[96] FIG. 9 shows a method of transmitting a scheduling request signal based on a selection rule on an ACK/NACK channel according to another embodiment of the present invention.

[97] Referring to FIG. 9, unlike the selection rule of FIG. 8, UE1 delays the ACK/NACK signal, not the scheduling request signal, as many times as the critical delay count at every transmission contention and transmits the scheduling request signal. However, if the delay count of the ACK/NACK signal is equal to the critical delay count, the ACK/NACK signal is transmitted.

[98] In another embodiment, the user equipment determines priorities of the scheduling request signal and the ACK/NACK signal, and selects and transmits either of the signals. The subject that determines the priority may be a user equipment or the base station. In the case where a user equipment determines the priority, when the user equipment by itself determines the priorities of the two signals and transmits either of the signals, the user equipment needs to transmit an additional signaling to the base station if the base station should know the information about the basis of the determination. Or, the user equipment does not transmit an additional signaling, and the base station itself may distinguish an ACK/NACK signal from a scheduling request signal in a blind method.

[99] In the case where the base station determines the priorities, the base station should inform the user equipment of the information on the determination of the priorities. Accordingly, transmission of various kinds of additional information is needed. In the method of transmitting any one of signals depending on the priorities when transmission contention occurs, the system can operate in a form that is most appropriate to a downlink service related to an ACK/NACK signal and an uplink service related to a scheduling request signal.

[100] FIG. 10 shows a method of transmitting a scheduling request signal based on a priority on an ACK/NACK channel according to another embodiment of the present invention. An ACK/NACK signal may be periodically transmitted at regular transmission intervals, or non-periodically transmitted without being restricted to a transmission interval. When the ACK/NACK signal is transmitted at regular intervals, each of a first to fourth transmission periods corresponds to a transmission interval. The transmission period may be referred to as a transmission timing.

[101] Referring to FIG. 10, UE1 transmits an ACK/NACK signal in the first transmission period. When UE1 transmits a scheduling request signal in the second transmission period, transmission contention with the ACK/NACK signal occurs. UE1 transmits the scheduling request signal and does not transmit the ACK/NACK signal depending on priorities. When UE1 transmits a scheduling request signal in the third transmission period, transmission contention occurs again with the ACK/NACK signal. UE1 transmits the ACK/NACK signal and does not transmit the scheduling request signal depending on priorities. UE1 transmits an ACK/NACK signal in the fourth transmission period. In this manner, when either of the signals is transmitted depending on priorities, a control channel, which is a limited radio resource, can be reasonably operated.

[102] In yet another embodiment, the user equipment simultaneously transmits a scheduling request signal and an ACK/NACK signal. In this case, all cases can be expressed in a method of modulating a signal with a higher order modulation scheme.

[103] FIG. 11 shows a method of transmitting a scheduling request signal together with an ACK/NACK signal according to still another embodiment of the present invention. FIG. 11 shows an example of a Single Input Multiple Output (SIMO) or a Multiple Input Multiple Output (MIMO) with rank 1, in which an ACK/NACK signal is expressed as 1-bit. The horizontal axis is I channel (In-phase), and the vertical axis is Q channel (Quadrature-phase).

[104] Referring to FIG. 11, when a user equipment transmits an ACK/NACK signal, there may be four signal combinations as shown in Table 1 depending on existence of a scheduling request signal.

[105] Table 1

[Table 1]

[Table]

Combination of signals	ACK/NACK signal	Transmission of scheduling request signal
First combination	ACK	X
Second combination	ACK	O
Third combination	NACK	X
Fourth combination	NACK	O

[106] In the first combination, a user equipment does not request scheduling and transmits only an ACK signal. In the second combination, a user equipment requests scheduling and simultaneously transmits an ACK signal. In the third combination, a user equipment does not request scheduling and transmits only a NACK signal. In the fourth combination, a user equipment requests scheduling and simultaneously transmits a NACK signal.

[107] In the figure, the constellation point marked with symbol + shows a case where only an ACK/NACK signal is transmitted, and the constellation point marked with symbol O shows a case where a scheduling request signal is transmitted together with an ACK/ NACK signal.

[108] If a user equipment transmits either ACK or NACK signal, Binary Phase Shift Keying (BPSK) modulation scheme may be used. Observing the constellation map, the point representing the ACK has a phase difference of 180 degrees from the point representing the NACK, and a signal having a phase of either of the two points is transmitted. That is, a signal having a phase of 45 degrees is transmitted in the first combination, and a signal having a phase of 225 degrees is transmitted in the third combination. Since the phase difference between a signal of the first combination and a signal of the third combination is 180 degrees, it is a BPSK modulation scheme rotated by pi/4.

[109] In order to further include two more cases where existence of a scheduling request signal is expressed in addition to the ACK and the NACK, the constellation map should have two constellation points at positions different from those of the points representing the ACK and the NACK. That is, a signal having a phase of 135 degrees is transmitted in the second combination, and a signal having a phase of 315 degrees is transmitted in the fourth combination. Since the phase difference between a signal of the second combination and a signal of the fourth combination is 180 degrees, it is a BPSK modulation scheme.

[110] Of course, the method described above can be generalized. Existence of a scheduling

request signal can be expressed by rotating the phase of an ACK/NACK signal using BPSK modulation scheme by a predetermined phase. That is, when an ACK signal and a scheduling request signal are simultaneously transmitted, only the phase of the ACK signal to be transmitted is rotated by a predetermined degree, e.g., 90 degrees, clockwise or counterclockwise. Or, when a NACK signal and a scheduling request signal are simultaneously transmitted, only the phase of the NACK signal to be transmitted is rotated by a predetermined degree, e.g., 90 degrees, clockwise or counterclockwise. FIG. 11 is a view showing a signal whose phase is rotated by 90 degrees.

[111] In addition to the method described above, an ACK/NACK signal and a scheduling request signal may be transmitted in different orthogonal spaces. For example, it is possible to transmit an ACK/NACK signal by multiplying a cosine value and a scheduling request signal by multiplying a sine value. In other words, respective signals can be transmitted on I channel and Q channel.

[112] On the other hand, when a scheduling request signal is transmitted in an ON/OFF keying method, the constellation map can be expressed in a form different from that of FIG. 11.

[113] FIG. 12 shows a method of transmitting a scheduling request signal together with an ACK/NACK signal according to still another embodiment of the present invention. FIG. 12 shows an example of a MIMO with rank 2, in which an ACK/NACK signal is expressed as 2-bit. The horizontal axis is I channel (In-phase), and the vertical axis is Q channel (Quadrature-phase).

[114] Referring to FIG. 12, an 8PSK structure of QPSK is used for an ACK/NACK signal of 2 bits and a scheduling request signal of 1 bit in QPSK modulation scheme. Each of the two bits configuring the ACK/NACK signal may be ACK/NACK signals for two data of a user. Unlike the case shown in FIG. 11, an ACK/NACK signal is modulated in QPSK modulation scheme to have four types of phases. When the scheduling request signal is simultaneously transmitted together with the ACK/NACK signal, the scheduling request signal can be transmitted together by rotating each of the four types of phases by a predetermined degree, e.g., 45 degrees.

[115] In the figure, the constellation point marked with symbol + shows a case where only an ACK/NACK signal is transmitted, and the constellation point marked with symbol O shows a case where a scheduling request signal is transmitted together with an ACK/NACK signal.

[116] Four constellation points of 45, 135, 225, 315 degrees are phases that the 2-bit ACK/NACK signal may have. The other four constellation points are phases that an ACK/NACK signal may have when the ACK/NACK signal is transmitted together with a scheduling request signal. Table 2 shows combinations of signals represented by each constellation point.

[117] Table 2

[Table 2]

[Table]

Phase of constellation point	ACK/NACK signal	Transmission of scheduling request signal
45 degrees	ACK, ACK	X
90 degrees	ACK, ACK	O
135 degrees	ACK, NACK	X
180 degrees	ACK, NACK	O
225 degrees	NACK, ACK	X
270 degrees	NACK, ACK	O
315 degrees	NACK, NACK	X
360 or 0 degrees	NACK, NACK	O

[118] For example, when a user equipment transmits (ACK, NACK) as an ACK/NACK signal, it transmits a signal having a phase of 45 degrees. If the user equipment transmits a scheduling request signal together with (ACK, NACK), it can transmit a signal having a phase of 45 degrees after further delaying the signal as much as 45 degrees. Of course, the phases of constellation points according to respective combinations of signals and the phase degree delayed when a scheduling request signal is transmitted are merely an example and can be diversely set.

[119] Next, described is a method of transmitting a scheduling request signal on a CQI channel when transmission contention occurs between CQI and the scheduling request signal in the CQI channel.

[120] FIG. 13 shows an example of occurrence of transmission contention between CQI and scheduling request signal in a CQI channel.

[121] Referring to FIG. 13, UE1 transmits CQI using a sequence allocated to the first transmission period and releases the sequence allocation between the first and second transmission periods for other UEs. Since UE1 tries to simultaneously transmit CQI and a scheduling request signal in the second transmission period, transmission contention occurs in the second transmission period. The sequence used to transmit the scheduling request signal may be a sequence allocated to UE1 for CQI transmission or a dedicated sequence allocated for the scheduling request signal. The rule of allocating and releasing a sequence can be implemented in another method. Accordingly, the sequence allocation rule shown in the exemplary figure is merely an example.

[122] In an embodiment, a scheduling request signal is transmitted preferentially to CQI. In

most cases, since it is expected that transmission of a scheduling request signal has a priority higher than that of transmission of CQI, a user equipment transmits only a scheduling request signal when transmission contention occurs.

[123] FIG. 14 shows a method of transmitting a scheduling request signal on a CQI channel according to an embodiment of the present invention. CQI may be periodically transmitted at regular transmission intervals, or non-periodically transmitted without being restricted to a transmission interval. When the CQI is transmitted at regular intervals, each of a first to fourth transmission periods corresponds to a transmission interval. The transmission period may be referred to as a transmission timing.

[124] Referring to FIG. 14, UE1 transmits CQI using a sequence allocated to the first transmission period and releases the allocated sequence between the first and second transmission periods for other UEs. Transmission contention occurs between a scheduling request signal and the CQI in the second transmission period. At this point, the scheduling request signal is transmitted preferentially to the CQI. The sequence used to transmit the scheduling request signal may be a sequence allocated to UE1 for CQI transmission or a dedicated sequence allocated for the scheduling request signal.

[125] If the scheduling request signal is transmitted using a sequence allocated for CQI transmission, the base station makes an agreement with the user equipment or performs a blind decoding in order to know whether the user equipment transmits CQI or a scheduling request signal. The sequence allocation rule for reserving and releasing a sequence can be applied in another method, and the method shown in FIG. 14 is an example introduced for the convenience of explanation.

[126] UE1 delays transmission of the CQI that is not transmitted in the second transmission period and transmits the CQI after a predetermined time or a unit control signal transmission time is elapsed, or UE1 skips transmission of the CQI. It is preferable that delay time of the CQI transmission is short. It is since that channel quality changes from time to time as time passes by, and thus previously measured CQI cannot correctly reflect the channel status if an extended period of time is elapsed.

[127] In another embodiment, the user equipment determines priorities of the scheduling request signal and the CQI, and selects and transmits either of the signals.

[128] FIG. 15 shows a method of transmitting a scheduling request signal on a CQI channel according to another embodiment of the present invention.

[129] Referring to FIG. 15, transmission contention occurs in the second transmission period. The user equipment selects and transmits either of the signals in a method of determining a priority agreed with the base station.

[130] The subject that determines the priority may be a user equipment or the base station. In the case where a user equipment determines the priority, when the user equipment by itself determines the priorities of the two signals and transmits either of the signals,

the user equipment needs to transmit an additional signaling to the base station if the base station should know the information about basis of the determination. Or, the user equipment does not transmit an additional signaling, and the base station itself may distinguish CQI from a scheduling request signal in a blind method.

[131] In the case where the base station determines the priorities, the base station should inform the user equipment of the information on the determination of the priorities. Accordingly, transmission of various kinds of additional information is needed. In the method of transmitting any one of signals depending on the additional when transmission contention occurs, the system can operate in a form that is most appropriate to a downlink service related to CQI and an uplink service related to a scheduling request signal.

[132] If the scheduling request signal is transmitted in the second transmission period, UE1 delays transmission of the CQI that is not transmitted in the second transmission period and transmits the CQI after a predetermined time or a unit control signal transmission time is elapsed, or UE1 skips transmission of the CQI.

[133] If the CQI is transmitted in the second transmission period, UE1 transmits the scheduling request signal in the transmission period of the next control signal, or transmits a new scheduling request signal. At this point, the sequence used for the scheduling request signal may be a dedicated sequence.

[134] In yet another embodiment, a user equipment selects and transmits a signal based on a predetermined selection rule. It is the principle of the selection rule to preferentially transmit CQI and then transmit a scheduling request signal after delaying the scheduling request signal for a predetermined time period. Exceptionally, the scheduling request signal is transmitted prior to the CQI although transmission contention occurs only if the number of delays of the scheduling request signal (hereinafter, referred to as a delay count) caused by transmission contention is equal to a critical delay count. In this exceptional case, the user equipment retransmits the CQI.

[135] FIG. 16 shows a method of transmitting a scheduling request signal based on a selection rule on a CQI channel according to an embodiment of the present invention.

[136] Referring to FIG. 16, UE1 having a critical delay count of 2 transmits CQI in the first transmission period. At this time, the delay count is 0. When UE1 transmits a scheduling request signal in the second transmission period, transmission contention with the CQI occurs. Since the delay count is 0, it is smaller than the critical delay count of 2. Accordingly, UE1 delays transmission of the scheduling request signal and transmits the CQI. At this time, the delay count becomes 1.

[137] When UE1 transmits a scheduling request signal again in the third transmission period, transmission contention with CQI occurs. Since the delay count is 1, it is still smaller than the critical delay count of 2. Accordingly, UE1 delays transmission of the

scheduling request signal again and transmits the CQI. At this time, the delay count becomes 2.

[138] When UE1 transmits a scheduling request signal again in the fourth transmission period, transmission contention with CQI occurs. Since the delay count is 2, it is equal to the critical delay count of 2. Therefore, UE1 delays transmission of the CQI and transmits the scheduling request signal. Since UE1 transmits the scheduling request signal, the delay count becomes 0 again.

[139] It is apparent that the critical delay count of the selection rule can be differently set depending on system status. The sequence used to transmit the scheduling request signal may be a sequence allocated to UE1 for CQI transmission or a dedicated sequence allocated for the scheduling request signal.

[140] If the scheduling request signal is transmitted using a sequence allocated for CQI transmission, the base station makes an agreement with the user equipment or performs a blind decoding in order to know whether the user equipment transmits CQI or a scheduling request signal.

[141] FIG. 17 shows a method of transmitting a scheduling request signal based on a selection rule on a CQI channel according to another embodiment of the present invention.

[142] Referring to FIG. 17, UE1 delays the CQI as many times as the critical delay count and transmits the scheduling request signal. However, if the delay count of the CQI is equal to the critical delay count, the CQI is transmitted. The sequence used to transmit the scheduling request signal may be a sequence allocated to UE1 for CQI transmission or a dedicated sequence allocated for the scheduling request signal. If the scheduling request signal is transmitted using a sequence allocated for CQI transmission, the base station makes an agreement with the user equipment or performs a blind decoding in order to know whether the user equipment transmits CQI or a scheduling request signal.

[143] Finally, described below is a method of transmitting only a scheduling request signal on the same physical channel structure with an ACK/NACK channel or CQI channel.

[144] FIG. 18 shows an example of transmitting only a scheduling request signal on a control channel.

[145] Referring to FIG. 18, a process of UE1 for transmitting CQI and a scheduling request signal on a CQI channel is shown. A sequence is allocated to transmit the CQI or scheduling request signal of UE1, or the sequence allocated to the UE1 is released for other UEs. UE1 transmits CQI in the first transmission period, a scheduling request signal in the second transmission period, and CQI in the third transmission period. That is, transmission contention does not occur among control signals transmitted by UE1.

[146] FIG. 19 shows a method of transmitting a scheduling request signal on a same physical channel structure with an ACK/NACK channel according to an embodiment of the present invention. Hereinafter, it is assumed that ZC CAZAC sequences are used in the frequency domain and orthogonal covering sequences (OC) are used in the time domain.

[147] Referring to FIG. 19, six ZC CAZAC sequences maintain orthogonality one another using cyclic shifts, and respective ZC CAZAC cyclic shifts are subsequently spread by orthogonal covering sequences in the time domain and maintain orthogonality one another again. That is, spreading codes can be applied to each SC-FDMA symbol in the time domain.

[148] At this time, for coherent detection, the number of orthogonal covering sequences that can be used for each cyclic shift is determined by the function of min (the number of SC-FDMA symbols in the data region, the number of SC-FDMA symbols in the reference signal region). In the coherent detection, a transmission signal, i.e., constellation of an ACK/NACK signal, is distinguished based on a defined reference signal. Since the number of SC-FDMA symbols for data is four and the number of SC-FDMA symbols for the reference signal is three in a slot, maximum three orthogonal covering sequences are possible for the coherent detection. That means a scheduling reference signal can be spread in time domain by an orthogonal covering sequence of maximum length three.

[149] Accordingly, if n cyclic shifts are used as a scheduling request signal in the coherent detection, maximum 3n user equipments can simultaneously transmit a scheduling request signal in a slot.

[150] Hereinafter, a code generated by applying an orthogonal covering sequence to each of the ZC CAZAC sequences in the time domain is referred to as an orthogonal code. As shown in FIG. 19, if there are six ZC CAZAC sequences in the frequency domain and each of the six ZC CAZAC sequences is spread across three SC-FDMA symbols in the time domain, the number of possible orthogonal codes is $6 \times 3 = 18$. If the ZC CAZAC sequence is not spread in the time domain, the number of possible orthogonal codes is six.

[151] Sine the eighteen orthogonal codes are orthogonal to one another, if at least one of the orthogonal codes among the eighteen orthogonal codes is allocated to a specific UE for a scheduling request, maximum eighteen UEs can transmit the scheduling request signal in a slot. Of course, the number of possible orthogonal codes can be changed, and two or more orthogonal codes can be allocated to each UE for the scheduling request signal. If a specific orthogonal code is allocated to UE1 for an ACK/NACK signal in an ACK/NACK channel, an orthogonal code different from the specific orthogonal code is allocated to UE2 for a scheduling request signal.

[152] Although six cyclic shifts are assumed using ZC CAZAC sequences in the frequency domain, this is merely an example, and other effective sequences can be used, or the cyclic shifts may be six or more.

[153] FIG. 20 shows a method of transmitting a scheduling request signal on the same physical channel structure with ACK/NACK channel according to another embodiment of the present invention. The horizontal axis is a time axis, which expresses the number of OFDM or SC-FDMA symbols, and the vertical axis is an index of an orthogonal code.

[154] Referring to FIG. 20, there can be four types of slot structures according to the length of orthogonal covering sequence which is spread in a slot.

[155] The first slot structure is related to a method of using six orthogonal code indexes for scheduling request signals that cannot be allocated for an ACK/NACK signal, among all orthogonal code indexes. Since the ACK/NACK signal is in a coherent relation with the reference signal, if the reference signal is not included in an ACK/NACK channel, the receiver cannot detect the ACK/NACK signal. On the other hand, a scheduling request signal can be detected only by detecting presence or absence of the scheduling request signal (in other means, presence or absence of energy) regardless of the reference signal. That is, the scheduling request signal can be detected in a coherent or non-coherent method. Such a difference between the ACK/NACK signal and scheduling request signal can be considered to be caused by difference in the methods of allocating symbols and sequences. Accordingly, even an orthogonal code that cannot be allocated for an ACK/NACK signal can be allocated for a scheduling request signal.

[156] Orthogonal code indexes 19 to 24 are SF4 slot structures. The SF4 slot structure is made by applying orthogonal covering sequence to four OFDM symbols for data except three OFDM symbols for a reference signal (the third, fourth, and fifth OFDM symbols).

[157] Since a reference signal of an ACK/NACK channel uses three OFDM symbols, the number of possible orthogonal codes allocated for the reference signal of the ACK/NACK signal is 3 (a spreading factor or the number of symbols) x 6 (cyclic shifts) = 18. Since the data region of the ACK/NACK channel uses four OFDM symbols, the number of possible orthogonal codes that can be allocated for data of the ACK/NACK signal is 4 (a spreading factor or the number of symbols) x 6 (cyclic shifts) = 24. In the coherent detection, since min(18, 24) = 18 (orthogonal code indexes 1 to 18), the other six orthogonal codes (orthogonal code indexes 19 to 24) cannot transmit the reference signal (i.e., the six orthogonal codes should be detected in the non-coherent method), and thus they cannot be allocated for an ACK/NACK signal. Accordingly, the other six orthogonal codes can be allocated for a scheduling request signal. Accordingly, the

other six orthogonal codes can be used as dedicated sequences for the scheduling request signal. For example, orthogonal code index 24 is a combination of ZC_Shift6 and orthogonal covering sequence OC 4, which is an example of SF4.

[158] The second slot structure is made by using some of orthogonal codes allocated to the reference signal region of an ACK/NACK channel (3 OFDM symbols, SF3) as a dedicated or shared sequence for a scheduling request signal. This is referred to as an SF3 slot structure. Orthogonal code indexes 1 to 18 are SF3 slot structures, which can be used for a scheduling request signal. For example, orthogonal code index 12 is a combination of ZC_Shift6 and orthogonal covering sequence OC 2, which is an example of SF3.

[159] The third slot structure is made by using some of orthogonal codes allocated to the data region of an ACK/NACK channel (4 OFDM symbols, SF4) as a dedicated sequence for a scheduling request signal. The third slot structure is an SF4 slot structure, which is the same as the first slot structure.

[160] Since a reference signal of an ACK/NACK channel uses three OFDM symbols, the number of possible orthogonal codes allocated for the reference signal of the ACK/NACK signal is 3 (a spreading factor or the number of symbols) x 6 (cyclic shifts) = 18. Since the data region of the ACK/NACK channel uses four OFDM symbols, the number of possible orthogonal codes that can be allocated for data of the ACK/NACK signal is 4 (a spreading factor or the number of symbols) x 6 (cyclic shifts) = 24. In the coherent detection, since min(18, 24) = 18, orthogonal code indexes 1 to 18 can be allocated for an ACK/NACK signal. For example, orthogonal code index 12 is a combination of ZC_Shift6 and orthogonal covering sequence OC 2, which is an example of SF4.

[161] Unlike the first slot structure (in the case of orthogonal code 24) where all of the orthogonal code indexes 19 to 24 are allocated for a scheduling request signal, the third slot structure can use all the eighteen orthogonal codes for an ACK/NACK signal and scheduling request signal. However, in this case, the scheduling request signal can be detected by coherent detection.

[162] The fourth slot structure is made by orthogonally covering the data region and reference signal regions by SF4 and SF3 repectively. This slot structure is referred to as SF4+SF3 structure. If a UE transmits the scheduling request signal by using the SF4+SF3 structure, the base station can restore the scheduling request signal by separately decovering each signal. For example, orthogonal code index 06 is a combination of ZC_Shift6 and orthogonal covering sequence OC 1, which is an example of SF4+SF3.

[163] FIG. 21 shows a method of transmitting a scheduling request signal on the same physical channel structure with ACK/NACK channel according to still another em-

bodiment of the present invention. Unlike the method shown in FIG. 20, FIG. 21 shows an example considering a case where an sounding reference signal (SRS), which is an uplink reference signal for uplink scheduling, is transmitted on at least one SC-FDMA symbol.

[164] Referring to FIG. 21, a slot is configured with seven OFDM symbols, and the seventh SC-FDMA symbol is allocated (or puctured) for sounding reference signal. Accordingly, time domain spreading can be performed across maximum six SC-FDMA symbols. This format of PUCCH is referred to as a shortened PUCCH format. There can be four types of slot structure according to the length of orthogonal covering sequence which is spread in a slot.

[165] The first slot structure is an SF3 slot structure in orthogonal code indexes 19 to 24. Since the first slot structure is based on non-coherent detection, six orthogonal indexes that cannot be allocated for an ACK/NACK signal can be allocated for a scheduling request signal.

[166] The second slot structure is an SF3 slot structure in orthogonal code indexes 1 to 18. Since time domain orthogonal covering is performed across three SC-FDMA symbols allocated for data of an ACK/NACK channel or three SC-FDMA symbols allocated for a reference signal of an ACK/NACK channel, orthogonal codes of maximum 3 (the number symbols or a spreading factor) x 6 (cyclic shifts) = 18 can be obtained in each case. Some of the eighteen orthogonal codes can be allocated for an ACK/NACK signal, and some of the other orthogonal codes can be allocated for a scheduling request signal (at this point, a sequence can be a dedicated sequence).

[167] The third slot structure is an SF3+SF3 slot structure, and the fourth slot structure is an SF6 slot structure. That is, unlike the method shown in FIG. 20, orthogonal codes corresponding to an amount as much as one OFDM symbol is reduced from the length of time domain orthogonal covering can be obtained.

[168] Of course, the position of an SC-FDMA symbol allocated for a sounding reference signal (SRS) can be other than that of the seventh SC-FDMA symbol, and the number of SC-FDMA symbols allocated for the sounding reference signal can be one or more. The slot structure can be changed depending on the number and positions of the SC-FDMA symbols for the sounding reference signal.

[169] Hereinafter, a method of allocating a separate dedicated resource block to a scheduling request signal will be described.

[170] Resource blocks can be categorized as described below. That is, there may be a resource block for transmitting only an ACK/NACK signal, a resource block for transmitting an ACK/NACK signal and a scheduling request signal, and a resource block for transmitting only a scheduling request signal using an SF7 slot structure (an SF6 slot structure in a slot where a sounding reference signal is added). Here, it is

operated to transmit only scheduling request signals in resource blocks dedicated to scheduling request signals.

[171] At this point, the scheduling request signal may be operated in a non-coherent method, or in a coherent method by allocating a reference signal for a scheduling request signal to some symbols.

[172] FIG. 22 shows a method of transmitting a scheduling request signal in one subframe according to an embodiment of the present invention.

[173] Referring to FIG. 22, one subframe is configured with a plurality of resource blocks. Each resource block can be any one of a resource block for a scheduling request signal, a resource block for an ACK/NACK signal, and a shared resource block for a scheduling request signal and an ACK/NACK signal. Since a sounding reference signal SRS is not transmitted in both of the two slots configuring one subframe, a scheduling request signal can be transmitted in a slot structure of SF7.

[174] FIG. 23 shows orthogonal code indexes that can be allocated in a resource block for a scheduling request signal according to an embodiment of the present invention.

[175] Referring to FIG. 23, since there is no sounding reference signal, a scheduling request signal can be transmitted using a SF7 slot structure. If one resource block can be entirely allocated to a scheduling request signal, the number of UEs multiplexed in the SF7 slot structure as shown in FIG. 23 can be as many as 6 (cyclic shifts) x 7 (orthogonal covering sequences) = 42 according to a non-coherent method. Accordingly, compared with a resource block shared by other control signals, further more scheduling request signals can be transmitted.

[176] For example, UE1 may transmit a scheduling request signal by a combination of ZC_Shift6 and orthogonal covering sequence OC 7, UE2 may transmit a scheduling request signal in a combination of ZC_Shift6 and orthogonal covering sequence OC 2, and UE3 may transmit a scheduling request signal by a combination of ZC_Shift6 and orthogonal covering sequence OC 1. In this manner, orthogonal code indexes used as a scheduling request signal can be assigned to maximum 42 UEs.

[177] FIG. 24 shows resource blocks for a scheduling request signal according to an embodiment of the present invention.

[178] Referring to FIG. 24, unlike the example of FIG. 22, a sounding reference signal is included in a first slot of one subframe. A scheduling request signal can be transmitted using the SF6 slot structure or SF3+SF3 slot structure in the first slot, and can be transmitted using the SF7 slot structure or SF3+SF4 slot structure in a second slot. The SF3+SF4 slot structure is made by orthogonally covering the scheduling request signal over the data region and reference signal regions by SF3 and SF4 repectively in the second slot. That is, different length of orthogonal covering sequence is used for data region and reference signal regions in the second slot. Of course, the position of an SC-

FDMA symbol allocated for a sounding reference signal (SRS) can be other than that of the seventh SC-FDMA symbol. SF3, SF4, SF6, SF7 and SF3+SF4 is explaned in FIG. 20 and FIG. 21 in detail.

[179] FIG. 25 shows orthogonal code indexes that can be allocated in a resource block for a scheduling request signal according to another embodiment of the present invention.

[180] Referring to FIG. 25, since a sounding reference signal is transmitted, a scheduling request signal can be transmitted using the SF6 slot structure. If one resource block can be entirely allocated to a scheduling request signal, the number of UEs multiplexed in the SF6 slot structure as shown in FIG. 25 can be as many as 6 (cyclic shifts) x 6 (orthogonal covering sequences) = 36 according to a non-coherent method.

[181] FIG. 26 shows a method of transmitting a scheduling request signal in one subframe according to another embodiment of the present invention. It is assumed that the subframe structure is the same as the subframe structure shown in FIG. 3.

[182] Referring to FIG. 26, since three OFDM symbols in the middle of the upper ACK/NACK channel of a first slot and OFDM symbols of two respectively positioned at the left and right sides of the lower ACK/NACK channel of a second slot form one SF3+SF4 structure (hereinafter, referred to as a first structure), a scheduling request signal can be transmitted using orthogonal codes obtained from the first structure. The method described referring to FIGS. 19 to 21 can be referenced for the method of transmitting an ACK/NACK signal or a scheduling request signal using the SF3+SF4 structure.

[183] In addition, since OFDM symbols of two positioned at the left and right sides of the upper ACK/NACK channel of the first slot and three OFDM symbols in the middle of the lower ACK/NACK channel of the second slot form one SF4+SF3 structure (the same as the SF3+SF4 structure) (hereinafter, referred to as a second structure), a scheduling request signal can be transmitted using orthogonal codes obtained from the second structure.

[184] The first and second structures are channel structures formed by combining some OFDM symbols taken from the first and second slots within the subframe. It is not necessarily limited to the SF3+SF4 structure formed as shown in the figure, but it is apparent that the number and positions of the OFDM symbols taken from each slot can be changed.

[185] It is assumed that a group of users using the first structure is referred to as group A, and a group of users using the second structure is referred to as group B. All users belonging group A can transmit a scheduling request signal configured with seven OFDM symbols within one subframe using the SF4 (the first slot) + SF3 (the second slot) structure. In addition, all users belonging group B can transmit a scheduling request signal configured with seven OFDM symbols within one subframe using the

SF3 (the first slot) + SF4 (the second slot) structure.

[186] Orthogonal codes allocated to one scheduling request signal may be different in each slot within one subframe, and the orthogonal codes can be paired between the groups. For example, for a user in group A, orthogonal code 1 of the first slot (SF4 portion) and orthogonal code 1 of the second slot (SF3 portion) can be used to transmit a scheduling request signal. On the other hand, for a user in group B, orthogonal code 1 of the first slot (SF3 portion) and orthogonal code 1 of the second slot (SF4 portion) can be used to transmit a scheduling request signal.

[187] Table 3 shows orthogonal codes pairing with each other between groups.

[188] Table 3

[Table 3]

[Table]

		First Slot	Second Slot
Group A	User 1	SF3(Orthogonal Code 1)	SF4(Orthogonal Code 1)
Group B	User 4	SF4(Orthogonal Code 1)	SF3(Orthogonal Code 1)
Group A	User 2	SF3(Orthogonal Code 2)	SF4(Orthogonal Code 2)
Group B	User 5	SF4(Orthogonal Code 2)	SF3(Orthogonal Code 2)
Group A	User 3	SF3(Orthogonal Code 3)	SF4(Orthogonal Code 3)
Group B	User 6	SF4(Orthogonal Code 3)	SF3(Orthogonal Code 3)

[189] Referring to Table 3, users 1 to 3 belong to group A, and users 4 to 6 belong to group B. For a scheduling request signal of group A, orthogonal codes are allocated to SF3 in the first slot and SF4 in the second group. For a scheduling request signal of group B, orthogonal codes are allocated to SF4 in the first slot and SF3 in the second group. User 1 of group A uses orthogonal code 1 of the length of SF3 in the first slot and orthogonal code 1 of the length of SF4 in the second slot. User 4 of group B paired with user 1 of group A uses orthogonal code 1 of the length of SF4 in the first slot and orthogonal code 1 of the length of SF3 in the second slot.

[190] In the same manner, user 2 of group A shares orthogonal codes with user 5 of group B in pairs, and user 3 of group A shares orthogonal codes with user 6 of group B in

pairs. If orthogonal codes required to transmit a scheduling request signal are shared in pairs between groups, orthogonal codes can be exchanged between users paired with each other, and thus resources can be efficiently operated.

[191] FIG. 27 shows a method of transmitting a scheduling request signal in one subframe according to still another embodiment of the present invention. It is assumed that the subframe structure shown in FIG. 27 is the same as the subframe structure shown in FIG. 3.

[192] Referring to FIG. 27, unlike FIG. 26, FIG. 27 shows a case where a sounding reference signal is transmitted together with a scheduling request signal. Since the sounding reference signal is positioned at the last OFDM symbol of the first slot, a user of group A transmits a scheduling request signal using an orthogonal code of the length of SF4 in the first and second slots. On the other hand, a user of group B transmits a scheduling request signal using an orthogonal code of the length of SF3 in the first slot and an orthogonal code of the length of SF4 in the second slot. The position of the sounding reference signal is not required to be the last OFDM symbol of the first slot. The position of the sounding reference signal and the number of OFDM symbols shown in FIG. 27 are not limited.

[193] Since a user of group C who should simultaneously transmit a sounding reference signal and a scheduling request signal should transmit the scheduling request signal using an orthogonal code of the length of SF3 in the first and second slots, in this case, orthogonal codes are not shared between users of different groups in pairs, but independent orthogonal codes can be used. Or, a separate orthogonal code is allocated and managed only in the first slot where a sounding reference signal is transmitted, and orthogonal codes can be operated in pairs between users of different groups in the other subframes and slots, like the relation between groups A and B. On the other hand, users who do not transmit a sounding reference signal can exchange orthogonal codes with users of the other groups in pairs.

[194] All functions described above may be performed by a processor such as a microprocessor, a controller, a microcontroller, and an application specific integrated circuit (ASIC) according to software or program code for performing the functions. The program code may be designed, developed, and implemented on the basis of the descriptions of the present invention, and this is well known to those skilled in the art.

[195] While the present invention has been particularly shown and described with reference to exemplary embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. The exemplary embodiments should be considered in descriptive sense only and not for purposes of limitation. Therefore, the scope of the invention is defined not by the detailed de-

scription of the invention but by the appended claims, and all differences within the scope will be construed as being included in the present invention.

[196]

[197]

[198]

Claims

[1] A method of transmitting a scheduling request signal, wherein the scheduling request signal is used to request a radio resource for uplink transmission in a wireless communication system, the method comprising:
configuring a physical uplink control channel (PUCCH) for transmission of a scheduling request signal in a subframe, the subframe comprising two consecutive slots, a slot comprising a plurality of single carrier-frequency division multiple access (SC-FDMA) symbols, the scheduling request signal being carried by a presence or absence of transmission of the PUCCH, wherein at least one SC-FDMA symbol in the subframe is assigned for transmission of a sounding reference signal; and
transmitting the scheduling request signal and the sounding reference signal in the subframe.

[2] The method of claim 1, wherein the PUCCH uses at least one resource block in each of the two slots in the subframe.

[3] The method of claim 2, wherein one of the two slots for the scheduling request signal uses different resource blocks in frequency domain.

[4] The method of claim 2, wherein each of the two slots in the subframe is spread by orthogonal covering sequences with different lengths.

[5] The method of claim 4, wherein the length of the orthogonal covering sequence for one slot including the at least one SC-FDMA symbol is shorter than that of the orthogonal sequence for the other slot.

[6] The method of claim 1, wherein the at least one SC-FDMA symbol for the sounding reference signal is the last SC-FDMA symbol in the subframe.

[7] The method of claim 1, wherein configuring the PUCCH comprises:
dividing the plurality of SC-FDMA symbols in the slot into a first set of SC-FDMA symbols and a second set of SC-FDMA symbols;
mapping each of first frequency domain sequences to each SC-FDMA symbol in the first set, the first frequency domain sequences being generated by cyclic shifts of a base sequence;
mapping each of second frequency domain sequences to each SC-FDMA symbol in the second set, the second frequency domain sequence being generated by cyclic shifts of the base sequence;
spreading the first frequency domain sequences in the first set with a first orthogonal covering sequence, the first orthogonal covering sequence having a length equal to the number of SC-FDMA symbols in the first set; and
spreading the second frequency domain sequences in the second set with a

second orthogonal covering sequence, the second orthogonal covering sequence having a length equal to the number of SC-FDMA symbols in the second set.

[8] The method of claim 7, wherein the first orthogonal covering sequence and the second orthogonal covering sequence are time domain sequences whose elements correspond to SC-FDMA symbols.

[9] The method of claim 7, wherein the two consecutive slots in the subframe use different subcarriers in frequency domain.

[10] The method of claim 7, wherein the number of SC-FDMA symbols in the first set is the same as that of SC-FDMA symbols in the second set, when the sounding reference signal is in the slot.

[11] The method of claim 7, wherein the number of SC-FDMA symbols in the first set is larger than that of SC-FDMA symbols in the second set.

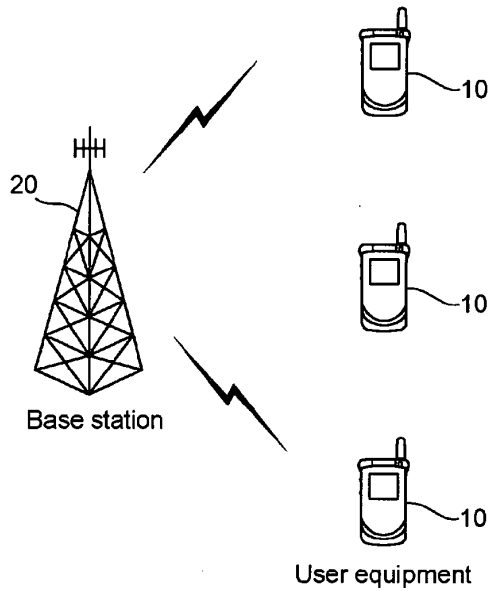
[12] The method of claim 11, wherein the first set is assigned for a reference signal corresponding to the scheduling reference signal.

[13] A method of transmitting a scheduling request signal, the method comprising: generating a physical uplink control channel (PUCCH) carrying a scheduling request signal in form of presence or absence in a subframe, the subframe comprising a first slot and a second slot, a slot comprising a plurality of SC-FDMA symbols, the scheduling request signal spreaded by a first orthogonal covering sequence in the first slot and a second orthogonal covering sequence in the second slot, wherein the length of the first orthogonal covering sequence is different from that of the second orthogonal covering sequence; and transmitting the scheduling request signal on the PUCCH and a sounding reference signal using a SC-FDMA symbol in the second slot.

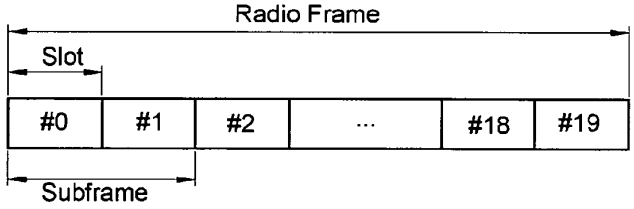
[14] The method of claim 13, wherein the sounding reference signal is transmitted using the last SC-FDMA symbol in the second slot.

[15] The method of claim 13, wherein a resource block in the PUCCH used for the transmission of the scheduling request signal is dedicated to the scheduling request signal.

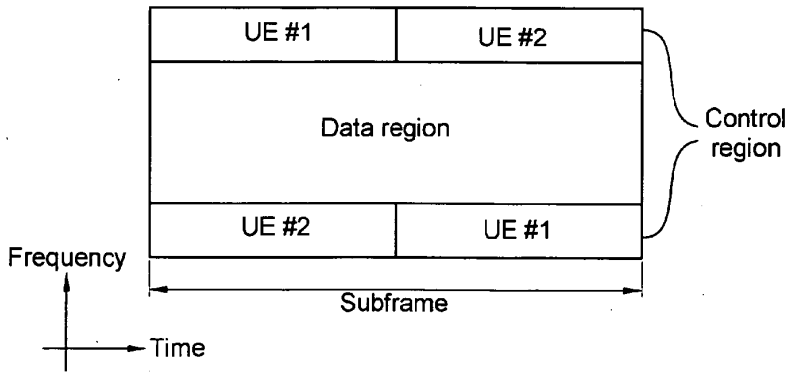
[Fig. 1]



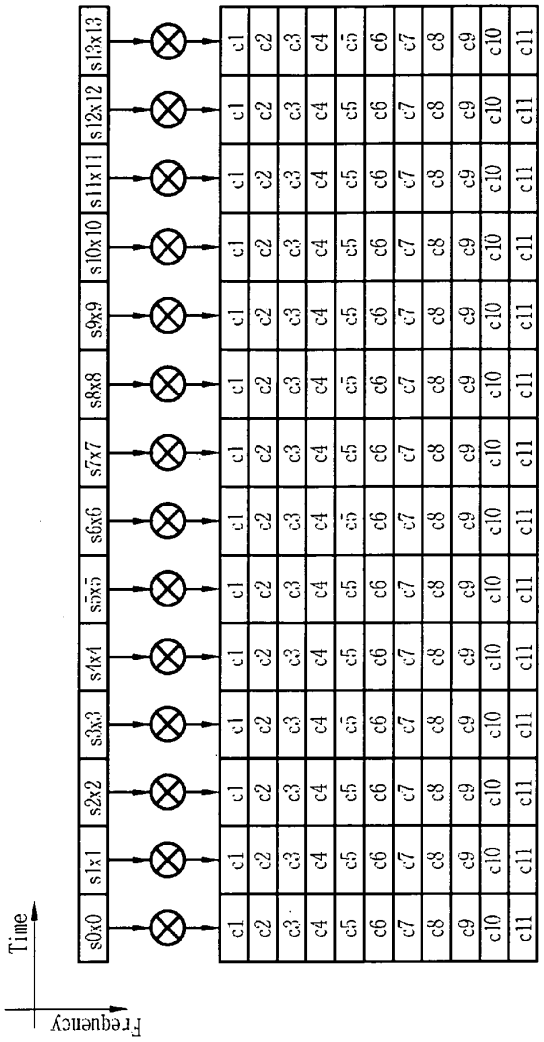
[Fig. 2]



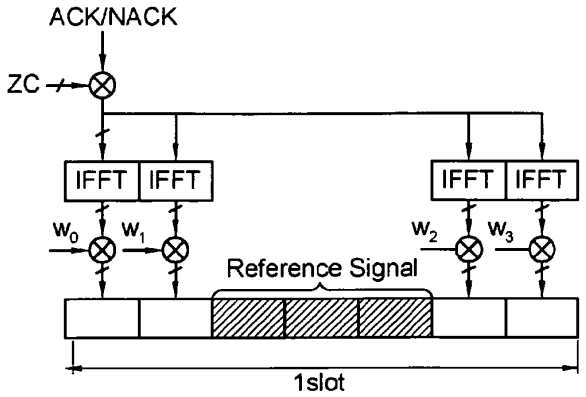
[Fig. 3]



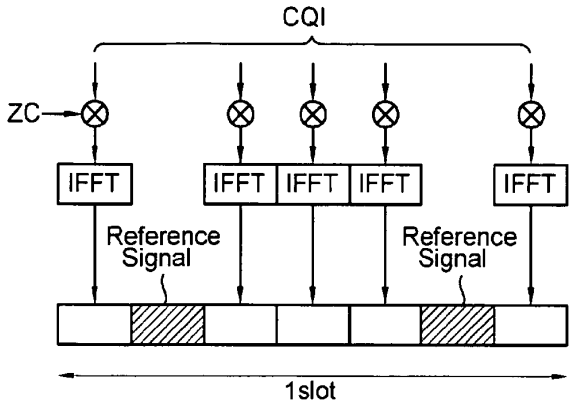
[Fig. 4]


s0x0
s1x1
s2x2
s3x3
s4x4
s5x5
s6x6
s7x7
s8x8
s9x9
s10x10
s11x11
s12x12
s13x13
c1
c2
c3
c4
c5
c6
c7
c8
c9
c10
c11
Time
Frequency

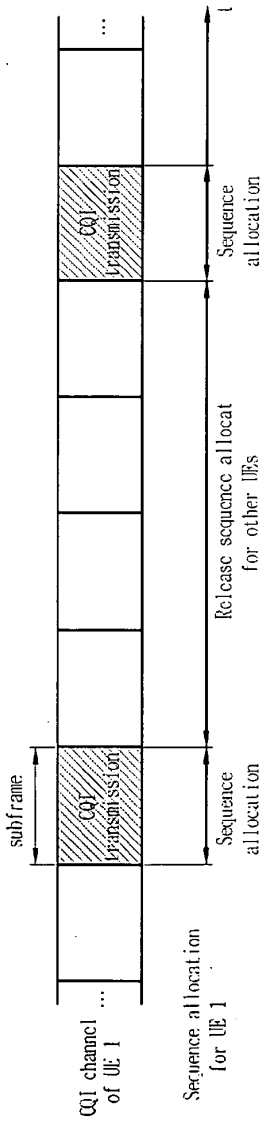
[Fig. 5]


ACK/NACK
ZC
IFFT
IFFT
IFFT
IFFT
w_0
w_1
w_2
w_3
Reference Signal
1slot

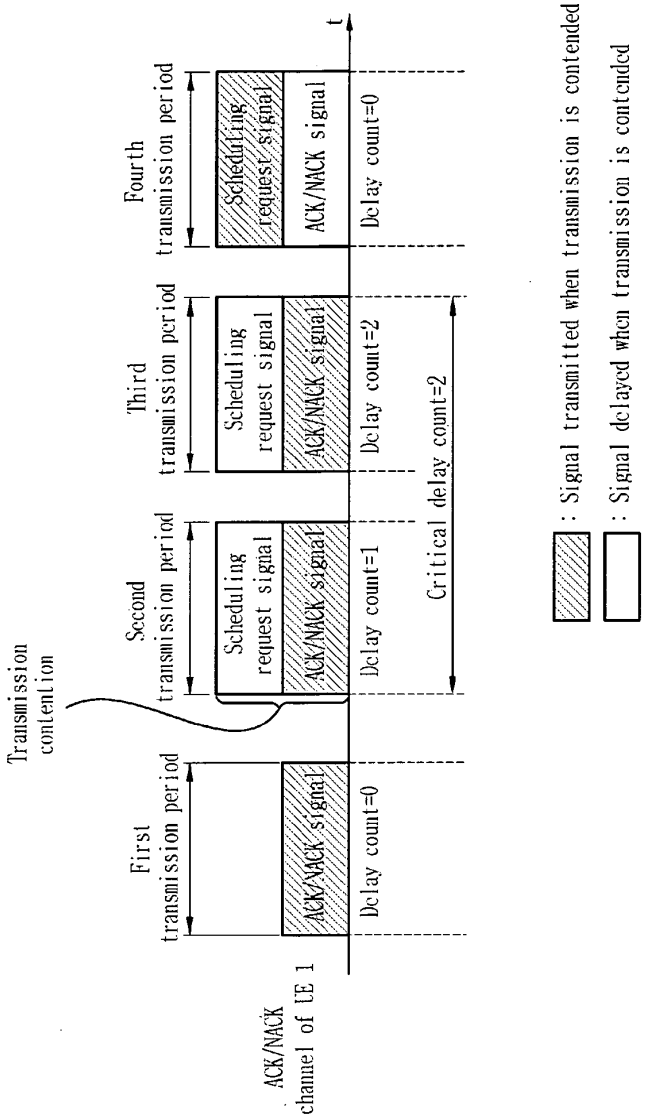
[Fig. 6]


CQI
ZC
IFFT
IFFT
IFFT
IFFT
IFFT
Reference Signal
Reference Signal
1slot

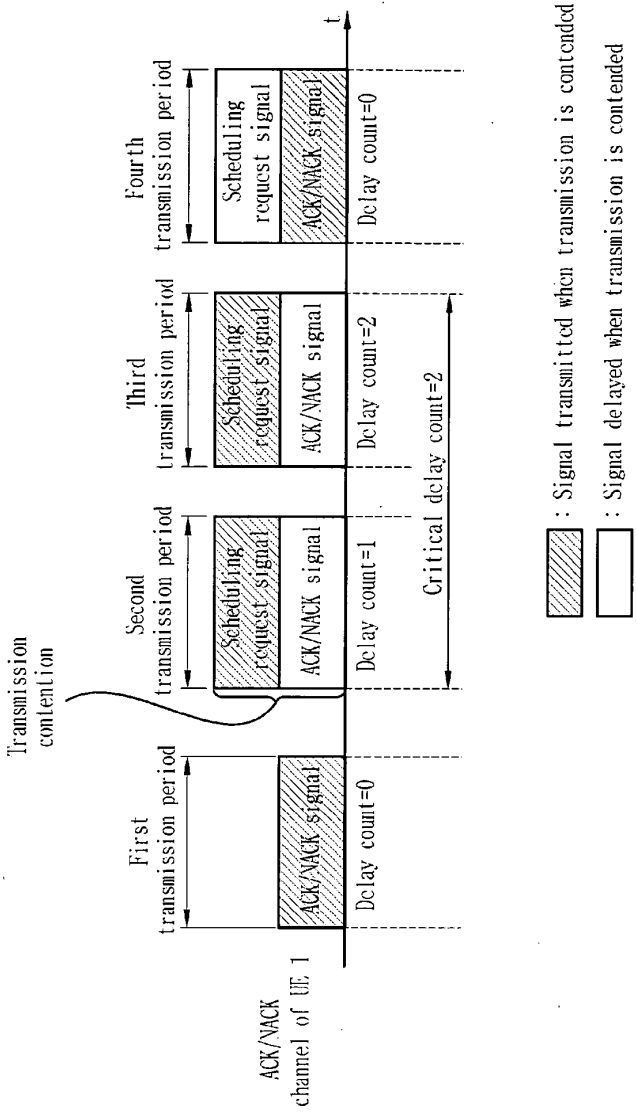
[Fig. 7]


CQI transmission
Sequence allocation
Release sequence allocat for other UEs
subframe
CQI transmission
Sequence allocation
CQI channel of UE 1
Sequence allocation for UE 1

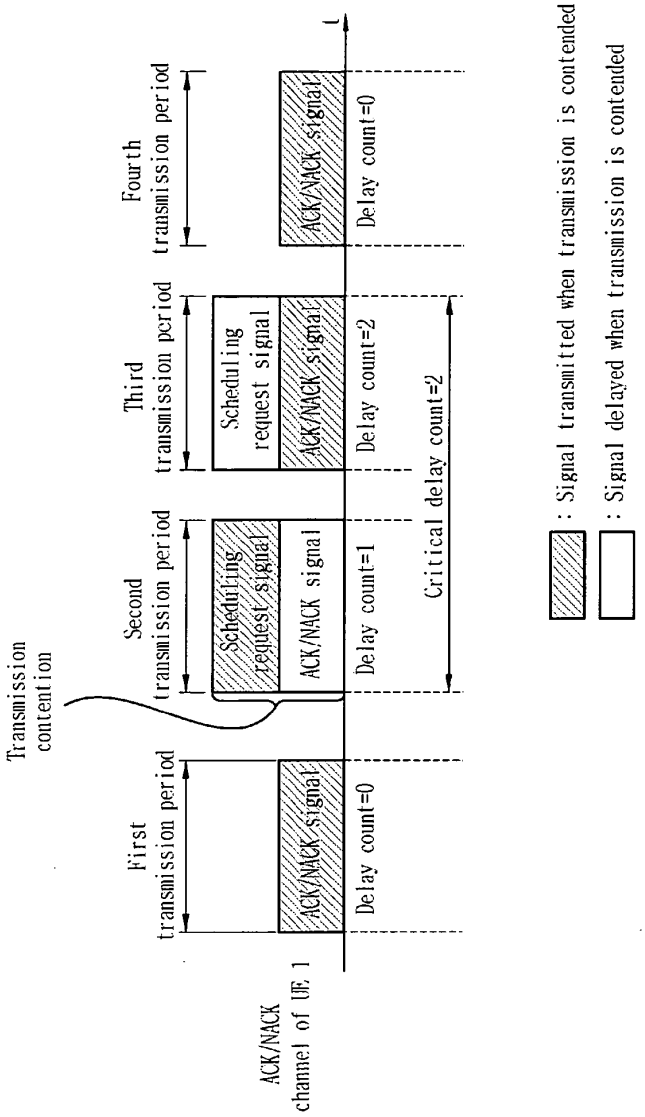
[Fig. 8]


ACK/NACK channel of UE 1
Transmission contention
First transmission period
Second transmission period
Third transmission period
Fourth transmission period
ACK/NACK signal
Scheduling request signal
Delay count=0
Delay count=1
Delay count=2
Critical delay count=2
t
: Signal transmitted when transmission is contended
: Signal delayed when transmission is contended

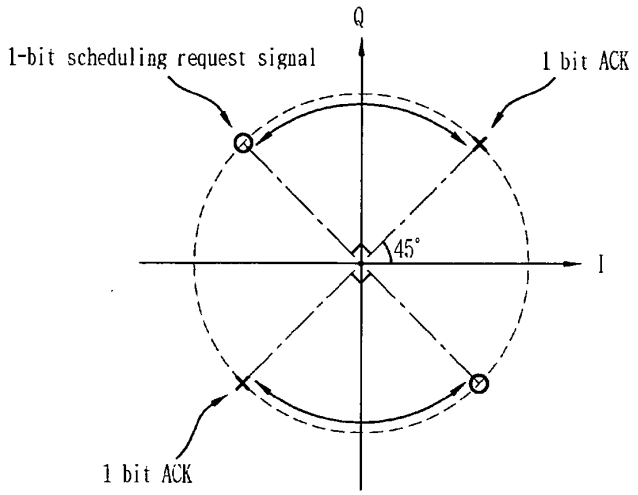
[Fig. 9]


ACK/NACK channel of UE 1
First transmission period
Second transmission period
Third transmission period
Fourth transmission period
Transmission contention
ACK/NACK signal
Scheduling request signal
ACK/NACK signal
Scheduling request signal
ACK/NACK signal
Scheduling request signal
ACK/NACK signal
Delay count=0
Delay count=1
Delay count=2
Delay count=2
Critical delay count=2
t
: Signal transmitted when transmission is contended
: Signal delayed when transmission is contended

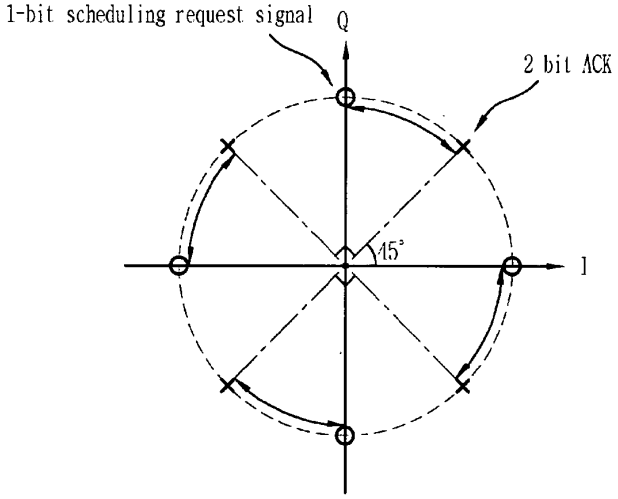
[Fig. 10]


ACK/NACK channel of UE 1
Transmission contention
First transmission period
Second transmission period
Third transmission period
Fourth transmission period
ACK/NACK signal
Scheduling request signal
ACK/NACK signal
Delay count=0
Delay count=1
Delay count=2
Delay count=0
Critical delay count=2
t
: Signal transmitted when transmission is contended
: Signal delayed when transmission is contended

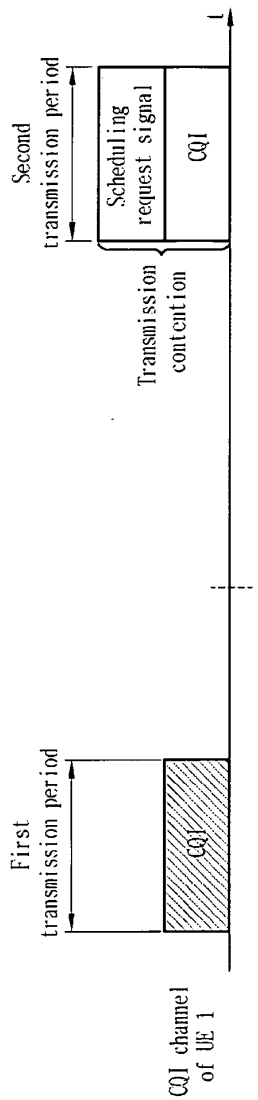
[Fig. 11]


Q
1-bit scheduling request signal
1 bit ACK
45°
I
1 bit ACK

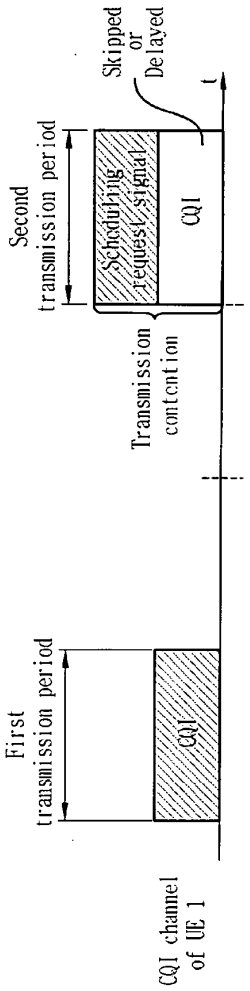
[Fig. 12]


1-bit scheduling request signal
Q
2 bit ACK
45°
I

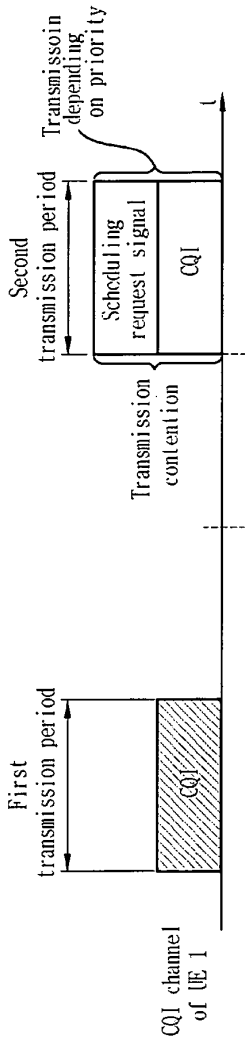
[Fig. 13]


t
Second transmission period
Scheduling request signal
CQI
Transmission contention
First transmission period
CQI
CQI channel of UE 1

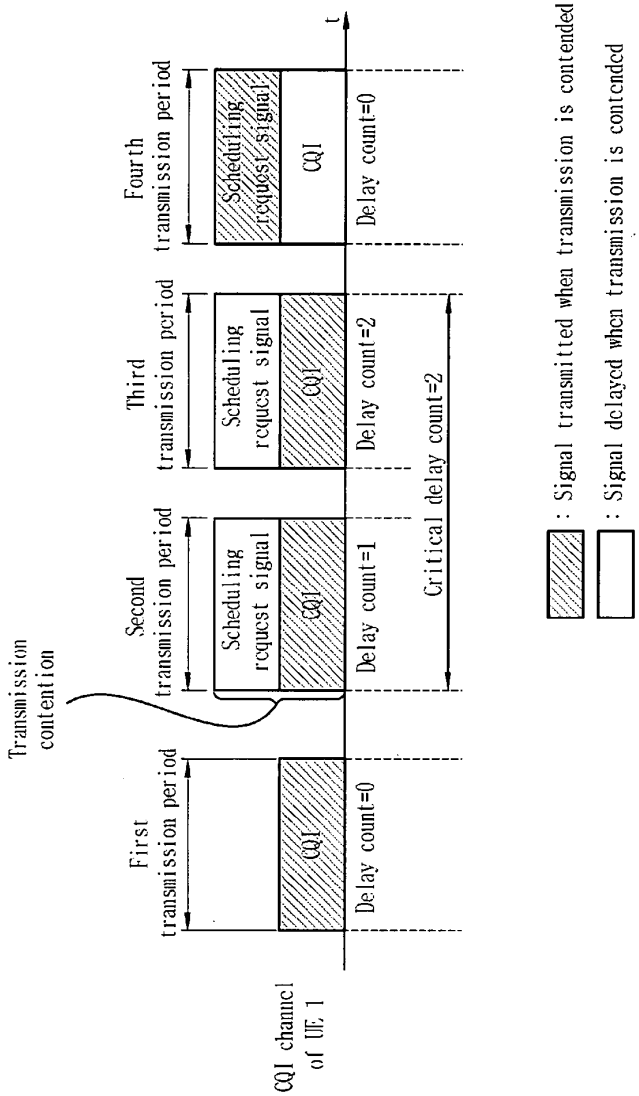
[Fig. 14]


Skipped or Delayed
t
Second transmission period
Scheduling request signal
CQI
Transmission contention
First transmission period
CQI
CQI channel of UE 1

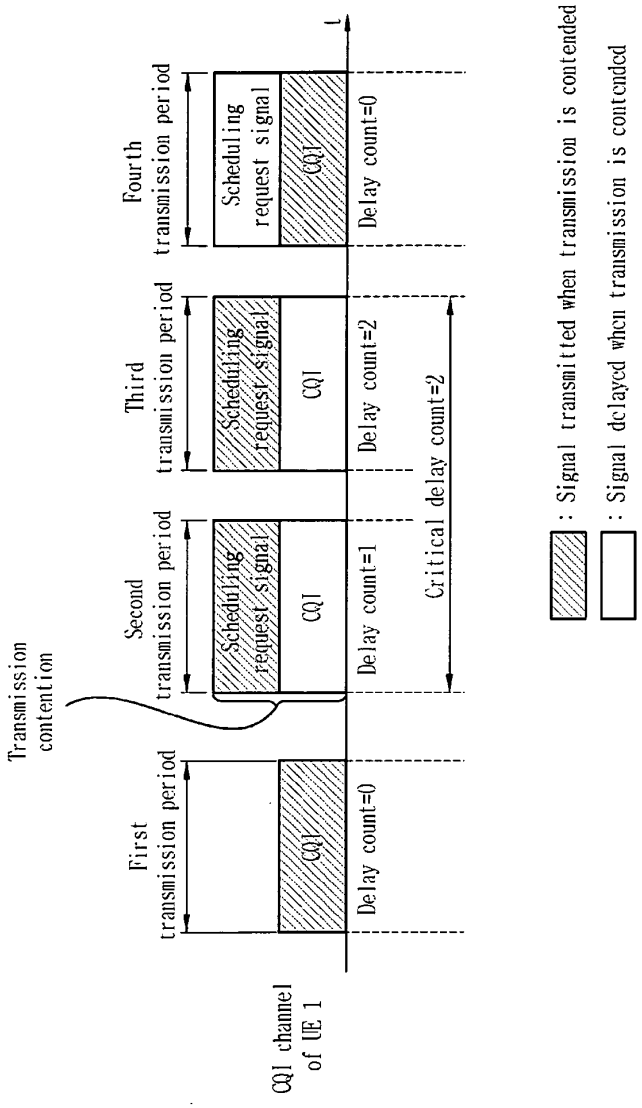
[Fig. 15]


Transmissoin depending on priority
t
Second transmission period
Scheduling request signal
CQI
Transmission contention
First transmission period
CQI
CQI channel of UE 1

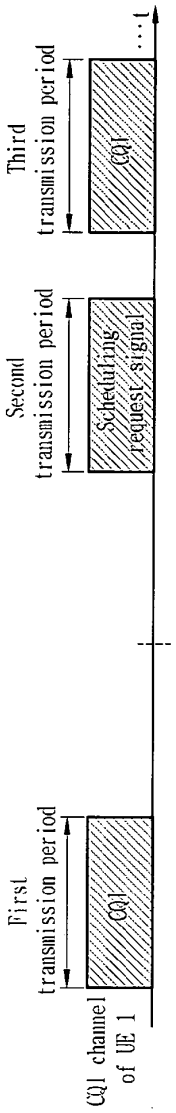
[Fig. 16]


Transmission contention
First transmission period
Second transmission period
Third transmission period
Fourth transmission period
CQI
Scheduling request signal
Delay count=0
Delay count=1
Delay count=2
Critical delay count=2
t
CQI channel of UE 1
: Signal transmitted when transmission is contended
: Signal delayed when transmission is contended

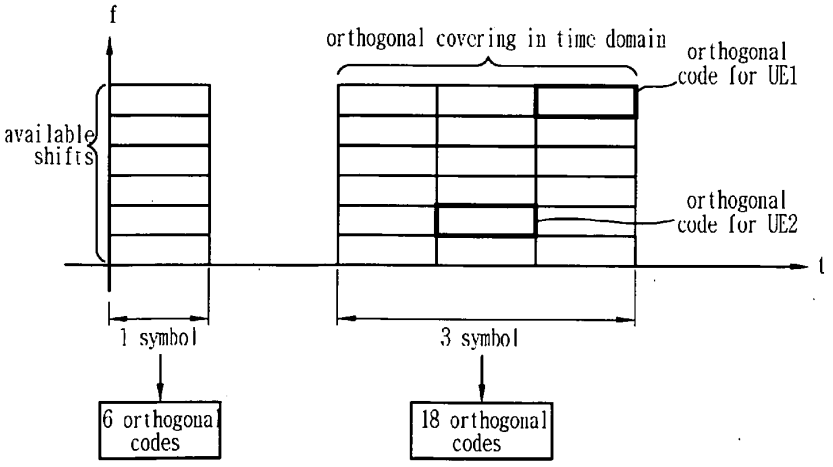
[Fig. 17]


CQI channel of UE 1
Transmission contention
First transmission period
Second transmission period
Third transmission period
Fourth transmission period
Scheduling request signal
CQI
Delay count=0
Delay count=1
Delay count=2
Critical delay count=2
t
: Signal transmitted when transmission is contended
: Signal delayed when transmission is contended

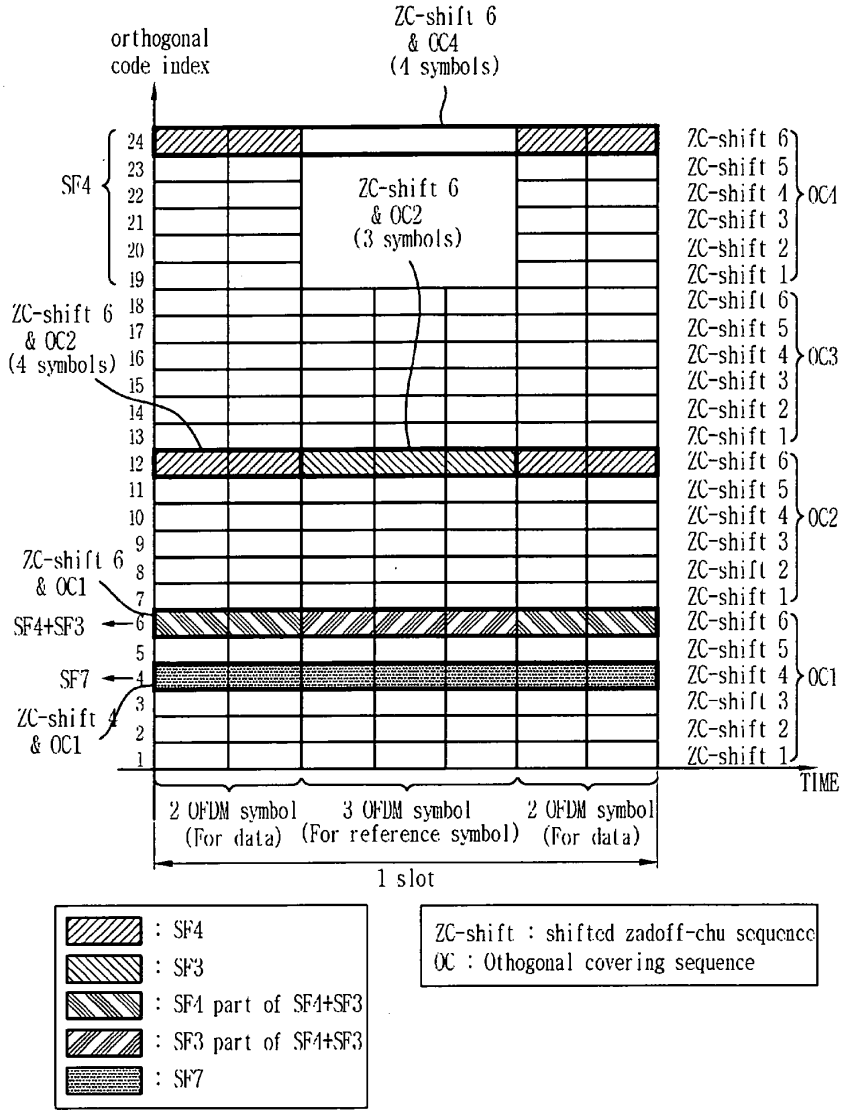
[Fig. 18]


Third transmission period
CQI
Second transmission period
Scheduling request signal
First transmission period
CQI
CQI channel of UE 1

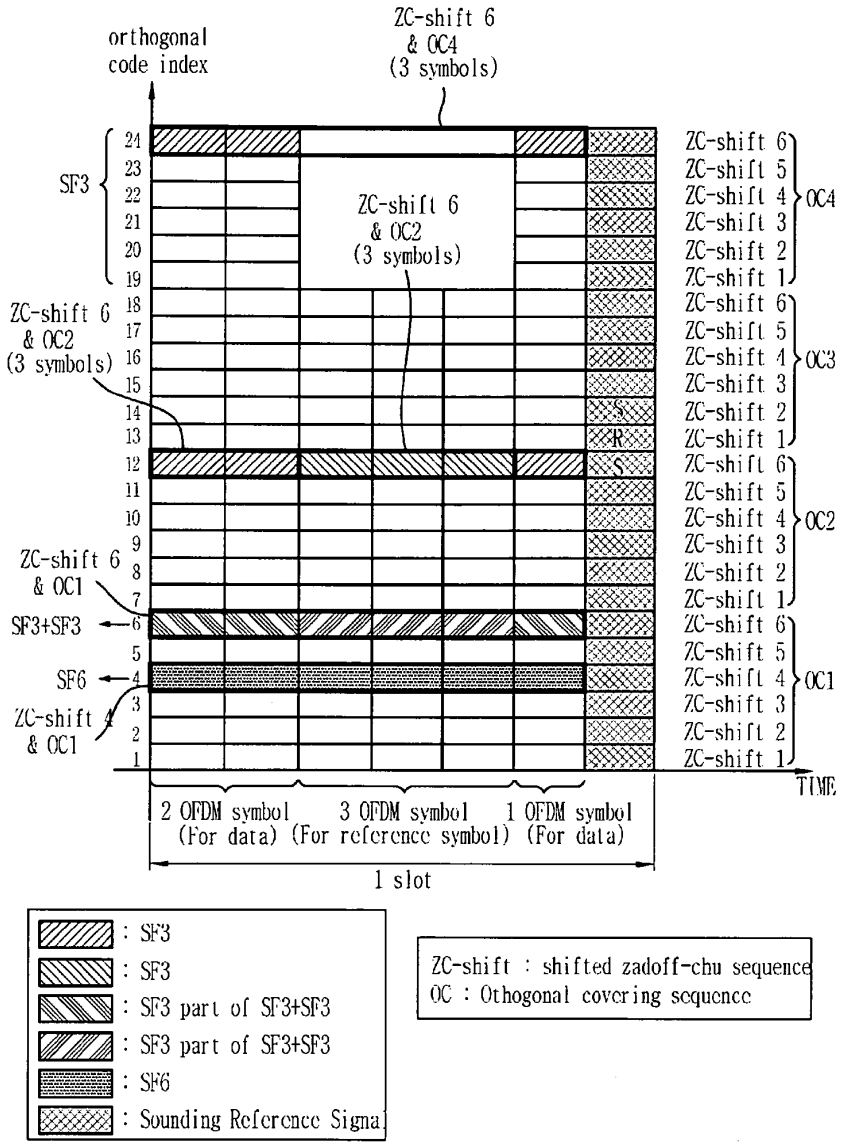
[Fig. 19]


f
orthogonal covering in time domain
orthogonal code for UE1
available shifts
orthogonal code for UE2
t
1 symbol
3 symbol
6 orthogonal codes
18 orthogonal codes

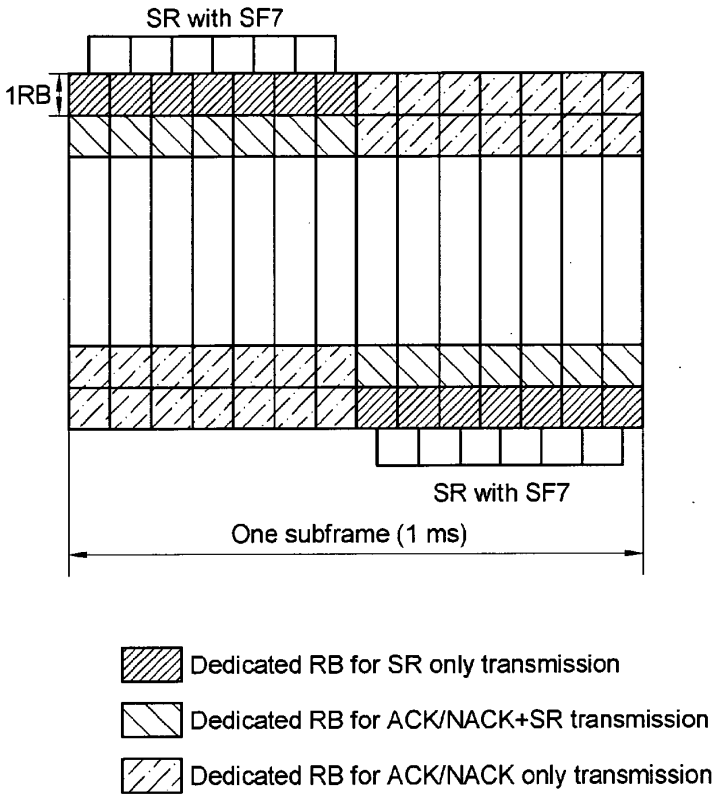
[Fig. 20]


orthogonal code index
ZC-shift 6 & OC4 (4 symbols)
ZC-shift 6 & OC2 (3 symbols)
ZC-shift 6 & OC2 (4 symbols)
ZC-shift 6 & OC1
SF4
SF4+SF3
SF7
ZC-shift 4 & OC1
24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
ZC-shift 6
ZC-shift 5
ZC-shift 4
ZC-shift 3
ZC-shift 2
ZC-shift 1
OC1
OC3
OC2
OC1
TIME
2 OFDM symbol (For data)
3 OFDM symbol (For reference symbol)
2 OFDM symbol (For data)
1 slot
: SF4
: SF3
: SF4 part of SF4+SF3
: SF3 part of SF4+SF3
: SF7
ZC-shift : shifted zadoff-chu sequence
OC : Othogonal covering sequence

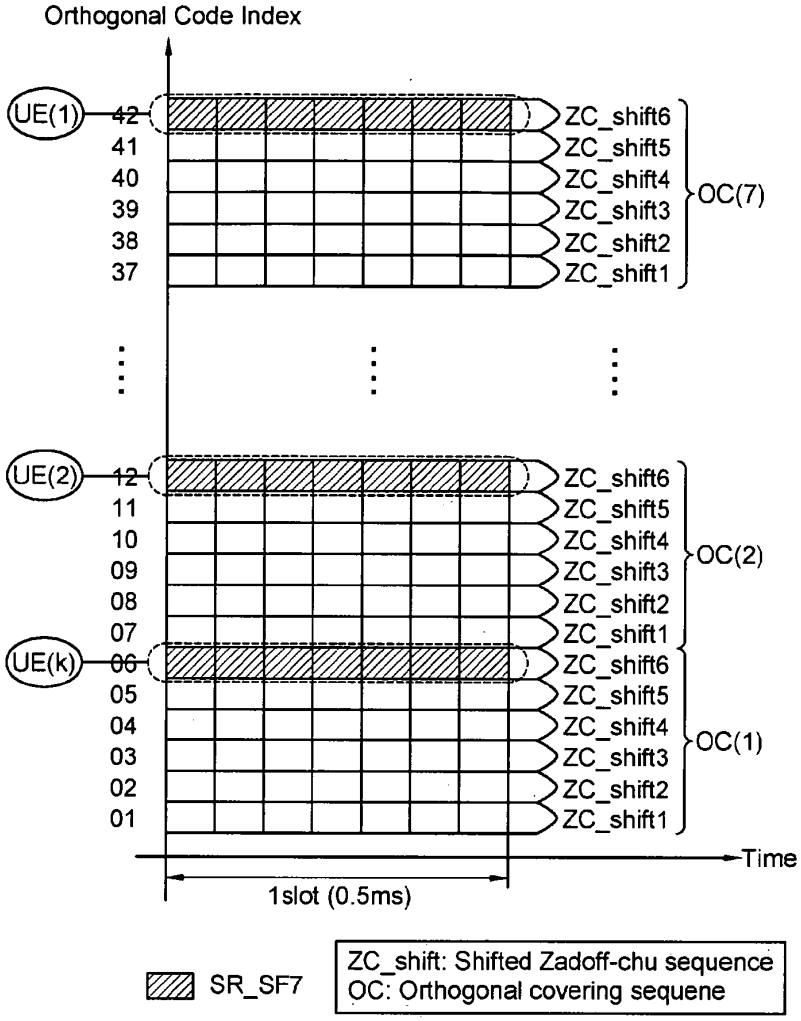
[Fig. 21]


orthogonal code index
ZC-shift 6 & OC4 (3 symbols)
ZC-shift 6 & OC2 (3 symbols)
ZC-shift 6 & OC2 (3 symbols)
ZC-shift 6 & OC1
SF3+SF3
SF6
ZC-shift 4 & OC1
SF3
24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
ZC-shift 6 ZC-shift 5 ZC-shift 4 ZC-shift 3 ZC-shift 2 ZC-shift 1
OC4
OC3
OC2
OC1
S
R
TIME
2 OFDM symbol (For data)
3 OFDM symbol (For reference symbol)
1 OFDM symbol (For data)
1 slot
: SF3
: SF3
: SF3 part of SF3+SF3
: SF3 part of SF3+SF3
: SF6
: Sounding Reference Signal
ZC-shift : shifted zadoff-chu sequence
OC : Othogonal covering sequence

[Fig. 22]

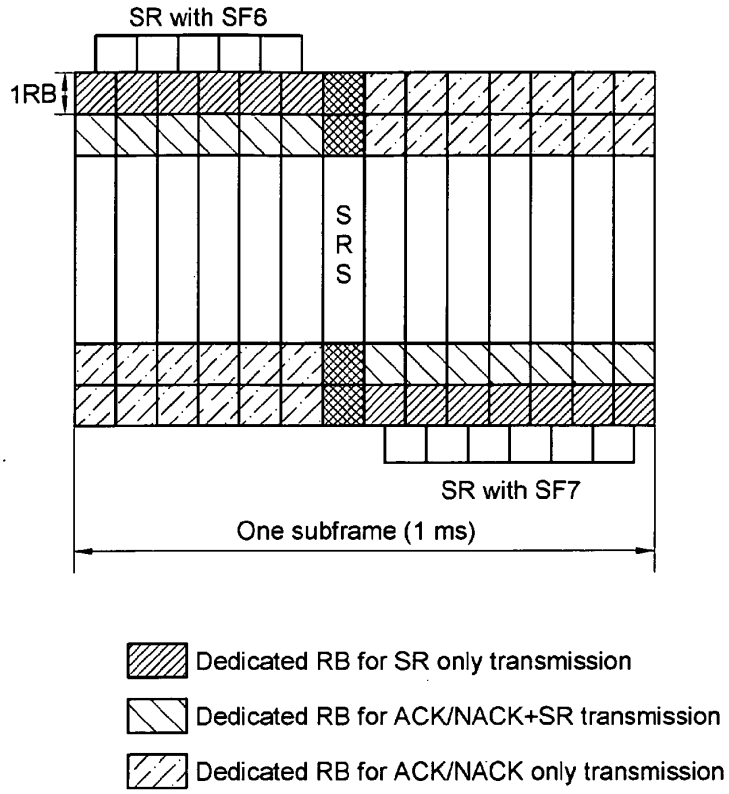

SR with SF7
1RB
SR with SF7
One subframe (1 ms)
Dedicated RB for SR only transmission
Dedicated RB for ACK/NACK+SR transmission
Dedicated RB for ACK/NACK only transmission

[Fig. 23]

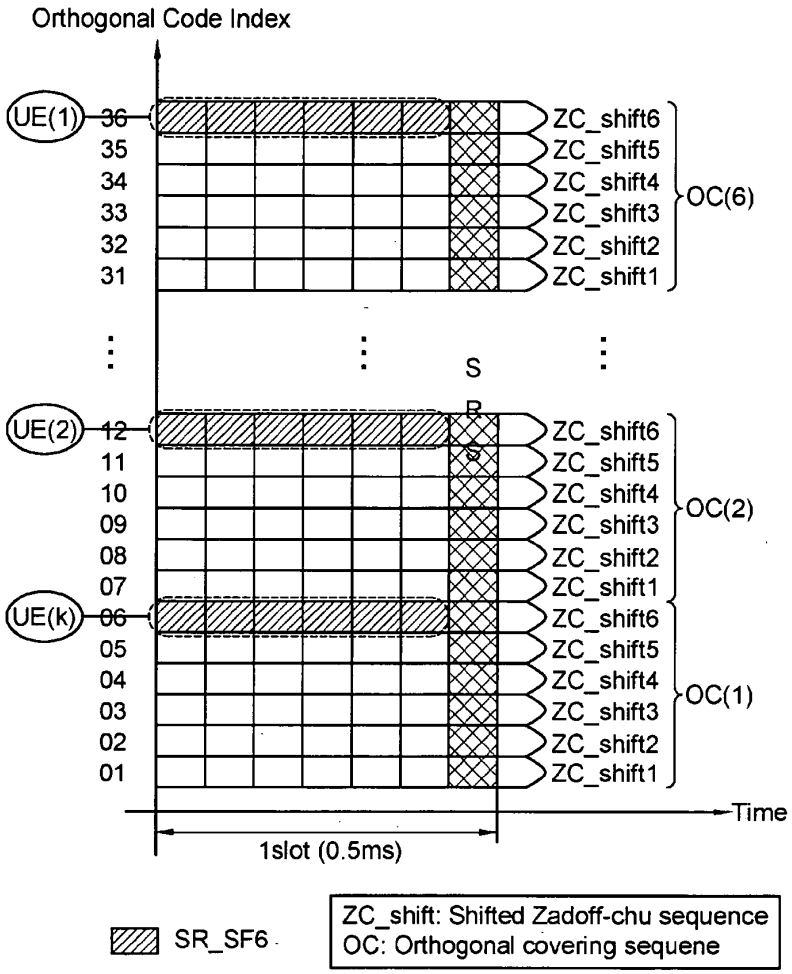


Sequence index management in
Dedicated RB for SR only transmission

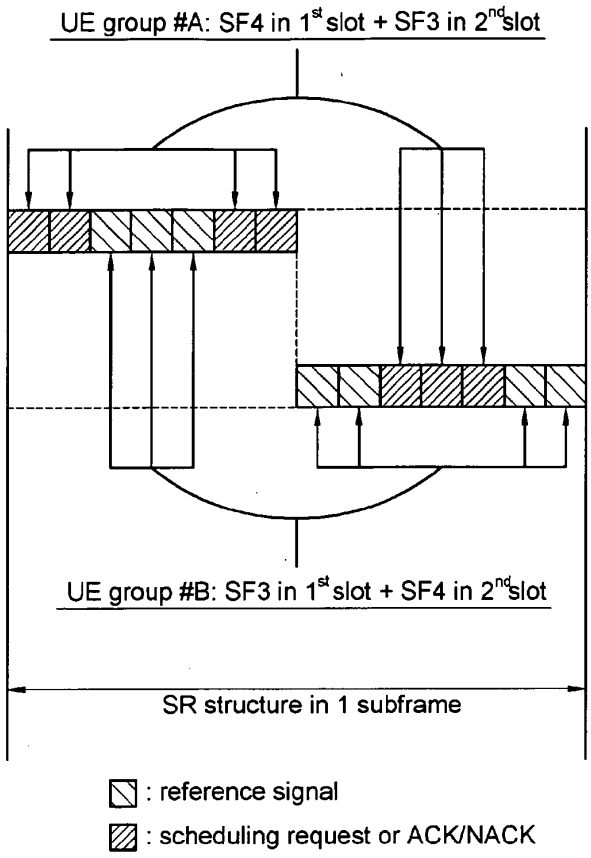
[Fig. 24]


SR with SF6
1RB
S
R
S
SR with SF7
One subframe (1 ms)
Dedicated RB for SR only transmission
Dedicated RB for ACK/NACK+SR transmission
Dedicated RB for ACK/NACK only transmission

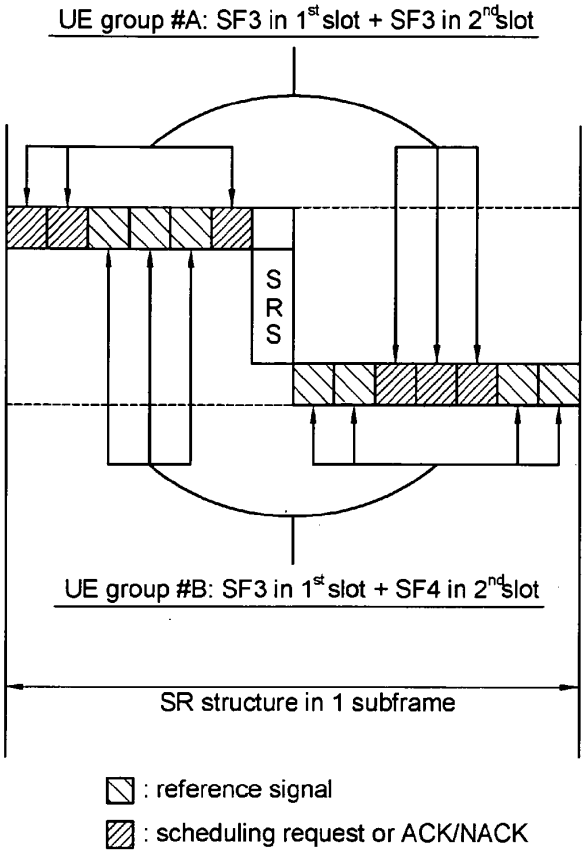
[Fig. 25]


Orthogonal Code Index
UE(1)
36
35
34
33
32
31
ZC_shift6
ZC_shift5
ZC_shift4
ZC_shift3
ZC_shift2
ZC_shift1
OC(6)
S
R
UE(2)
12
11
10
09
08
07
ZC_shift6
ZC_shift5
ZC_shift4
ZC_shift3
ZC_shift2
ZC_shift1
OC(2)
UE(k)
06
05
04
03
02
01
ZC_shift6
ZC_shift5
ZC_shift4
ZC_shift3
ZC_shift2
ZC_shift1
OC(1)
Time
1slot (0.5ms)
SR_SF6
ZC_shift: Shifted Zadoff-chu sequence
OC: Orthogonal covering sequene

[Fig. 26]


UE group #A: SF4 in 1st slot + SF3 in 2nd slot
UE group #B: SF3 in 1st slot + SF4 in 2nd slot
SR structure in 1 subframe
: reference signal
: scheduling request or ACK/NACK

[Fig. 27]


UE group #A: SF3 in 1st slot + SF3 in 2nd slot
S
R
S
UE group #B: SF3 in 1st slot + SF4 in 2nd slot
SR structure in 1 subframe
: reference signal
: scheduling request or ACK/NACK

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2008/004724

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/26(2006.01)i, H04L 27/26(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 8 : H04B, H04L, H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Utility models and applications for Utility models since 1975

Japanese Utility models and application for Utility models since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EKIPASS(KIPO, internal), 3GPP, IEEE xplore "Keyword: scheduling, request and uplink."

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	ALCATEL-LUCENT, "Multiplexing the Scheduling Request in the Uplink." R1-073066, 3GPP TSG-RAN WG1 #49bis, Orlando, US, June 25-29, 2007.	1-15
A	NOKIA SIEMENS NETWORKS, NOKIA, "Multiplexing of Scheduling Request and ACK/NACK and/or CQI.", 3GPP TSG RAN WG1 #49bis, R1-073011, Orlando, USA, June 25-29, 2007.	1-15
A	NOKIA SIEMENS NETWORKS, NOKIA, "Performance of CQI+ACK/NACK transmission on PUCCH.", 3GPP TSG RAN WG1 Meeting #49bis, R1-073003, Orlando, USA, June 25-29, 2007.	1-15
A	NEC GROUP, NTT DOCOMO, "Multiplexing of uplink data-non-associated control signal with data.", 3GPP TSG RAN WG1 #49bis, R1-072833, Orlando, USA, June 25-29, 2007.	1-15

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 DECEMBER 2008 (29.12.2008)	**29 DECEMBER 2008 (29.12.2008)**

Name and mailing address of the ISA/KR	Authorized officer
Korean Intellectual Property Office Government Complex-Daejeon, 139 Seonsa-ro, Seo-gu, Daejeon 302-701, Republic of Korea	Kim, Yun Bae
Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-5715

Form PCT/ISA/210 (second sheet) (July 2008)

IN THE U.S. PATENT AND TRADEMARK OFFICE

In re U.S. Patent Application of:

APPLICANTS: Kari P. Pajukoski et al.

SERIAL NO.: 14/051,646 FILING DATE: October 11, 2013

EXAMINER: Thompson, Jr, Otis L ART UNIT: 2477

ATTORNEY'S DOCKET NO.: 863.0076.U2 (US)

TITLE: PROVIDING IMPROVED SCHEDULING REQUEST SIGNALING WITH ACK/NACK OR CQI

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SUPPLEMENTAL RESPONSE TO OFFICE ACTION

This paper is herewith filed as a Supplemental Response to the Response filed December 29, 2014 in response to the Examiner's Office Action mailed on August 1, 2014 for the above-captioned U.S. Patent Application. This Response includes the amendments to the claims as presented in the original Response filed December 29, 2014, as well as additional amendments. For at least the reason that the original Response filed December 29, 2014 included fees necessary to effect the Response no petition for an extension of time or late fee is believed to be due for this Supplemental Response. However, should the undersigned attorney be mistaken, please consider this a petition for any extension of time that may be required to maintain the pendency of this Patent Application, and charge deposit account no. 50-1924 for any required fee deficiency.

AMENDMENTS TO THE CLAIMS:

This listing of the claims will replace all prior versions, and listings, of the claims in this application.

Listing of Claims:

1. (Currently Amended) A method comprising:

determining that an acknowledgment is to be sent on a physical uplink control channel, where transmission of the acknowledgement on the physical uplink control channel comprises an unmodulated sequence in addition to the acknowledgement data; and

for [[the]] a case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource,

else placing the acknowledgment in another resource.

2. (Original) The method of claim 1, comprising:

for the case where there is also the scheduling request to be sent, transmitting the acknowledgment with the scheduling request on the scheduling resource.

3. (Previously Presented) The method of claim 1, comprising:

for a case where a channel quality indicator is also to be sent, the channel quality indicator is not sent and the another resource is unused.

4. (Previously Presented) The method of claim 1, where the another resource is a data-non-associated resource.

5. (Original) The method of claim 2, where the transmitting is on a physical uplink control channel.

6. (Previously Presented) The method of claim 2, where the transmitting is on an uplink.

7. (Currently Amended) The method of claim 1, where the ~~transmission of the acknowledgment comprises an~~ unmodulated sequence [[1]] comprises reference signals and the acknowledgement data is a BPSK/QPSK modulated sequence [[2]].

8. (Cancelled)

9. (Previously Presented) The method of claim 1 implemented in a wireless communications network.

10. (Previously Presented) The method of claim 1 implemented in an evolved universal terrestrial radio access network.

11. (Currently Amended) A non-transitory computer readable medium encoded with a computer program executable by a processor to perform actions comprising:

determining that an acknowledgment is to be sent on a physical uplink control channel, where transmission of the acknowledgement on the physical uplink control channel comprises an unmodulated sequence in addition to the acknowledgement data; and

for [[the]] a case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource,

else placing the acknowledgment in another resource.

12. (Currently Amended) The non-transitory computer readable medium encoded with a computer program of claim 11, comprising:

for the case where there is also the scheduling request to be sent, transmitting the acknowledgment with the scheduling request on the scheduling resource.

13. (Currently Amended) The non-transitory computer readable medium encoded with a computer program of claim 11, comprising:

for a case where a channel quality indicator is also to be sent, the channel quality indicator is not sent and the another resource is unused.

14. (Currently Amended) The non-transitory computer readable medium encoded with a computer program of claim 11, where the another resource is a data-non-associated resource.

15. (Currently Amended) An apparatus comprising:

at least one processor; and

at least one memory including computer program code, where the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to at least:

~~a processor configured to~~ determine that an acknowledgment is to be sent on a physical uplink control channel, where transmission of the acknowledgement on the physical uplink control channel comprises an unmodulated sequence in addition to the acknowledgement data; and

~~the processor further configured to,~~ for [[the]] a case where there is also a scheduling request to be sent, combine the acknowledgment with the scheduling request on a scheduling resource,

else placing the acknowledgment in another resource.

16. (Currently Amended) The apparatus of claim 15, ~~comprising:~~

~~a transmitter configured to~~ where the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus, for the case where there is also the scheduling request to be sent, to transmit the acknowledgment with the scheduling request on the scheduling resource.

17. (Currently Amended) The apparatus of claim 15 ~~comprising:~~

~~the processor further configured to~~ where the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus, for a case where a channel quality indicator is also to be sent, to drop the channel quality indicator such that it is not sent and the another resource is unused.

18. (Previously Presented) The apparatus of claim 15, where the another resource is a data-non-associated resource.

19. (Currently Amended) The apparatus of claim 16, where the ~~transmitter is configured to transmit~~ the acknowledgment with the scheduling request is transmitted on a physical uplink control channel.

20. (Previously Presented) The apparatus of claim 16, where the transmitter is configured to transmit the acknowledgment with the scheduling request on an uplink.

21. (Currently Amended) The apparatus of claim 15, where the ~~transmission of the acknowledgment comprises an~~ unmodulated sequence [[1]] comprises reference signals and the acknowledgement data is a BPSK/QPSK modulated sequence [[2]].

22. (Previously Presented) The apparatus of claim 15, embodied in a user equipment.

23. (Previously Presented) The apparatus of claim 15, configured to operate in a wireless communications network.

24. (Previously Presented) The apparatus of claim 15 configured to operate in an evolved universal terrestrial radio access network.

25. – 34. (Cancelled)

35. (Currently Amended) A method comprising:

receiving information on a scheduling resource; and

determining that the information received on the scheduling resource comprises an acknowledgment transmission, where the acknowledgement transmission comprises an unmodulated sequence in addition to the acknowledgement data.

36. (Original) The method of claim 35, comprising

responding accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment.

37. (Previously Presented) The method of claim 35 where the information is received on a physical uplink control channel.

38. (Previously Presented) The method of claim 35 where the information is received from a wireless communications network.

39. (Previously Presented) The method of claim 31 where the information is received from an evolved universal terrestrial radio access network.

40. (Currently Amended) A non-transitory computer readable medium encoded with a computer program executable by a processor to perform actions comprising:

receiving information on a scheduling resource; and

determining that the information received on the scheduling resource comprises an acknowledgment transmission, where the transmission comprises an unmodulated sequence in addition to the acknowledgement data.

41. (Currently Amended) The non-transitory computer readable medium encoded with a computer program of claim 40, comprising

responding accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment

42. (Currently Amended) An apparatus comprising:

~~a receiver;~~

~~the receiver configured to~~ at least one processor; and

at least one memory including computer program code, where the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to at least:

receive information on a scheduling resource; and

~~a processor configured to~~ determine that the information received on the scheduling resource comprises an acknowledgment transmission, where the acknowledgement transmission comprises an unmodulated sequence in addition to the acknowledgment data.

43. (Currently Amended) The apparatus of claim 42 ~~further comprising:~~

~~a transmitter;~~

~~the transmitter and the processor responding~~ where the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to respond accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment transmission.

44. (Currently Amended) The apparatus of claim 42 where the ~~receiver is further configured~~ at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to receive the information on a physical uplink control channel.

45. (Currently Amended) The apparatus of claim 42 where the ~~receiver is further configured~~ at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to receive the information from a wireless communications network.

46. (Currently Amended) The apparatus of claim 42 where the ~~receiver is further configured~~ at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to receive the information from an evolved universal terrestrial radio access network.

47. – 49. (Cancelled)

50. (Currently Amended) A method comprising:

determining that a scheduling request resource and at least one other resource are reserved for a user equipment in a same sub-frame; and

based on whether a scheduling request is desired to be transmitted by the user equipment, placing at least one of an acknowledgment/negative acknowledgement and a channel quality indicator that is desired to be transmitted by the user equipment in one of the resources and leaving at least one other resource unused, where the transmission is to comprise an unmodulated sequence in addition to the acknowledgement data.

51. (Original) The method of claim 50, where the scheduling request resource and the at least one other resource are physical uplink control channel resources.

52. (Currently Amended) The method of claim 50 comprising:

for [[the]] a case where the user equipment desires to transmit a scheduling request and transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement with the scheduling request on the scheduling request resource and leaving the at least one other resource unused; or

for [[the]] a case where the user equipment does not desire to transmit a scheduling request and does desire to transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement on the at least one other resource and leaving the scheduling request resource unused.

53. (Currently Amended) The method of claim 50 comprising:

for [[the]] a case where the user equipment desires to transmit a scheduling request and a channel quality indicator but no acknowledgment/negative acknowledgement,

transmitting the scheduling request on the scheduling request resource and not transmitting the channel quality indicator leaving the at least one other resource unused.

54. (Currently Amended) The method of claim 50 comprising:

for [[the]] a case where the user equipment desires to transmit a scheduling request, transmit a channel quality indicator, and transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement with the scheduling request on the scheduling request resource and not transmitting the channel quality indicator leaving the at least one other resource unused; or

for [[the]] a case where the user equipment does not desire to transmit a scheduling request and does desire to transmit a channel quality indicator and an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement and the channel quality indicator on the at least one other resource and leaving the scheduling request resource unused.

55. (Previously Presented) The method of claim 50, where the scheduling request information is conveyed based on a selected physical uplink control channel selection.

56. (New) A method comprising:

determining that an acknowledgment transmission is to be sent; and

for a case where there is also a scheduling request to be sent, transmitting the acknowledgment data with the scheduling request on a scheduling resource in an uplink, where there is no need to specify a separate modulation or multiplexing operation used for transmission of the acknowledgement data with the scheduling request, from a modulation or multiplexing operation used for transmission of the acknowledgement on another resource.

57. (New) The method of claim 56, comprising: transmitting the acknowledgment with the scheduling request on the scheduling resource.

58. (New) The method of claim 57, where the transmitting is on a physical uplink control channel.

59. (New) An apparatus comprising:

at least one processor; and

at least one memory including computer program code, where the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to at least:

determine that an acknowledgment transmission is to be sent; and

for a case where there is also a scheduling request to be sent, transmit the acknowledgment with the scheduling request on a scheduling resource in an uplink, where there is no need to specify a separate modulation or multiplexing operation used for transmission of the acknowledgement with the scheduling request, from a modulation or multiplexing operation used for transmission of the acknowledgement on another resource.

60. (New) The apparatus of claim 59, where the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to transmit the acknowledgment with the scheduling request on the scheduling resource.

61. (New) The apparatus of claim 59, where the transmitting is on a physical uplink control channel.

REMARKS:

This paper is herewith filed as a Supplemental Response to the Response filed December 29, 2014 in response to the Examiner's Office Action mailed on August 1, 2014 for the above-captioned U.S. Patent Application. This Response includes the amendments to the claims as presented in the original Response filed December 29, 2014, as well as additional amendments to claims 1, 7, 11, 15, 21, 35, 40, and new claim 56.

This office action is a rejection of claims 1-55 of the application. More specifically, the Examiner has rejected claims 1, 3-4, 7, 9-10, 50-51 and 55 under 35 USC 101 asserting that the claimed invention is directed to non-statutory subject matter; rejected claims 1-34 and 52-54 under 35 USC 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention; rejected claims 1-2, 4-12, 14-16, 18-26, 28-52 and 55 under 35 USC 102(e) as anticipated by Bachl (US20080316959); and rejected claims 3, 13, 17, 27 and 53-54 under 35 USC 103(a) as being unpatentable over Bachl and further in view of Papasakellariou (US2009002135). The Applicant respectfully traverses the rejection.

Claims 1, 7, 11-17, 19, 21, 35, 40-46, 50, and 52-54 have been amended. Claims 56-61 have been added. Claims 25-34, and 47-49 are cancelled. Support for the amendments can be found at least in paragraphs [0005], [0036], and [0055] of the application as filed. No new matter is added.

Rejections under 35 USC 101

Regarding the rejection under 35 USC 101 the Applicant's Representative kindly requests that the Examiner allow this rejection to be addressed at a later time. The Applicant's Representative is working with the client to identify a suitable response to the rejection. The Examiner is sincerely thanked for his consideration in this matter.

Rejections under 35 USC 112, second paragraph

Claims 1, 11, and 52-53 have been amended to address the rejection. The rejection under 35 USC 112, second paragraph, is seen to be overcome and the Examiner is requested to remove the rejection.

Rejection of Independent Claims 1, 11, 15, 35, 40, 42, and 50

First, it is noted that in this Supplemental Response to Office Action independent claims 1, 11, 15, 35, 40, and new claim 56 have been amended to relate to sending or receiving an acknowledgement including an unmodulated sequence in addition to the acknowledgement data. Further, in this regards dependent claims 7 and 21 have been amended to relate to the unmodulated sequence comprises reference signals and the acknowledgement data is a BPSK/QPSK modulated sequence. These amendments are seen to further distinguish at least these claims from the references cited.

Although the rejections are not expressly or impliedly agree with, in order to facilitate the prosecution of this patent application towards allowance each of the independent claims 1, 11, 15, 35, 40, 42, and 50 have been amended in a somewhat similar fashion to recite features similar to claim 21. For example, claim 1 now recites:

> A method comprising: determining that an acknowledgment is to be sent on a physical uplink control channel, where transmission of the acknowledgement on the physical uplink control channel comprises an unmodulated sequence in addition to the acknowledgement data; and for a case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource, else placing the acknowledgment in another resource.

In accordance with an exemplary embodiment of the invention in an acknowledgment transmission is sent in a physical uplink control channel wherein the acknowledgement transmission includes an unmodulated sequence such as a demodulation reference signal sequence for Format 1/1a/1b *in addition to acknowledgment data*. Bachl does not anticipate at least these similar features as

claimed in amended claim 1.

In the rejection of claim 21, now similarly incorporated into claim 1, the Examiner asserts:

> "**Regarding claims 21 and 31,** Bachl et al. discloses *where the acknowledgment comprises an unmodulated sequence I and a BPSK/QPSK modulate sequence 2* (Paragraph 0032, wherein the ACK/NACK uses BPSK and QPSK modulation)," (emphasis added), (page 8 of the Office Action).

First, it is respectfully noted that in the rejection the Examiner cites where Bachl discloses that the ACK/NACK uses BPSK and QPSK modulation. However, Bachl does not disclose a transmission of an acknowledgment on a physical uplink control channel which comprises an unmodulated sequence in addition to acknowledgement data.

Bachl as cited discloses:

> "Referring back to FIG. 1, scheduling requests may also collide with other control information transmitted over the unscheduled uplink channel 130. For example, the mobile unit 110 may need to transmit a scheduling request over the unscheduled uplink channel 130 concurrently with transmitting an acknowledgment or non-acknowledgment message. The mobile unit 110 may therefore be able to transmit information indicative of the scheduling request and the other control information using the resources allocated for transmission of the other control information over the unscheduled uplink channel 130. For example, when the scheduling request collides with an acknowledgment or non-acknowledgment message, the mobile unit 110 may switch from the Binary Phase Shift Key (BPSK) modulation that is typically used to modulate the acknowledgment or non-acknowledgment message to a higher order modulation scheme such as Quadrature Phase Shift Key (QPSK) modulation. Using the higher order modulation scheme increases the size of the constellation of symbol values so that information indicative of both the scheduling request and the acknowledgement or non-acknowledgment message can be transmitted using the resources allocated for transmission of the acknowledgment or non-acknowledgment message without increasing the peak-to-average power ratio," (emphasis added), (paragraph [0032]).

Here, Bachl discloses that when the scheduling request collides with an acknowledgment or non-

acknowledgment message the mobile unit 110 may switch from BPSK modulation to QPSK modulation alleging that using the higher order modulation scheme the ack/nack messages can be transmitted without increasing a peak-to-average power ratio.

Bachl does not disclose that the ack/nack messages are transmitted where the transmission on a physical uplink control channel and where the transmission comprises an unmodulated sequence in *addition to the ack/nack message*. For at least these reasons Bachl does not disclose or suggest at least where amended claim 1 recites in part:

> determining that an acknowledgment is to be sent on a physical uplink control channel, where transmission of the acknowledgement on the physical uplink control channel comprises an unmodulated sequence in addition to the acknowledgement data; and for a case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource, else placing the acknowledgment in another resource

For at least these reasons the rejection of claim 1 should be removed and amended claim 1 should be allowed.

In addition, none of the references cited overcome at least the above stated shortfalls of Bachl.

Papasakellariou

First it is noted that only the provisional applications 60/950,002 and 60/954,171 of Papasakellariou have a filing date earlier than the priority date October 30, 2007 of the instant application based of the filing date of the provisional application No. 61/001,207. The provisional application 60/954,171 of Papasakellariou was filed on January 8, 2008 whereas the provisional filing date of the pending application is October 30, 2007. It is submitted that none of the Papasakellariou provisional applications disclose or suggest at least where amended claim 1 recites in part:

> determining that an acknowledgment is to be sent on a physical uplink control

> channel, where transmission of the acknowledgement on the physical uplink control channel comprises an unmodulated sequence in addition to the acknowledgement data; and for a case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource, else placing the acknowledgment in another resource

Thus, none of the Papasakellariou provisional applications can be seen to overcome at least the shortfalls of Bachl as stated above. Furthermore, it is noted that the Papasakellariou non-provisional application 2009/0022135 as cited in the rejection of claims 3, 13, 17, 27, and 53-54 (see page 16 of the Office Action) discloses:

> "As described above in the background, the CQI transmission from a UE in a Physical Uplink Control CHannel (PUCCH), which is typically periodic in nature, may occur in the same sub-frame as the ACK/NACK signal transmission to support Hybrid Automatic Repeat reQuest (HARQ) (HARQ-ACK) in response to a prior data reception by the UE in the downlink of the communication system. As the ACK/NACK signal transmission usually cannot be postponed, it is beneficial to multiplex it with the CQI signal transmission. Otherwise, the CQI signal transmission should be dropped, which may cause scheduling inefficiencies in the downlink of the communication system due to the absence of relevant CQI," (emphasis added), (US20090022135 paragraph [0062]).

Although the rejection using Papasakellariou is not agreed to it is respectfully submitted that after a thorough review of each of the three provisional applications of Papasakellariou, as stated above, there cannot be found in any disclosure that the CQI is dropped, as asserted by the Examiner. For this reason alone the rejection is improper and the rejection should be removed.

Further, according to Papasakellariou, "Referring to FIG. 3, the CAZAC sequence 310 is generated through one of the previously described methods (modulated for transmission of CQI bits, un-modulated for RS transmission)," (paragraph [0018]). Thus, for at least these reasons Papasakellariou does not overcome the shortfalls of Bachl as stated above.

Further, it is submitted that the Examiner allow claims 3, 13, 17, 27, and 53-54 or else cite support for the rejection in an application which *in its entirety* predates the pending application. For these reasons alone the rejection using Papasakellariou should be removed. Therefore, for at

least these reasons the Examiner is respectfully requested to remove the rejection and allow claim 1.

In addition, for similar reasons as stated above with regards to claim 1 the references cited do not disclose or suggest independent claims 11, 15, 35, 40, 42, and 50. Thus, for at least these reasons the Examiner is respectfully requested to remove the rejection and allow these claims.

Regarding New Independent Claim 56

It is respectfully submitted that for at least the reasons already stated none of the references cited disclose or suggest at least where new claim 56 recites in part:

> determining that an acknowledgment data transmission is to be sent; and for a case where there is also a scheduling request to be sent, transmitting the acknowledgment with the scheduling request on a scheduling resource in an uplink, where there is no need to specify a separate modulation or multiplexing operation used for transmission of the acknowledgement data with the scheduling request, from a modulation or multiplexing operation used for transmission of the acknowledgement on another resource

Therefore, the Examiner is respectfully requested to allow claim 56.

In addition, for similar reasons as stated above with regards to claim 56 the references cited do not disclose or suggest independent claim 59. Thus, for at least these reasons the Examiner is respectfully requested to allow claims 56 and 59.

Regarding the Rejection of Amended Claims 7 and 21

In the rejection of claim 7 the Examiner asserts:

> "Bachl et al. discloses *where the acknowledgment comprises an unmodulated sequence 1 and a BPSK/QPSK modulate sequence 2* (Paragraph 0032, wherein the ACK/NACK uses BPSK and QPSK modulation)," (page 15 of the Office

Action).

First, it is noted that claim 7 has been amended to recite "The method of claim 1, where the unmodulated sequence comprises reference signals and the acknowledgement data is a BPSK/QPSK modulated sequence."

Bachl as cited discloses:

> "Referring back to FIG. 1, scheduling requests may also collide with other control information transmitted over the unscheduled uplink channel 130. For example, the mobile unit 110 may need to transmit a scheduling request over the unscheduled uplink channel 130 concurrently with transmitting an acknowledgment or non-acknowledgment message. The mobile unit 110 may therefore be able to transmit information indicative of the scheduling request and the other control information using the resources allocated for transmission of the other control information over the unscheduled uplink channel 130. For example, when the scheduling request collides with an acknowledgment or non-acknowledgment message, the mobile unit 110 may switch from the Binary Phase Shift Key (BPSK) modulation that is typically used to modulate the acknowledgment or non-acknowledgment message to a higher order modulation scheme such as Quadrature Phase Shift Key (QPSK) modulation. Using the higher order modulation scheme increases the size of the constellation of symbol values so that information indicative of both the scheduling request and the acknowledgement or non-acknowledgment message can be transmitted using the resources allocated for transmission of the acknowledgment or non-acknowledgment message without increasing the peak-to-average power ratio," (emphasis added), (paragraph [0032]).

Here, Bachl discloses switching **from** the Binary Phase Shift Key (BPSK) modulation to a higher order modulation scheme such as Quadrature Phase Shift Key (QPSK) modulation, and using the higher order modulation scheme to modulate information indicative of both the scheduling request and the acknowledgement or non-acknowledgment message. Bachl does not disclose that the higher order modulation scheme is somehow comprises reference signals and acknowledgement data that is a BPSK/QPSK modulated sequence.

For at least these reasons the Examiner is respectfully requested to remove the rejection and allow amended claim 7.

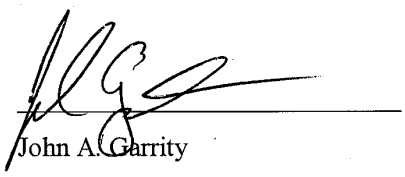
In addition, for similar reasons as stated above with regards to claim 7, the Examiner is respectfully requested to remove the rejection of amended claim 21 and allow this claim.

Further, for at least the reason that claims 2-5, 7, and 9; claims 12-14; claims 16-24; claims 36-39; claim 41, claims 43-46; claims 51-55; claims 57-58; and claims 60-61 depend from claims 1, 11, 15, 25, 35, 40, 42, 50, 59, and 59, respectively, the references cited do not disclose or suggest these claims.

Based on the above explanations and arguments, it is clear that the reference cited cannot be seen to disclose or suggest claims 1-7, 9-24, 35-46, and 50-61. The Examiner is respectfully requested to reconsider and remove the rejections of claims 1-7, 9-24, 35-46, and 50-61 and to allow all of the pending claims 1-7, 9-24, 35-46, and 50-61 as now presented for examination.

For all of the foregoing reasons, it is respectfully submitted that all of the claims now present in the application are clearly novel and patentable over the prior art of record. Should any unresolved issue remain, the Examiner is invited to call Applicants' attorney at the telephone number indicated below.

Respectfully submitted:



2/23/2015

John A. Garrity Date

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Electronic Acknowledgement Receipt

EFS ID:	21564722
Application Number:	14051646
International Application Number:	
Confirmation Number:	6128
Title of Invention:	Providing Improved Scheduling Request Signaling With ACK/NACK Or CQI
First Named Inventor/Applicant Name:	Kari P. Pajukoski
Customer Number:	29683
Filer:	Mark F. Harrington/John Sheehan
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Receipt Date:	23-FEB-2015
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Time Stamp:	09:39:23
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Supplemental Response or Supplemental Amendment	2007P03991US02_Amendment.pdf	736628 a4cedec72d07a767cc78df30e57db28e409f c66c	no	19
Warnings:					
Information:					

Total Files Size (in bytes):	736628

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 14/051,646	Filing Date 10/11/2013	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)		
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	02/23/2015	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 47	Minus	** 55	= 0	X $80 =	0
	Independent (37 CFR 1.16(h))	* 9	Minus	***9	= 0	X $420 =	0
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/CAROL BARNES/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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DEC 29 2014
PATENT & TRADEMARK OFFICE

IN THE U.S. PATENT AND TRADEMARK OFFICE

In re U.S. Patent Application of:

APPLICANTS: Kari P. Pajukoski et al.

SERIAL NO.: 14/051,646 FILING DATE: October 11, 2013

EXAMINER: Thompson, Jr, Otis L ART UNIT: 2477

ATTORNEY'S DOCKET NO.: 863.0076.U2 (US)

TITLE: PROVIDING IMPROVED SCHEDULING REQUEST SIGNALING WITH ACK/NACK OR CQI

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

RESPONSE TO OFFICE ACTION

This paper is herewith filed in response to the Examiner's Office Action mailed on August 1, 2014 for the above-captioned U.S. Patent Application. This Response is filed within two months following the shortened statutory period for reply recited in the referenced Office Action. Please consider this as a petition for an extension of time necessary to effect this Response, and charge Deposit Account No. 50-1924 ($600) for an extension of time fee. However, should the undersigned attorney be mistaken, please consider this a petition for any extension of time that may be required to maintain the pendency of this Patent Application, and charge deposit account no. 50-1924 for any required fee deficiency.

12/30/2014 HVUONG1 00000006 501924 14051646
01 FC:1252 600.00 DA

AMENDMENTS TO THE CLAIMS:

This listing of the claims will replace all prior versions, and listings, of the claims in this application.

Listing of Claims:

1. (Currently Amended) A method comprising:

determining that an acknowledgment is to be sent on a physical uplink control channel, where transmission of the acknowledgement on the physical uplink control channel comprises an unmodulated sequence in addition to the acknowledgement; and

for [[the]] a case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource,

else placing the acknowledgment in another resource.

2. (Original) The method of claim 1, comprising:

for the case where there is also the scheduling request to be sent, transmitting the acknowledgment with the scheduling request on the scheduling resource.

3. (Previously Presented) The method of claim 1, comprising:

for a case where a channel quality indicator is also to be sent, the channel quality indicator is not sent and the another resource is unused.

4. (Previously Presented) The method of claim 1, where the another resource is a data-non-associated resource.

5. (Original) The method of claim 2, where the transmitting is on a physical uplink control channel.

6. (Previously Presented) The method of claim 2, where the transmitting is on an uplink.

7. (Currently Amended) The method of claim 1, where the transmission of the acknowledgment comprises an unmodulated sequence 1 and a BPSK/QPSK modulated sequence 2.

8. (Cancelled)

9. (Previously Presented) The method of claim 1 implemented in a wireless communications network.

10. (Previously Presented) The method of claim 1 implemented in an evolved universal terrestrial radio access network.

11. (Currently Amended) A non-transitory computer readable medium encoded with a computer program executable by a processor to perform actions comprising:

determining that an acknowledgment is to be sent on a physical uplink control channel, where transmission of the acknowledgement on the physical uplink control channel comprises an unmodulated sequence in addition to the acknowledgement; and

for [[the]] a case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource,

else placing the acknowledgment in another resource.

12. (Currently Amended) The non-transitory computer readable medium encoded with a computer program of claim 11, comprising:

for the case where there is also the scheduling request to be sent, transmitting the acknowledgment with the scheduling request on the scheduling resource.

13. (Currently Amended) The non-transitory computer readable medium encoded with a computer program of claim 11, comprising:

for a case where a channel quality indicator is also to be sent, the channel quality indicator is not sent and the another resource is unused.

14. (Currently Amended) The non-transitory computer readable medium encoded with a computer program of claim 11, where the another resource is a data-non-associated resource.

15. (Currently Amended) An apparatus comprising:

at least one processor; and

at least one memory including computer program code, where the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to at least:

~~a processor configured to~~ determine that an acknowledgment is to be sent on a physical uplink control channel, where transmission of the acknowledgement on the physical uplink control channel comprises an unmodulated sequence in addition to the acknowledgement; and

~~the processor further configured to,~~ for [[the]] a case where there is also a scheduling request to be sent, combine the acknowledgment with the scheduling request on a scheduling resource,

else placing the acknowledgment in another resource.

16. (Currently Amended) The apparatus of claim 15, ~~comprising:~~

~~a transmitter configured to~~ where the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus, for the case where there is also the scheduling request to be sent, to transmit the acknowledgment with the scheduling request on the scheduling resource.

17. (Currently Amended) The apparatus of claim 15 ~~comprising:~~

~~the processor further configured to~~ where the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus, for a case where a channel quality indicator is also to be sent, to drop the channel quality indicator such that it is not sent and the another resource is unused.

18. (Previously Presented) The apparatus of claim 15, where the another resource is a data-non-associated resource.

19. (Currently Amended) The apparatus of claim 16, where the ~~transmitter is configured to transmit~~ the acknowledgment with the scheduling request is transmitted on a physical uplink control channel.

20. (Previously Presented) The apparatus of claim 16, where the transmitter is configured to transmit the acknowledgment with the scheduling request on an uplink.

21. (Currently Amended) The apparatus of claim 15, where the transmission of the acknowledgment comprises an unmodulated sequence 1 and a BPSK/QPSK modulated sequence 2.

22. (Previously Presented) The apparatus of claim 15, embodied in a user equipment.

23. (Previously Presented) The apparatus of claim 15, configured to operate in a wireless communications network.

24. (Previously Presented) The apparatus of claim 15 configured to operate in an evolved universal terrestrial radio access network.

25. – 34. (Cancelled)

35. (Currently Amended) A method comprising:

receiving information on a scheduling resource; and

determining that the information received on the scheduling resource comprises an acknowledgment transmission, where the acknowledgement transmission comprises an unmodulated sequence in addition to the acknowledgement.

36. (Original) The method of claim 35, comprising

responding accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment.

37. (Previously Presented) The method of claim 35 where the information is received on a physical uplink control channel.

38. (Previously Presented) The method of claim 35 where the information is received from a wireless communications network.

39. (Previously Presented) The method of claim 31 where the information is received from an evolved universal terrestrial radio access network.

40. (Currently Amended) A non-transitory computer readable medium encoded with a computer program executable by a processor to perform actions comprising:

receiving information on a scheduling resource; and

determining that the information received on the scheduling resource comprises an acknowledgment transmission, where the transmission comprises an unmodulated sequence in addition to the acknowledgement.

41. (Currently Amended) The non-transitory computer readable medium encoded with a computer program of claim 40, comprising

responding accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment

42. (Currently Amended) An apparatus comprising:

~~a receiver;~~

~~the receiver configured to~~ at least one processor; and

at least one memory including computer program code, where the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to at least:

receive information on a scheduling resource; and

~~a processor configured to~~ determine that the information received on the scheduling resource comprises an acknowledgment transmission, where the acknowledgement transmission comprises an unmodulated sequence in addition to the acknowledgment.

43. (Currently Amended) The apparatus of claim 42 ~~further comprising:~~

~~a transmitter;~~

~~the transmitter and the processor responding~~ where the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to respond accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment transmission.

44. (Currently Amended) The apparatus of claim 42 where the ~~receiver is further configured~~ at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to receive the information on a physical uplink control channel.

45. (Currently Amended) The apparatus of claim 42 where the ~~receiver is further configured~~ at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to receive the information from a wireless communications network.

46. (Currently Amended) The apparatus of claim 42 where the ~~receiver is further configured~~ at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to receive the information from an evolved universal terrestrial radio access network.

47. – 49. (Cancelled) ~~An apparatus comprising:~~

~~means for receiving information on a scheduling resource; and~~

~~means for determining that the information received on the scheduling resource comprises an acknowledgment.~~

~~48. (Original) The apparatus of claim 47, comprising~~

~~means for responding accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment.~~

~~49. (Previously Presented) The apparatus of claim 46 where the means for receiving comprises a receiver; the means for determining comprises a processor; and the means for responding comprises a transmitter.~~

50. (Currently Amended) A method comprising:

determining that a scheduling request resource and at least one other resource are reserved for a user equipment in a same sub-frame; and

based on whether a scheduling request is desired to be transmitted by the user equipment, placing at least one of an acknowledgment/negative acknowledgement and a channel quality indicator that is desired to be transmitted by the user equipment in one of the resources and leaving at least one other resource unused, where the transmission comprises an unmodulated sequence in addition to the acknowledgement.

51. (Original) The method of claim 50, where the scheduling request resource and the at least one other resource are physical uplink control channel resources.

52. (Currently Amended) The method of claim 50 comprising:

for [[the]] a case where the user equipment desires to transmit a scheduling request and transmit an acknowledgment/negative acknowledgement, transmitting the

acknowledgment/negative acknowledgement with the scheduling request on the scheduling request resource and leaving the at least one other resource unused; or

for [[the]] a case where the user equipment does not desire to transmit a scheduling request and does desire to transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement on the at least one other resource and leaving the scheduling request resource unused.

53. (Currently Amended) The method of claim 50 comprising:

for [[the]] a case where the user equipment desires to transmit a scheduling request and a channel quality indicator but no acknowledgment/negative acknowledgement, transmitting the scheduling request on the scheduling request resource and not transmitting the channel quality indicator leaving the at least one other resource unused.

54. (Currently Amended) The method of claim 50 comprising:

for [[the]] a case where the user equipment desires to transmit a scheduling request, transmit a channel quality indicator, and transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement with the scheduling request on the scheduling request resource and not transmitting the channel quality indicator leaving the at least one other resource unused; or

for [[the]] a case where the user equipment does not desire to transmit a scheduling request and does desire to transmit a channel quality indicator and an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement and the channel quality indicator on the at least one other resource and leaving the scheduling request resource unused.

55. (Previously Presented) The method of claim 50, where the scheduling request information is conveyed based on a selected physical uplink control channel selection.

56. (New) A method comprising:

determining that an acknowledgment transmission is to be sent; and

for a case where there is also a scheduling request to be sent, transmitting the acknowledgment with the scheduling request on a scheduling resource in an uplink, where there is no need to specify a separate modulation or multiplexing operation used for transmission of the acknowledgement with the scheduling request, from a modulation or multiplexing operation used for transmission of the acknowledgement on another resource.

57. (New) The method of claim 56, comprising: transmitting the acknowledgment with the scheduling request on the scheduling resource.

58. (New) The method of claim 57, where the transmitting is on a physical uplink control channel.

59. (New) An apparatus comprising:

at least one processor; and

at least one memory including computer program code, where the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to at least:

determine that an acknowledgment transmission is to be sent; and

for a case where there is also a scheduling request to be sent, transmit the acknowledgment with the scheduling request on a scheduling resource in an uplink, where there is

no need to specify a separate modulation or multiplexing operation used for transmission of the acknowledgement with the scheduling request, from a modulation or multiplexing operation used for transmission of the acknowledgement on another resource.

60. (New) The apparatus of claim 59, where the at least one memory including the computer program code is configured with the at least one processor to cause the apparatus to transmit the acknowledgment with the scheduling request on the scheduling resource.

61. (New) The apparatus of claim 59, where the transmitting is on a physical uplink control channel.

REMARKS:

This paper is herewith filed in response to the Examiner's Office Action mailed on August 1, 2014 for the above-captioned U.S. Patent Application. This office action is a rejection of claims 1-55 of the application.

More specifically, the Examiner has rejected claims 1, 3-4, 7, 9-10, 50-51 and 55 under 35 USC 101 asserting that the claimed invention is directed to non-statutory subject matter; rejected claims 1-34 and 52-54 under 35 USC 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention; rejected claims 1-2, 4-12, 14-16, 18-26, 28-52 and 55 under 35 USC 102(e) as anticipated by Bachl (US20080316959); and rejected claims 3, 13, 17, 27 and 53-54 under 35 USC 103(a) as being unpatentable over Bachl and further in view of Papasakellariou (US2009002135). The Applicant respectfully traverses the rejection.

Claims 1, 7, 11-17, 19, 21, 35, 40-46, 50, and 52-54 have been amended. Claims 56-61 have been added. Claims 25-34, and 47-49 are cancelled. Support for the amendments can be found at least in paragraphs [0036] and [0055] of the application as filed. No new matter is added.

Rejections under 35 USC 101

Regarding the rejection under 35 USC 101 the Applicant's Representative kindly requests that the Examiner allow this rejection to be addressed at a later time. The Applicant's Representative is working with the client to identify a suitable response to the rejection. The Examiner is sincerely thanked for his consideration in this matter.

Rejections under 35 USC 112, second paragraph

Claims 1, 11, and 52-53 have been amended to address the rejection. The rejection under 35 USC 112, second paragraph, is seen to be overcome and the Examiner is requested to remove the

rejection.

Rejection of Independent Claims 1, 11, 15, 35, 40, 42, and 50

Although the rejections are not expressly or impliedly agree with, in order to facilitate the prosecution of this patent application towards allowance each of the independent claims 1, 11, 15, 35, 40, 42, and 50 have been amended in a somewhat similar fashion to recite features similar to claim 21. For example, claim 1 now recites:

> A method comprising: determining that an acknowledgment is to be sent on a physical uplink control channel, where transmission of the acknowledgement on the physical uplink control channel comprises an unmodulated sequence in addition to the acknowledgement; and for a case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource, else placing the acknowledgment in another resource

In accordance with an exemplary embodiment of the invention in an acknowledgment transmission is sent in a physical uplink control channel wherein the acknowledgement transmission includes an unmodulated sequence such as a demodulation reference signal sequence for Format 1/1a/1b *in addition to* an acknowledgment. Bachl does not anticipate at least these similar features as claimed in amended claim 1.

In the rejection of claim 21, now similarly incorporated into claim 1, the Examiner asserts:

> "**Regarding claims 21 and 31,** Bachl et al. discloses *where the acknowledgment comprises an unmodulated sequence 1 and a BPSK/QPSK modulate sequence 2* (Paragraph 0032, wherein the ACK/NACK uses BPSK and QPSK modulation)," (emphasis added), (page 8 of the Office Action).

First, it is respectfully noted that in the rejection the Examiner cites where Bachl discloses that the ACK/NACK uses BPSK and QPSK modulation. However, Bachl does not disclose a transmission of an acknowledgment on a physical uplink control channel which comprises an unmodulated sequence in addition to the acknowledgement.

Bachl as cited discloses:

> "Referring back to FIG. 1, scheduling requests may also collide with other control information transmitted over the unscheduled uplink channel 130. For example, the mobile unit 110 may need to transmit a scheduling request over the unscheduled uplink channel 130 concurrently with transmitting an acknowledgment or non-acknowledgment message. The mobile unit 110 may therefore be able to transmit information indicative of the scheduling request and the other control information using the resources allocated for transmission of the other control information over the unscheduled uplink channel 130. For example, when the scheduling request collides with an acknowledgment or non-acknowledgment message, the mobile unit 110 may switch from the Binary Phase Shift Key (BPSK) modulation that is typically used to modulate the acknowledgment or non-acknowledgment message to a higher order modulation scheme such as Quadrature Phase Shift Key (QPSK) modulation. Using the higher order modulation scheme increases the size of the constellation of symbol values so that information indicative of both the scheduling request and the acknowledgement or non-acknowledgment message can be transmitted using the resources allocated for transmission of the acknowledgment or non-acknowledgment message without increasing the peak-to-average power ratio," (emphasis added), (paragraph [0032]).

Here, Bachl discloses that when the scheduling request collides with an acknowledgment or non-acknowledgment message the mobile unit 110 may switch from BPSK modulation to QPSK modulation alleging that using the higher order modulation scheme the ack/nack messages can be transmitted without increasing a peak-to-average power ratio.

Bachl does not disclose that the ack/nack messages are transmitted where the transmission on a physical uplink control channel and where the transmission comprises an unmodulated sequence in addition to the ack/nack message. For at least these reasons Bachl does not disclose or suggest at least where amended claim 1 recites in part:

> determining that an acknowledgment is to be sent on a physical uplink control channel, where transmission of the acknowledgement on the physical uplink control channel comprises an unmodulated sequence in addition to the acknowledgement; and for a case where there is also a scheduling request to be

> sent, combining the acknowledgment with the scheduling request on a scheduling resource, else placing the acknowledgment in another resource

For at least these reasons the rejection of claim 1 should be removed and amended claim 1 should be allowed.

In addition, none of the references cited overcome at least the above stated shortfalls of Bachl.

Papasakellariou

First it is noted that only the provisional applications 60/950,002 and 60/954,171 of Papasakellariou have a filing date earlier than the priority date October 30, 2007 of the instant application based of the filing date of the provisional application No. 61/001,207. The provisional application 60/954,171 of Papasakellariou was filed on January 8, 2008 whereas the provisional filing date of the pending application is October 30, 2007. It is submitted that none of the Papasakellariou provisional applications disclose or suggest at least where amended claim 1 recites in part:

> determining that an acknowledgment is to be sent on a physical uplink control channel, where transmission of the acknowledgement on the physical uplink control channel comprises an unmodulated sequence in addition to the acknowledgement; and for a case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource, else placing the acknowledgment in another resource

Thus, none of the Papasakellariou provisional applications can be seen to overcome at least the shortfalls of Bachl as stated above. Furthermore, it is noted that the Papasakellariou non-provisional application 2009/0022135 as cited in the rejection of claims 3, 13, 17, 27, and 53-54 (see page 16 of the Office Action) discloses:

> "As described above in the background, the CQI transmission from a UE in a Physical Uplink Control CHannel (PUCCH), which is typically periodic in nature, may occur in the same sub-frame as the ACK/NACK signal transmission to

> support Hybrid Automatic Repeat reQuest (HARQ) (HARQ-ACK) in response to a prior data reception by the UE in the downlink of the communication system. As the ACK/NACK signal transmission usually cannot be postponed, it is beneficial to multiplex it with the CQI signal transmission. Otherwise, the CQI signal transmission should be dropped, which may cause scheduling inefficiencies in the downlink of the communication system due to the absence of relevant CQI," (emphasis added), (US20090022135 paragraph [0062]).

Although the rejection using Papasakellariou is not agreed to it is respectfully submitted that after a thorough review of each of the three provisional applications of Papasakellariou, as stated above, there cannot be found in any disclosure that the CQI is dropped, as asserted by the Examiner. For this reason alone the rejection is improper and the rejection should be removed.

Further, according to Papasakellariou, "Referring to FIG. 3, the CAZAC sequence 310 is generated through one of the previously described methods (modulated for transmission of CQI bits, un-modulated for RS transmission)," (paragraph [0018]). Thus, for at least these reasons Papasakellariou does not overcome the shortfalls of Bachl as stated above.

Further, it is submitted that the Examiner allow claims 3, 13, 17, 27, and 53-54 or else cite support for the rejection in an application which *in its entirety* predates the pending application. For these reasons alone the rejection using Papasakellariou should be removed. Therefore, for at least these reasons the Examiner is respectfully requested to remove the rejection and allow claim 1.

In addition, for similar reasons as stated above with regards to claim 1 the references cited do not disclose or suggest independent claims 11, 15, 35, 40, 42, and 50. Thus, for at least these reasons the Examiner is respectfully requested to remove the rejection and allow these claims.

Regarding New Independent Claim 56

It is respectfully submitted that for at least the reasons already stated none of the references cited disclose or suggest at least where new claim 56 recites in part:

> determining that an acknowledgment transmission is to be sent; and for a case where there is also a scheduling request to be sent, transmitting the acknowledgment with the scheduling request on a scheduling resource in an uplink, where there is no need to specify a separate modulation or multiplexing operation used for transmission of the acknowledgement with the scheduling request, from a modulation or multiplexing operation used for transmission of the acknowledgement on another resource

Therefore, the Examiner is respectfully requested to allow claim 56.

In addition, for similar reasons as stated above with regards to claim 56 the references cited do not disclose or suggest independent claim 59. Thus, for at least these reasons the Examiner is respectfully requested to allow claims 56 and 59.

Further, for at least the reason that claims 2-5, 7, and 9; claims 12-14; claims 16-24; claims 36-39; claim 41, claims 43-46; claims 51-55; claims 57-58; and claims 60-61 depend from claims 1, 11, 15, 25, 35, 40, 42, 50, 59, and 59, respectively, the references cited do not disclose or suggest these claims.

Based on the above explanations and arguments, it is clear that the reference cited cannot be seen to disclose or suggest claims 1-7, 9-24, 35-46, and 50-61. The Examiner is respectfully requested to reconsider and remove the rejections of claims 1-7, 9-24, 35-46, and 50-61 and to allow all of the pending claims 1-7, 9-24, 35-46, and 50-61 as now presented for examination.

For all of the foregoing reasons, it is respectfully submitted that all of the claims now present in the application are clearly novel and patentable over the prior art of record. Should any unresolved issue remain, the Examiner is invited to call Applicants' attorney at the telephone number indicated below.

Respectfully submitted:

12/23/2014

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 14/051,646	Filing Date 10/11/2013	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

	(Column 1)	(Column 2)		
FOR	NUMBER FILED	NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	12/29/2014	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 46	Minus	** 55	= 0	X $80 =	0
	Independent (37 CFR 1.16(h))	* 9	Minus	***9	= 0	X $420 =	0
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	0

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))						
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
						TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/SANDRA TUCKER SMITH/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/051,646	10/11/2013	Kari P. Pajukoski	863.0076.U2(US)	6128

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EXAMINER	
THOMPSON, JR, OTIS L	
ART UNIT	PAPER NUMBER
2477	
MAIL DATE	DELIVERY MODE
08/01/2014	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 14/051,646	Applicant(s) PAJUKOSKI ET AL.	
	Examiner OTIS L. THOMPSON, JR	Art Unit 2477	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *10/13/2013*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1-55* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-55* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☒ The drawing(s) filed on *10/11/2013* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date *10/11/2013*.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

1. The present application is being examined under the pre-AIA first to invent provisions.

DETAILED ACTION

Claim Rejections – 35 USC § 101

2. 35 U.S.C. 101 reads as follows:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

3. Claims 1, 3, 4, 7, 9, 10, 50, 51, and 55 are rejected under 35 U.S.C. 101 because the claimed invention is directed to non-statutory subject matter. Claims 1, 3, 4, 7, 9, 10, 50, 51, and 55 recite steps of a method that do not appear to be specifically or inherently performed by a machine and that do not appear to transform in any way. In accordance with the interim guidelines for examining 35 USC 101 subject matter, these method claims do not pass the machine or transformation test and are considered non-statutory.

4. Claims 11-14, 40, and 41 rejected under 35 U.S.C. 101 because the claimed invention is directed to non-statutory subject matter. Claims 11-14, 40, and 41 recite computer readable mediums encoded with computer programs executable by a processor. This recitation is non-statutory because the recited computer readable mediums are transitory and therefore encompass transmission media including signals and carrier waves. In accordance with the interim guidelines for examining 35 USC 101 subject matter, Examiner suggests that Applicant amend the claims to recite "non-transitory" computer-readable mediums.

Claim Rejections - 35 USC § 112

5. The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

6. Claims 1-34, 52, 53, and 54 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

7. Each of claims 1, 11, 15, 25, and 52-54 recites the limitation "the case" in various features. There is insufficient antecedent basis for this limitation in the claim.

Claim Rejections – 35 USC § 102

8. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

9. Claims 1, 2, 4-12, 14-16, 18-26, 28-52, and 55 are rejected under 35 U.S.C. 102(e) as being anticipated by Bachl et al. (US 2008/0316959, IDS Reference).

10. **Regarding claims 1 and 11,** Bachl et al. discloses *a method comprising and a computer readable medium encoded with a computer program executable by a processor to perform actions* (Paragraphs 0023-0024, wherein processing is performed in a computing system and a program storage medium with encoded software thereon are disclosed) *comprising:*

a. *Determining that an acknowledgment is to be sent* (Abstract, see "...determining whether a first resource for transmission of a scheduling request over an unscheduled

uplink control channel is allocated concurrently with a second resource for transmission of other control information [i.e. acknowledgment is to be sent]..."; Paragraph 0008, wherein three types of control information (ACK/NACK, CQI, and scheduling request) are transmitted over the PUCCH); *and*

b. *For the case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource* (Abstract, see "...determining whether a first resource [i.e. scheduling resource] for transmission of a scheduling request over an unscheduled uplink control channel is allocated concurrently with a second resource for transmission of other control information [i.e. acknowledgment] over the unscheduled uplink control channel…modulating the scheduling request and the other control information into one symbol for transmission using the first resource [i.e. scheduling resource]..."; Paragraph 0012, wherein ACK/NACK and the scheduling request are multiplexed and transmitted on the PUCCH),

c. *Else placing the acknowledgment in another resource* (Abstract, wherein a second resource [i.e. another resource] is allocated for transmission of other control information [i.e. acknowledgment] besides the scheduling request; If the second resource is allocated concurrently [collides] with the first resource of the scheduling request, the two are combined and transmitted together over first resource. If the two are not concurrently allocated, the other control information [i.e. acknowledgement] remains in the second resource).

11. **Regarding claims 2 and 12,** Bachl et al. discloses *for the case where there is also the scheduling request to be sent, transmitting the acknowledgment with the scheduling request on*

the scheduling resource (Abstract, see "...determining whether a first resource [i.e. scheduling resource] for transmission of a scheduling request over an unscheduled uplink control channel is allocated concurrently with a second resource for transmission of other control information [i.e. acknowledgment] over the unscheduled uplink control channel…modulating the scheduling request and the other control information into one symbol for transmission using the first resource [i.e. scheduling resource]...").

12. **Regarding claims 4 and 14,** Bachl et al. discloses *where the another resource is a data-non-associated resource* (Paragraph 0008, wherein ACK/NACK is a data-non-associated signal transmitted over a data-non-associated resource of the PUCCH; Abstract, wherein the data-non-associated resource is represented by the second resource for the other control information).

13. **Regarding claim 5,** Bachl et al. discloses *where the transmitting is on a physical uplink control channel* (Paragraph 0008, 0028, 0036, 0040, see where the PUCCH is used for transmission of the control information including scheduling request, ACK/NACK, and CQI).

14. **Regarding claim 6,** Bachl et al. discloses *where the transmitting is on an uplink* (Paragraph 0008, 0028, 0036, 0040, see where the PUCCH is an uplink).

15. **Regarding claim 7,** Bachl et al. discloses *where the acknowledgment comprises an unmodulated sequence 1 and a BPSK/QPSK modulate sequence 2* (Paragraph 0032, wherein the ACK/NACK uses BPSK and QPSK modulation).

16. **Regarding claim 8,** Bachl et al. discloses *the method of claim 1 being implemented in a user equipment* (Paragraph 0032 and figure 1, wherein the mobile unit 110 [i.e. user equipment] multiplexes the scheduling request and ACK/NACK; Also see paragraph 0008, wherein mobile units transmit ACK/NACK, scheduling request, and CQI over PUCCH to base stations).

17. **Regarding claim 9,** Bachl et al. discloses *the method of claim 1 being implemented in a wireless communications network* (Figure 1 depicts wireless network communication between a mobile unit and a base station).

18. **Regarding claim 10,** Bachl et al. discloses *the method of claim 1 being implemented in an evolved universal terrestrial radio access network* (Paragraph 0007-0008, wherein UMTS-LTE wireless system is disclosed).

19. **Regarding claims 15 and 25,** Bachl et al. discloses *an apparatus* (Figure 1 mobile unit 110) *comprising:*

d. *A processor configured to determine and means for determining* (Paragraphs 0023-0024, wherein processing is performed in a computing system and the processor [i.e. means for determining] in the mobile unit is therefore inherent for performing the features of the invention) *that an acknowledgment is to be sent* (Abstract, see "...determining whether a first resource for transmission of a scheduling request over an unscheduled uplink control channel is allocated concurrently with a second resource for transmission of other control information [i.e. acknowledgment is to be sent]..."; Paragraph 0008, wherein three types of control information (ACK/NACK, CQI, and scheduling request) are transmitted over the PUCCH); *and*

e. *The processor further configured to combine and means for combining* (Paragraphs 0023-0024, wherein processing is performed in a computing system and the processor [i.e. means for combining] in the mobile unit is therefore inherent for performing the features of the invention), *in the case where there is also a scheduling request to be sent, the acknowledgment with the scheduling request on a scheduling*

resource (Abstract, see "...determining whether a first resource [i.e. scheduling resource] for transmission of a scheduling request over an unscheduled uplink control channel is allocated concurrently with a second resource for transmission of other control information [i.e. acknowledgment] over the unscheduled uplink control channel…modulating the scheduling request and the other control information into one symbol for transmission using the first resource [i.e. scheduling resource]..."; Paragraph 0012, wherein ACK/NACK and the scheduling request are multiplexed and transmitted on the PUCCH),

f. *Else placing the acknowledgment in another resource* (Abstract, wherein a second resource [i.e. another resource] is allocated for transmission of other control information [i.e. acknowledgment] besides the scheduling request; If the second resource is allocated concurrently [collides] with the first resource of the scheduling request, the two are combined and transmitted together over first resource. If the two are not concurrently allocated, the other control information [i.e. acknowledgement] remains in the second resource).

20. **Regarding claims 16 and 26,** Bachl et al. discloses *a transmitter configured to transmit and means for transmitting* (Figure 1, wherein mobile unit 110 transmits via uplink channel 130 and thus comprises a transmitter as means for transmitting), *in the case where there is also the scheduling request to be sent, the acknowledgment with the scheduling request on the scheduling resource* (Abstract, see "...determining whether a first resource [i.e. scheduling resource] for transmission of a scheduling request over an unscheduled uplink control channel is allocated concurrently with a second resource for transmission of other control information [i.e.

acknowledgment] over the unscheduled uplink control channel…modulating the scheduling request and the other control information into one symbol for transmission using the first resource [i.e. scheduling resource]...").

21. **Regarding claims 18 and 28,** Bachl et al. discloses *where the another resource is a data-non-associated resource* (Paragraph 0008, wherein ACK/NACK is a data-non-associated signal transmitted over a data-non-associated resource of the PUCCH; Abstract, wherein the data-non-associated resource is represented by the second resource for the other control information).

22. **Regarding claims 19 and 29,** Bachl et al. discloses *where the transmitter/means for transmitting is configured to transmit the acknowledgment with the scheduling request on a physical uplink control channel* (Paragraph 0008, 0028, 0036, 0040, see where the PUCCH is used for transmission of the control information including scheduling request, ACK/NACK, and CQI; Paragraph 0032, wherein ACK/NACK and scheduling request are transmitted on uplink 130 of figure 1, which is the PUCCH according to paragraph 0028).

23. **Regarding claims 20 and 30,** Bachl et al. discloses *where the transmitter/means for transmitting is configured to transmit the acknowledgment with the scheduling request on an uplink* (Paragraph 0008, 0028, 0036, 0040, see where the PUCCH is an uplink; Paragraph 0032, wherein ACK/NACK and scheduling request are transmitted on uplink 130 of figure 1, which is the PUCCH according to paragraph 0028).

24. **Regarding claims 21 and 31,** Bachl et al. discloses *where the acknowledgment comprises an unmodulated sequence 1 and a BPSK/QPSK modulate sequence 2* (Paragraph 0032, wherein the ACK/NACK uses BPSK and QPSK modulation).

25. **Regarding claims 22 and 32,** Bachl et al. discloses *the apparatus of claims 15 and 25 being embodied in a user equipment* (Paragraph 0032 and figure 1, wherein the mobile unit 110 [i.e. user equipment] multiplexes the scheduling request and ACK/NACK; Also see paragraph 0008, wherein mobile units transmit ACK/NACK, scheduling request, and CQI over PUCCH to base stations).

26. **Regarding claims 23 and 33,** Bachl et al. discloses *the apparatus of claims 15 and 25 configured to operate in a wireless communications network* (Figure 1 depicts wireless network communication between a mobile unit and a base station).

27. **Regarding claims 24 and 34,** Bachl et al. discloses *the apparatus of claim 15 and 25 configured to operate in an evolved universal terrestrial radio access network* (Paragraph 0007-0008, wherein UMTS-LTE wireless system is disclosed).

28. **Regarding claims 35 and 40,** Bachl et al. discloses *a method comprising and a computer readable medium encoded with a computer program executable by a processor to perform the actions* (Paragraphs 0023-0024, wherein processing is performed in a computing system and a program storage medium with encoded software thereon are disclosed; Also see paragraph 0026 wherein functionality of base station is implemented in hardware, firmware, software, or combination thereof) *comprising:*

g. *Receiving information on a scheduling resource* (Figure 1, base station 105 receives information on the PUCCH 130 [paragraph 0028]; Abstract, wherein a scheduling request of a first resource [scheduling resource] and other control information of a second resource are multiplexed and transmitted to the base station from a mobile unit via PUCCH 130);

h. *Determining that the information received on the scheduling resource comprises an acknowledgment* (Claim 25, wherein the base station determines whether the first resource [scheduling resource] of the scheduling request is allocated concurrently with the second resource of other control information [i.e. determination that acknowledgment is comprised in the received information]; Paragraph 0008, wherein three types of control information (ACK/NACK, CQI, and scheduling request) are transmitted over the PUCCH).

29. **Regarding claims 36 and 41,** Bachl et al. discloses *responding accordingly to the determining that the information received on the scheduling resource is an acknowledgment* (Claim 25, wherein in response to the determination, the base station demodulates the symbol comprising the scheduling request and the other control information [acknowledgment]).

30. **Regarding claim 37,** Bachl et al. discloses *where the information is received on a physical uplink control channel* (Figure 1, base station 105 receives information on the PUCCH 130 [paragraph 0028]).

31. **Regarding claim 38,** Bachl et al. discloses *where the information is received from a wireless communications network* (Figure 1, base station 105 receives via uplink channels wirelessly).

32. **Regarding claim 39,** Bachl et al. discloses *where the information is received from an evolved universal terrestrial radio access network* (Paragraph 0007-0008, wherein UMTS-LTE wireless system is disclosed as the wireless system in which the bases receives from the mobile unit).

33. **Regarding claims 42 and 47,** Bachl et al. discloses *an apparatus* (Figure 1 Base Station 105) *comprising:*

i. *A receiver and means for receiving* (Figure 1 Base station 105 received transmissions from mobile unit via channels 125 and 130. A receiver is therefore present in the base station);

j. *The receiver and means for receiving configured to receive information on a scheduling resource* (Figure 1, base station 105 receives information on the PUCCH 130 [paragraph 0028]; Abstract, wherein a scheduling request of a first resource [scheduling resource] and other control information of a second resource are multiplexed and transmitted to the base station from a mobile unit via PUCCH 130);

k. *A processor and means for determining configured to determine that the information received on the scheduling resource comprises an acknowledgment* (Claim 25, wherein the base station comprises a processing unit that determines whether the first resource [scheduling resource] of the scheduling request is allocated concurrently with the second resource of other control information [i.e. determination that acknowledgment is comprised in the received information]; Paragraph 0008, wherein three types of control information (ACK/NACK, CQI, and scheduling request) are transmitted over the PUCCH).

34. **Regarding claims 43 and 48,** Bachl et al. discloses *the apparatus of claims 42 and 47 further comprising a transmitter* (Figure 1, wherein base station 105 transmits via downlink 115 to mobile unit 110. Hence, the transmitter is present in the base station); *the transmitter, the processor, and a means for responding accordingly to the determining that the information*

received on the scheduling resource comprises the acknowledgment (Claim 25, wherein in response to the determination, the processing unit [means for responding] of the base station demodulates the symbol comprising the scheduling request and the other control information [acknowledgment]).

35. **Regarding claim 44,** Bachl et al. discloses *where the receiver is further configured to receive the information on a physical uplink control channel* Figure 1, base station 105 receives information on the PUCCH 130 [paragraph 0028]).

36. **Regarding claim 45,** Bachl et al. discloses *where the receiver is further configured to receive the information from a wireless communications network* (Figure 1, base station 105 receives via uplink channels wirelessly).

37. **Regarding claim 46,** Bachl et al. discloses *where the receiver is further configured to receive the information from an evolved universal terrestrial radio access network* (Paragraph 0007-0008, wherein UMTS-LTE wireless system is disclosed as the wireless system in which the bases receives from the mobile unit).

38. **Regarding claim 49,** Bachl et al. discloses *where the means for receiving comprises a receiver* (Figure 1, wherein base station 105 receives uplink data from the mobile unit 110 and therefore comprises a receiver), *the means for determining comprises a processor* (Claim 25, wherein the base station comprises a processing unit), *and the means for responding comprises a transmitter* (Figure 1, wherein base station 105 transmits data on the downlink to mobile unit 110 and therefore comprises a transmitter for responding to the mobile unit 110).

39. **Regarding claim 50,** Bachl et al. discloses *a method comprising:*

l. *Determining that a scheduling request resource and at least one other resource are reserved for a user equipment in a same sub-frame* (Abstract, see "...determining whether a first resource [i.e. scheduling resource] for transmission of a scheduling request over an unscheduled uplink control channel is allocated concurrently with a second resource [i.e. one other resource] for transmission of other control information..."; Paragraph 0008, wherein three types of control information (ACK/NACK, CQI, and scheduling request) are transmitted over the PUCCH from the mobile unit 110 of figure 1); *and*

m. *Based on whether a scheduling request is desired to be transmitted by the user equipment, placing at least one of an acknowledgment/negative acknowledgment and a channel quality indicator that is desired to be transmitted by the user equipment in one of the resources and leaving the at least one other resource unused* (Abstract, see "...determining whether a first resource [i.e. scheduling resource] for transmission of a scheduling request over an unscheduled uplink control channel is allocated concurrently with a second resource for transmission of other control information [i.e. acknowledgment or channel quality indicator] over the unscheduled uplink control channel…modulating the scheduling request and the other control information [i.e. acknowledgment or channel quality indicator] into one symbol for transmission using the first resource [i.e. one of the resource in which the scheduling request and ACK/NACK or CQI are placed]..."; Paragraph 0012, wherein ACK/NACK and the scheduling request are multiplexed and transmitted on the PUCCH; According to the abstract, since the first resource [i.e. scheduling resource] is used to transmit both the scheduling request and

other control information, the second resource that has been allocated for the other control information is left unused).

40. **Regarding claim 51,** Bachl et al. discloses *where the scheduling request resource and the at least one other resource are physical uplink control channel resources* (Figure 1, base station 105 receives information on the PUCCH 130 [paragraph 0028]j; Abstract, wherein the first and second resources [i.e. scheduling request and other control information resources] are of an unscheduled uplink control channel which is the PUCCH according to paragraph 0028).

41. **Regarding claim 52,** Bachl et al. discloses *for the case where the user equipment desires to transmit a scheduling request and transmit an acknowledgment/negative acknowledgment, transmitting the acknowledgment/negative acknowledgment with the scheduling request on the scheduling request resource and leaving the at least on other resource unused* (Abstract, see "...determining whether a first resource [i.e. scheduling resource] for transmission of a scheduling request over an unscheduled uplink control channel is allocated concurrently with a second resource for transmission of other control information [i.e. acknowledgment] over the unscheduled uplink control channel…modulating the scheduling request and the other control information [i.e. acknowledgment] into one symbol for transmission using the first resource [i.e. one of the resource in which the scheduling request and ACK/NACK or CQI are placed]..."; Paragraph 0012, wherein ACK/NACK and the scheduling request are multiplexed and transmitted on the PUCCH; According to the abstract, since the first resource [i.e. scheduling resource] is used to transmit both the scheduling request and other control information, the second resource that has been allocated for the other control information is left unused); *or for the case where the user equipment does not desire to transmit a scheduling request and does*

desire to transmit an acknowledgment/negative acknowledgment, transmitting the acknowledgment/negative acknowledgment on the at least one other resource and leaving the scheduling request resource unused (Paragraph 0038 and figure 4 step 445, wherein the mobile unit determines that there is an ACK/NACK to transmit to the base station; Step 450, wherein the mobile unit determines that there is no SR (scheduling request) to transmit; Step 460, wherein the mobile unit transmits the ACK/NACK on the resource allocated for transmission of the ACK/NACK [i.e. at least one other resource] in the PUCCH and leaves the scheduling request resource unused).

42. **Regarding claim 55,** Bachl et al. discloses *wherein the scheduling request information is conveyed based on a selected physical uplink control channel selection* (Abstract, wherein a first resource of the physical uplink control channel is allocated for the scheduling request).

Claim Rejections - 35 USC § 103

43. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

44. Claims 3, 13, 17, 27, 53, and 54 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bachl et al. as applied to claims 1, 11, 15, 25, and 50 above, and further in view of Papasakellariou et al. (US 2009/0022135, IDS Reference).

45. **Regarding claims 3, 13, 17, and 27,** Bachl et al. discloses the claimed invention above but does not specifically disclose *for a case where a channel quality indicator is also to be sent,*

the channel quality indicator is not sent and the another resource is unused [the processor/means, in case where a channel quality indicator is also to be sent, for dropping the channel quality indicator such that it is not sent and the another resource is unused]. However, Papasakellariou et al. discloses a method for multiplexing ACK/NACK signals with CQI signals (See Abstract). In paragraph 0062, Papasakellariou et al. discloses that a UE has a CQI transmission that is typically periodic and may occur in the same sub-frame as the ACK/NACK transmission. While Papasakellariou et al. discloses that multiplexing ACK/NACK signals with CQI signals is beneficial, Papasakellariou et al. also discloses that the CQI signal transmission is dropped (i.e. *channel quality indicator is not sent [dropped such that it is not sent]*) when it occurs in the same sub-frame as the ACK/NACK, and the PUCCH is used to transmit only the ACK/NACK (Paragraph 0062). Since the CQI signal transmission has an allocated resource for transmission in the PUCCH (i.e. periodic transmission), it is clear that this *resource remains unused [the another resource is unused]* for transmission.

Therefore, it would have been obvious to one of ordinary skill in the art at the time the applicant's invention was made to incorporate the teachings of Papasakellariou et al. into Bachl et al. in order to multiplex or not multiplex ACK/NACK transmissions with CQI transmissions.

46. **Regarding claim 53,** Bachl et al. discloses the claimed invention above as well as *the case where the user equipment desires to transmit a scheduling request* (Figure 4 Step 435) *but no acknowledgment/negative acknowledgment* (Figure 4 Step 420), *and transmitting the scheduling request on the scheduling resource* (Figure 4 Step 440) but does not specifically disclose *where the user equipment desires to transmit a channel quality indicator at the same*

time, but not transmitting the channel quality indicator leaving the at least one other resource unused.

However, Papasakellariou et al. discloses a method for multiplexing an ACK/NACK signal and a CQI signal (See Abstract). In paragraph 0062, Papasakellariou et al. discloses a case in which a CQI signal is dropped when it collides with the transmission an ACK/NACK (i.e. *desires to transmit a channel quality indicator at the same time, but not transmitting the channel quality indicator leaving the at least one other resource unused*). In combination with Bachl et al., since there is a scheduling request transmission but no ACK/NACK transmission, dropping the CQI transmission is an obvious action since, according to Bachl et al., the scheduling request and CQI use different resources within the PUCCH for transmission (Abstract of Bachl et al. wherein the scheduling request has a first resource in the channel and other control information, such as the CQI, has a second resource in the channel).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the applicant's invention was made to incorporate the teachings of Papasakellariou et al. in order to multiplex ACK/NACK transmissions with CQI transmissions when possible.

47. **Regarding claim 54,** Bachl et al. discloses the claimed invention above but does not specifically disclose *for the case where the user equipment desires to transmit a scheduling request, transmit a channel quality indicator, and transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement with the scheduling request on the scheduling request resource and not transmitting the channel quality indicator leaving the at least one other resource unused; or for the case where the user equipment does not desire to transmit a scheduling request and does desire to transmit a channel*

quality indicator and an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement and the channel quality indicator on the at least one other resource and leaving the scheduling request resource unused.

However, Papasakellariou et al. discloses a method for multiplexing an ACK/NACK signal and a CQI signal (See Abstract). Bachl et al. discloses a case wherein there is an ACK/NACK to transmit but *there is no desire to transmit a scheduling request*, and the ACK/NACK is transmitted on its allocated resource (i.e. *transmitting on the at least one other resource*) in PUCCH while the *scheduling resource is left unused* (Paragraph 0038 and Figure 4, See steps 445, 450, and 460). In Papasakellariou et al., *there is a desire to transmit a channel quality indicator and an acknowledgment/negative acknowledgment* as evidenced by the multiplexing of the two in the abstract. In paragraph 0062, Papasakellariou et al. discloses that a CQI transmission, which is periodic in nature, may occur in the same sub-frame as the ACK/NACK transmission. Since the ACK/NACK transmission cannot be postponed, it is beneficially multiplexed with the CQI transmission and transmitted from the mobile unit to the base station (i.e. *transmitting the acknowledgment/negative acknowledgement and the channel quality indicator on the at least one other resource and leaving the scheduling request resource unused*). By incorporating Papasakellariou et al. into Bach et al., the system is able to multiplex ACK/NACK and CQI while maintaining CQI performance and ACK/NACK accuracy (Paragraph 0068).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the applicant's invention was made to incorporate the teachings of Papasakellariou et al. into Bachl

et al. in order to multiplex ACK/NACK and CQI while maintaining CQI performance and ACK/NACK accuracy.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to OTIS L. THOMPSON, JR whose telephone number is (571)270-1953. The examiner can normally be reached on Monday to Thursday 7:30 am to 5:00 pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chirag Shah can be reached on (571)272-3144. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/OTIS L THOMPSON, JR/
Primary Examiner, Art Unit 2477

July 30, 2014

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14051646	PAJUKOSKI ET AL.
	Examiner	Art Unit
	OTIS L THOMPSON, JR	2477

CPC- SEARCHED		
Symbol	Date	Examiner

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
370	310-350 with text in EAST	7/30/2014	OT

SEARCH NOTES		
Search Notes	Date	Examiner
Double Patenting Search	7/30/2014	OT
EAST Text Search	7/30/2014	OT
Prior art consideration from parent case	7/30/2014	OT

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

	/OTIS L THOMPSON, JR/ Primary Examiner.Art Unit 2477

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	2	("8638729").PN.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	OR	OFF	2014/07/30 14:39
L2	116959	370/310-350.ccls.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2014/07/30 14:46
L3	66402	l2 and (ack or nack or acknowledg$5 or reply$3 or response or resopnd$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2014/07/30 14:47
L4	1950	l2 and (ack or nack or acknowledg$5 or reply$3 or response or resopnd$3) same schedul$3 request	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2014/07/30 14:47
L5	76	l2 and (ack or nack or acknowledg$5 or reply$3 or response or resopnd$3) same schedul$3 request same (combin$5 or merg$3)	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2014/07/30 14:47
L6	213	((Kari) near2 (Pajukoski)).INV.	US-PGPUB; USPAT; USOCR	ADJ	ON	2014/07/30 14:53
L7	228	((Esa) near2 (Tiirola)).INV.	US-PGPUB; USPAT; USOCR	ADJ	ON	2014/07/30 14:53
L8	258	l6 or l7	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2014/07/30 14:53
L9	8	l8 and acknowledg$5.clm. and combin$5.clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2014/07/30 14:53
L10	5	l9 and schedul$3 request.clm.	US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB	ADJ	ON	2014/07/30 14:54

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp

L11	59	((Esa) near2 (Tiirola)).INV.	USPAT; UPAD	ADJ	ON	2014/07/30 14:55
L12	59	((Kari) near2 (Pajukoski)).INV.	USPAT; UPAD	ADJ	ON	2014/07/30 14:55
L13	71	l11 or l12	USPAT; UPAD	ADJ	ON	2014/07/30 14:55
L14	14	l13 and schedul$3.clm.	USPAT; UPAD	ADJ	ON	2014/07/30 14:55
L15	8	l14 and acknowledg$5.clm.	USPAT; UPAD	ADJ	ON	2014/07/30 14:55
L16	2	l15 and combin$5.clm.	USPAT; UPAD	ADJ	ON	2014/07/30 14:55

7/30/2014 2:56:12 PM
C:\Users\othompson1\Documents\EAST\Workspaces\12-290547.wsp

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT: Kari Pajukoski et al.

SERIAL NO.: ART UNIT:

FILED: herewith EXAMINER:

TITLE: Providing Improved Scheduling Request Signaling with ACK/NACK or CQI

ATTORNEY DOCKET NO.: 863.0076.U2(US)

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Information Disclosure Statement

(37 C.F.R. §1.97(b))

Sir:

The following information is being disclosed to the U.S. Patent and Trademark Office as information that may be material to the examination of the above-identified patent application.

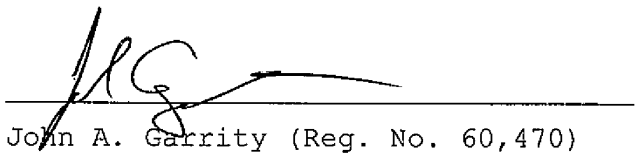
A Form PTO-1449 is enclosed for the Examiner's use which lists all the art cited in the parent application (Serial No.: 12/290,547). In accordance with 37 C.F.R. §1.98(d) copies of the art are not included. These can be obtained by the Examiner from the file of the parent application.

The filing of this Statement is not to be construed as a representation that a search has been made regarding the

[1] ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /O.T./

claimed invention (37 C.F.R. §1.97(g)) or that no other possible material information exists. In addition, the filing of this Statement is not to be construed to be an admission that the information cited in the Statement is, or is considered to be, material to Patentability (37 C.F.R. §1.97(h)).

Respectfully submitted,



10/11/2013

John A. Garrity (Reg. No. 60,470) Date

Customer No.: 29683
Harrington & Smith, Attorneys At Law, LLC
4 Research Drive
Shelton, CT 06484-6212
203-925-9400

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INFORMATION DISCLOSURE CITATION FORM FOR PATENT APPLICATION (FORM PTO-1449) (Substitute)	Docket No.: 863.0076.U2(US) Serial No. Applicant(s): Kari Pajukoski et al. Filing Date: herewith Group:

U.S. PATENT DOCUMENTS

Examiner Initials	Document Number (Number-Kind Code)	Publication Date (MM-DD-YYYY)	Name of Patentee or Applicant	Class	Sub-class
	US-2007/0133458 A1	06-14-2007	Chandra et al.	370	329
	US-2003/0228876 A1	12-11-2003	Hwang	455	522
	US-2005/0047393 A1	03-03-2005	Liu	370	352
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	US-				
	US-				
	US-				

FOREIGN PATENT DOCUMENTS

Examiner Initials	Document Number (Country Code-Number-Kind Code)	Publication Date (MM-DD-YYYY)	Name Of Patentee of Applicant	Translation? Yes/No/n/a
	WO-2007/1--547-A2	09-07-2007	International Digital Technology Corporation	
	JP-2009/049578-A	03-05-2009	KDDI Corp	Abstract
	RU-2305372-C2	08-27-2007	Samsung Electronics Co., Ltd.	Abstract
	WO-2004/110081-A1	12-16-2004	Nokia Corporation	
	WO-2005/015942-A1	02-17-2005	Qualcomm Incorporated	
	WO-2007/044414-A1	04-19-2007	Inter-Digital Technology Corporation	
	WO-2007/008123-A1	01-18-2007	Telefonaktiebolaget LM Ericsson	

OTHER DOCUMENTS (Author (Capitalize), Title, Date, Pages, Etc., if known)

	"X2 downlink forwarding delay", NEC, 3GPP TSG-RAN WG2#59bis, October 2007, R2-074139, 4 pgs.
	"Multiplexing of Scheduling Request and ACK/NACK and/or CQI", Nokia Siemens Networks, 3GPP TSG RAN WG1#49bis, R1-073011, 3 pgs.
	"Handling NAS message during HO", Alcatel-Lucent, 3 GPP TSG RAN WG2 #59bis, October 2007, R2-074333, 2 pgs.
	3GPP TSG RAN WG1 #48bis, R1-071662, St. Julians, Malta, March 26-30, 2007, Nokia Siemens, "Uplink Scheduling Request for LTE", 4 pgs.

Examiner's Signature: /Otis Thompson, Jr/	Date Considered: 07/30/2014

Initial if reference was considered, whether or not citation is in conformance with MPEP. Mark through citation if not considered. Include a copy of this citation form with your next correspondence to the Applicant(s).

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /O.T./

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14051646	PAJUKOSKI ET AL.
	Examiner	Art Unit
	OTIS L THOMPSON, JR	2477

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	07/30/2014								
	1	✓								
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	34	✓								
	35	✓								
	36	✓								

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CLAIM		DATE								
Final	Original	07/30/2014								
	37	✓								
	38	✓								
	39	✓								
	40	✓								
	41	✓								
	42	✓								
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	55	✓								

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BIB DATA SHEET

CONFIRMATION NO. 6128

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
14/051,646	10/11/2013	370	2477	863.0076.U2(US)

APPLICANTS

Nokia Solutions and Networks Oy, Espoo, FINLAND, Assignee (with 37 CFR 1.172 Interest);

INVENTORS

Kari P. Pajukoski, Oulu, FINLAND;
Esa T. Tiirola, Kempele, FINLAND;

**** CONTINUING DATA ***************************

This application is a CON of 12/290,547 10/30/2008 PAT 8638729
which claims benefit of 61/001,207 10/30/2007

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

10/28/2013

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /OTIS L THOMPSON, JR/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		FINLAND	9	55	9

ADDRESS

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UNITED STATES

TITLE

Providing Improved Scheduling Request Signaling With ACK/NACK Or CQI

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7060	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/051,646	10/11/2013	Kari P. Pajukoski	863.0076.U2(US)

CONFIRMATION NO. 6128

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PUBLICATION NOTICE

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Title: Providing Improved Scheduling Request Signaling With ACK/NACK Or CQI

Publication No.US-2014-0036842-A1
Publication Date:02/06/2014

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/051,646	10/11/2013	Kari P. Pajukoski	863.0076.U2(US)

CONFIRMATION NO. 6128

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POA ACCEPTANCE LETTER

OC000000064936422

Date Mailed: 11/15/2013

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 11/04/2013.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/qtran/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

Doc Code: PA..

Document Description: Power of Attorney

PTO/AIA/82A (07-12)

Approved for use through 11/30/2014. OMB 0651-0035

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PATENT & TRADEMARK OFFICE
AKIMA-16

TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B or equivalent) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5. If the Power of Attorney by Applicant form is not accompanied by this transmittal form or an equivalent, the Power of Attorney will not be recognized in the application.

Application Number	14/051,646
Filing Date	10/11/2013
First Named Inventor	Pajukoski et al
Title	Providing Improved Scheduling Request Signaling With ACK/NACK or CQI
Art Unit	2414
Examiner Name	
Attorney Docket Number	863.0076.U2(US)

SIGNATURE of Applicant or Patent Practitioner

Signature		Date	10/30/2013
Name	John Garrity	Telephone	(203) 925-9400
Registration Number	60,470		

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications.

■ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.31, 1.32 and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

OPAP AKIMA-16
NOV 0 4 2013
PATENT & TRADEMARK OFFICE

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

GENERAL POWER OF ATTORNEY

The undersigned:

Nokia Siemens Networks Oy
Karaportti 3
02610 Espoo
Finland

hereby appoints all practitioners associated with:

Customer Number: **29,683**

to represent the undersigned in the U.S. Patent and Trademark Office in connection with any and all patent applications and patents which the undersigned is the applicant or patent owner.

Signatures:

By: _____
Name: Gottfried Weidel
Nokia Siemens Networks Oy
Title: Head of IPR
Date:23rd October 2012

By: _____
Name: Bernd Schaar
Nokia Siemens Networks Oy
Title: Head of IPR Business Strategy
Date: 23rd October 2012



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.: 14/051,646 Confirmation No.: 6128

Applicant(s): Pajukoski et al

Filed: 10/11/2013

Art Unit: 2414

Examiner:

Title: Providing Improved Scheduling Request Signaling with ACK/NACK or CQI

Attorney Docket No.: 863.0076.U2(US)

Customer No.: 29,683

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Submission of Declaration

Sir:

Further to the Application filed October 11, 2013, enclosed is a Declaration signed by the inventors for this case. There is no fee due for the filing of this Declaration. However, should the undersigned attorney be mistaken, please charge Deposit Account No.: 50-1924 for any required fee deficiency.

Respectfully submitted,

John Garrity (Reg. No. 60,470)
Harrington & Smith,
Attorneys at Law, LLC
4 Research Drive
Shelton, CT 06484-6212
Customer No. 29683
Telephone: (203) 925-9400

10/31/2013
Date



CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail on the date shown below in an envelope addressed to: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313

10.30.2013
Date

Jessica Capra

Harrington & Smith, Attorneys at Law, LLC, Docket No.: 863.0076.U2(US)

OPAP AKIMA-15
NOV 04 2013
PATENT & TRADEMARK OFFICE

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter, which is claimed and for which a patent is sought on the invention entitled:

PROVIDING IMPROVED SCHEDULING REQUEST SIGNALING WITH ACK/NACK OR CQI

the specification of which:

(check one) ☐ is attached hereto.

☒ was filed on **11.10.2013** as U.S. Application Serial No. **14/051,646**, and was amended on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the U.S. Patent and Trademark Office all information known to me to be material to the patentability of this application as defined in Title 37, Code of Federal Regulations, §1.56

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate(s) listed below and have also identified below any foreign application(s) for patent or inventor's certificate(s) having a filing date before that of the application on which priority is claimed:

Prior foreign applications			Priority Claimed	
(Number)	(Country)	(Day Month Year Filed)	☐ Yes	☐ No

I hereby claim the benefit under Title 35, United States Code, §119(e) of the United States provisional patent application(s) listed below:

61/001,207	30.10.2007
(Application Serial No.)	(Filing Date)

I hereby claim benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

12/290,547	30.10.2008	Pending
(Application Serial No.)	(Filing Date)	(Status)

POWER OF ATTORNEY: As a named inventor I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the U.S. Patent and Trademark Office connected therewith:

And all attorneys or agents associated with Customer No.: **29,683**

Harrington & Smith, Attorneys at Law, LLC.
4 Research Drive Shelton, Connecticut 06484-6212 UNITED STATES OF AMERICA
Telephone: +1 203 925 9400 and Facsimile +1 203 944 0245

Or

Customer No. 29,683

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Authorization To Permit Access To Application by Participating Offices

☒ The undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the above-identified patent application is filed access to the above-identified patent application. See 37 CFR 1.14(c) and (h).

This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the above-identified patent application is filed to have access to the above-identified patent application. In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the above-identified patent application with respect to: 1) the above-identified patent application-as-filed; 2) any foreign application to which the above-identified patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the above-identified patent application; and 3) any U.S. application-as-filed from which benefit is sought in the above-identified patent application. In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing the Authorization to Permit Access to Application by Participating Offices.

(1) FULL NAME OF INVENTOR:

LAST NAME:	**Pajukoski**
FIRST NAME	**Kari Pekka**
RESIDENCE:	
CITY:	**Oulu,**
STATE OR COUNTRY:	**FINLAND**
CITIZENSHIP:	**FI**
POST OFFICE ADDRESS:	**Purantie 3,** **90240 Oulu,** **FINLAND**

Signature _____ Date _____

(2) FULL NAME OF INVENTOR:

LAST NAME: **Tiirola**
FIRST NAME **Esa Tapani**

RESIDENCE:
CITY: **Kempele,**
STATE OR COUNTRY: **FINLAND**

CITIZENSHIP: **FI**

POST OFFICE ADDRESS: **Porttikellonkuja 12,**
90450 Kempele,
FINLAND

Signature _____ Date 15.10.2013

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 14/051,646

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	280
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	600
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	720
TOTAL CLAIMS (37 CFR 1.16(i))	55 minus 20 =	* 35			OR	x 80 =	2800
INDEPENDENT CLAIMS (37 CFR 1.16(h))	9 minus 3 =	* 6				x 420 =	2520
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	6920

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/051,646	10/11/2013	Kari P. Pajukoski	863.0076.U2(US)

CONFIRMATION NO. 6128

29683
HARRINGTON & SMITH
4 RESEARCH DRIVE, Suite 202
SHELTON, CT 06484-6212

NOTICE

OC000000064663685

Date Mailed: 10/31/2013

INFORMATIONAL NOTICE TO APPLICANT

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):
  Kari P. Pajukoski
  Esa T. Tiirola

  Applicant may submit the inventor's oath or declaration at any time before the Notice of Allowance and Fee(s) Due, PTOL-85, is mailed.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
14/051,646	10/11/2013	2414	7060	863.0076.U2(US)	55	9

CONFIRMATION NO. 6128

29683
HARRINGTON & SMITH
4 RESEARCH DRIVE, Suite 202
SHELTON, CT 06484-6212

FILING RECEIPT

OC000000064663684

Date Mailed: 10/31/2013

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

Kari P. Pajukoski, Oulu, FINLAND;
Esa T. Tiirola, Kempele, FINLAND;

Applicant(s)

Nokia Solutions and Networks Oy, Espoo, FINLAND

Assignment For Published Patent Application

Nokia Solutions and Networks Oy, Espoo, FINLAND

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 12/290,547 10/30/2008
which claims benefit of 61/001,207 10/30/2007

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access - A proper **Authorization to Permit Access to Application by Participating Offices** (PTO/SB/39 or its equivalent) has been received by the USPTO.

If Required, Foreign Filing License Granted: 10/28/2013
The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 14/051,646**
Projected Publication Date: 02/06/2014

Non-Publication Request: No

Early Publication Request: No

Title

Providing Improved Scheduling Request Signaling With ACK/NACK Or CQI

Preliminary Class

370

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANT: Kari Pajukoski et al.

SERIAL NO.: ART UNIT:

FILED: herewith EXAMINER:

TITLE: Providing Improved Scheduling Request Signaling with ACK/NACK or CQI

ATTORNEY DOCKET NO.: 863.0076.U2(US)

Commissioner For Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Information Disclosure Statement

(37 C.F.R. §1.97(b))

Sir:

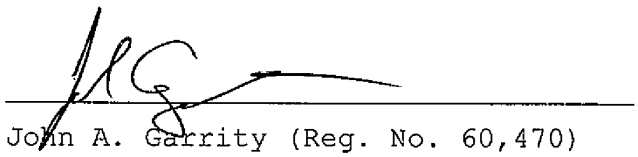
The following information is being disclosed to the U.S. Patent and Trademark Office as information that may be material to the examination of the above-identified patent application.

A Form PTO-1449 is enclosed for the Examiner's use which lists all the art cited in the parent application (Serial No.: 12/290,547). In accordance with 37 C.F.R. §1.98(d) copies of the art are not included. These can be obtained by the Examiner from the file of the parent application.

The filing of this Statement is not to be construed as a representation that a search has been made regarding the

claimed invention (37 C.F.R. §1.97(g)) or that no other possible material information exists. In addition, the filing of this Statement is not to be construed to be an admission that the information cited in the Statement is, or is considered to be, material to Patentability (37 C.F.R. §1.97(h)).

Respectfully submitted,



10/11/2013

John A. Garrity (Reg. No. 60,470) Date

Customer No.: 29683
Harrington & Smith, Attorneys At Law, LLC
4 Research Drive
Shelton, CT 06484-6212
203-925-9400

INFORMATION DISCLOSURE CITATION FORM FOR PATENT APPLICATION (FORM PTO-1449) (Substitute)	Docket No.: 863.0076.U2(US) Serial No. Applicant(s): Kari Pajukoski et al. Filing Date: herewith Group:

U.S. PATENT DOCUMENTS

Examiner Initials	Document Number (Number-Kind Code)	Publication Date (MM-DD-YYYY)	Name of Patentee or Applicant	Class	Sub-class
	US-2007/0133458 A1	06-14-2007	Chandra et al.	370	329
	US-2003/0228876 A1	12-11-2003	Hwang	455	522
	US-2005/0047393 A1	03-03-2005	Liu	370	352
	US-2007/0171849 A1	07-26-2007	Zhang et al.	370	310
	US-2009/0022110 A1	01-2009	Muharenovic et al.	370	336
	US-2009/0316811	12-2009	Maeda et al.	375	250
	US-2008/0316959	12-2008	Bachi et al.	370	329
	US-2009/0022135	01-2009	Papasakellariou et al.	370	344
	US-2009/0046667	02-2009	Pelletier et al.	370	335
	US-				
	US-				
	US-				
	US-				
	US-				
	US-				
	US-				

FOREIGN PATENT DOCUMENTS

Examiner Initials	Document Number (Country Code-Number-Kind Code)	Publication Date (MM-DD-YYYY)	Name Of Patentee of Applicant	Translation? Yes/No/n/a
	WO-2007/1--547-A2	09-07-2007	International Digital Technology Corporation	
	JP-2009/049578-A	03-05-2009	KDDI Corp	Abstract
	RU-2305372-C2	08-27-2007	Samsung Electronics Co., Ltd.	Abstract
	WO-2004/110081-A1	12-16-2004	Nokia Corporation	
	WO-2005/015942-A1	02-17-2005	Qualcomm Incorporated	
	WO-2007/044414-A1	04-19-2007	Inter-Digital Technology Corporation	
	WO-2007/008123-A1	01-18-2007	Telefonaktiebolaget LM Ericsson	

OTHER DOCUMENTS (Author (Capitalize), Title, Date, Pages, Etc., if known)

	"X2 downlink forwarding delay", NEC, 3GPP TSG-RAN WG2#59bis, October 2007, R2-074139, 4 pgs.
	"Multiplexing of Scheduling Request and ACK/NACK and/or CQI", Nokia Siemens Networks, 3GPP TSG RAN WG1#49bis, R1-073011, 3 pgs.
	"Handling NAS message during HO", Alcatel-Lucent, 3 GPP TSG RAN WG2 #59bis, October 2007, R2-074333, 2 pgs.
	3GPP TSG RAN WG1 #48bis, R1-071662, St. Julians, Malta, March 26-30, 2007, Nokia Siemens, "Uplink Scheduling Request for LTE", 4 pgs.

Examiner's Signature:	Date Considered:

Initial if reference was considered, whether or not citation is in conformance with MPEP. Mark through citation if not considered. Include a copy of this citation form with your next correspondence to the Applicant(s).

Electronic Patent Application Fee Transmittal	
Application Number:	
Filing Date:	
Title of Invention:	Providing Improved Scheduling Request Signaling With ACK/NACK Or CQI
First Named Inventor/Applicant Name:	Kari P. Pajukoski
Filer:	Robert J. Mauri/Elaine Mian
Attorney Docket Number:	863.0076.U2(US)
Filed as Large Entity	

Utility under 35 USC 111(a) Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility application filing	1011	1	280	280
Utility Search Fee	1111	1	600	600
Utility Examination Fee	1311	1	720	720
Pages:				
Claims:				
Claims in Excess of 20	1202	35	80	2800
Independent claims in excess of 3	1201	6	420	2520
Miscellaneous-Filing:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
		Total in USD ($)		**6920**

Electronic Acknowledgement Receipt	
EFS ID:	17103568
Application Number:	14051646
International Application Number:	
Confirmation Number:	6128
Title of Invention:	Providing Improved Scheduling Request Signaling With ACK/NACK Or CQI
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1	Transmittal of New Application	Transmittal.pdf	77944 d6a6ac79fc0cb60aae17fd782bd4e346bc247492	no	3
Warnings:					
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2	Specification	Specification.pdf	1070150 83843458e1d3e70a47daf6ae74101f06530bbaf3	no	34
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5	Application Data Sheet	ADS.pdf	199350 4e2554bd7298ba012afd4ed378ecfb39e94a80fd	no	6
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7	Information Disclosure Statement (IDS) Form (SB08)	IDS.pdf	67309 931ea8ceaa5b9f3494549308b55a354815ed6598	no	3
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Attorney Docket No.: 863.0076.U2(US)

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Transmitted herewith for filing is the patent application of

Inventor(s): **Kari P. Pajukoski, Esa T. Tiirola**

For (title): **Providing Improved Scheduling Request Signaling with ACK/NACK or CQI**

Enclosed are the following:

- ☐ Application Cover Page
- ☒ **34** pages of Specification that consists of, **24** pages of Description, **9** pages of Claims and **1** page of Abstract;
- ☒ **9** sheet of drawings;
- ☐ Inventor(s) Declaration;
- ☐ Power of Attorney from Applicant;
- ☒ Preliminary Amendment;
- ☐ Certified Copy of priority document(s);
- ☐ English language translation of priority document;
- ☒ Application Data Sheet;
- ☒ Information Disclosure Statement and/or Form PTO 1449 and cited non-U.S. art (if applicable);
- ☐ Assignment,
  - ☐ Inventor Declaration is in Assignment document (Assignment contains the statements required by § 1.63 (35 U.S.C 115(e) and § 1.63(e)));
- ☐ Recordation Form Cover Sheet for Assignment;
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- ☒ Other: **Formal Drawings (9 replacement sheets)**

Assignment Data

☒ An assignment of the invention to Nokia Solutions and Networks Oy
- ☐ is attached.
- ☐ will follow.
- ☒ has been previously filed.

Small Entity Status

☐ Applicant claims small entity status.

Fees

☒ Utility ☐ Reissue

☐ Design

Basic Filing Fee					$ 280.00
Excess Claim Fee					
	Number Filed	Number Extra		Rate	
Total Claims	**55** -20 =	**35**	x	$ 80.00	**$ 2800.00**
Independent Claims	**9** - 3 =	**6**	**x**	$ 420.00	**$ 2520.00**
☐ Multiple Dependent Claim Fee ($780.00)					$
Examination Fee					$ 720.00
Patent Search Fee					$ 600.00
Exceeding of 100 sheets of paper fee ($400.00 per each 50 sheets)					$
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PROVIDING IMPROVED SCHEDULING REQUEST SIGNALING WITH ACK/NACK OR CQI

CROSS-REFERENCE TO RELATED APPLICATIONS:

[0001] This patent application claims priority under 35 U.S.C. §119(e) from Provisional Patent Application No.: 61/001,207, filed October 30, 2007, the disclosure of which is incorporated by reference herein in its entirety.

TECHNICAL FIELD:

[0002] The exemplary and non-limiting embodiments of this invention relate generally to wireless communication systems, apparatus, methods and computer program products and, more specifically, relate to improved signaling of a scheduling request in conjunction with an acknowledgement or channel quality indicator.

BACKGROUND:

[0003] This section is intended to provide a background or context to the invention that is recited in the claims. The description herein may include concepts that could be pursued, but are not necessarily ones that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, what is described in this section is not prior art to the description and claims in this application and is not admitted to be prior art by inclusion in this section.

[0004] The following abbreviations are utilized herein:

3GPP	third generation partnership project
ACK	acknowledgement
BPSK	binary phase-shift keying
CAZAC	constant amplitude zero autocorrelation
CM	cubic metric
CQI	channel quality indicator
DNA	data-non-associated

DL	downlink (Node B to UE)
DL-SCH	downlink shared channel
eNode B	evolved Node B (LTE base station)
E-UTRAN	evolved universal terrestrial radio access network
LTE	long term evolution of UTRAN (E-UTRAN)
NACK	negative acknowledgement
Node B	base station
PAR	peak-to-average ratio
PUCCH	physical uplink control channel
PUSCH	physical uplink shared channel
QPSK	quadrature phase-shift keying
RACH	random access channel
RAN	radio access network
RRC	radio resource control
RS	reference signal
SF	spreading factor
SR	scheduling request
TSG	technical specifications group
TTI	transmission time interval
UE	user equipment, such as a mobile station or mobile terminal
UL	uplink (UE to Node B)
UTRAN	universal terrestrial radio access network
VoIP	voice over internet protocol
WG	working group

[0005] The 3GPP has been working on the standardization of LTE (E-UTRAN). In the absence of UL data, data-non-associated control signals (e.g., ACK/NACK, periodic CQI) are transmitted on the PUCCH. Furthermore, it has been decided that:

(a) ACK/NACK (only) signals are transmitted utilizing modulated CAZAC[1] sequences (coherent): BPSK is used for 1-bit ACK/NACK and QPSK for 2-bit

1 The applied sequences may not be true CAZAC but computer searched Zero-Autocorrelation (ZAC) sequences. The same sequences are applied as reference signals with bandwidth allocation of one resource block.

ACK/NACK. Block-wise spreading with SF=3/SF=4 (pilot/data) is applied for the modulated CAZAC sequences.

(b) Periodic CQI (and combinations of CQI and ACK/NACK) is also transmitted utilizing modulated CAZAC sequences. Block-spreading is not used.

[0006] In the 3GPP TSG RAN WG1 meeting #47bis in Sorrento, it was agreed that a non-contention based SR mechanism for time synchronized users will be supported.

[0007] The basic principles for SR multiplexing were agreed to in the 3GPP TSG RAN WG1 meeting #50bis in Shanghai. Reference in this regard may further be made to R2-074333, 3GPP TSG-RAN WG2#59bis, Alcatel-Lucent, "Handling NAS messages during HO," October 8-12, 2007, Shanghai, China.

[0008] In the Shanghai meeting, the following was also decided:

(i) There are two sizes of the SR corresponding to two states. Either the UE requests to be scheduled or (in case of no transmission) the UE does not request to be scheduled.

(ii) On-off keying based on ACK/NACK design: The length 7 sequence is split into two orthogonal sequences of length 3 and length 4. FIG. 1 shows the length 7 sequence 40 with two constituent orthogonal sequences 42, 44 of lengths 3 and 4, respectively.

(iii) There will be compatibility with ACK/NACK transmissions from different UEs.

(iv) Different resources corresponding to a cyclic shift and an orthogonal cover code can be assigned for scheduling requests and ACK/NACK.

[0009] It is noted that the ACK/NACK signaled on the UL is related to DL-SCH (Physical Downlink Shared Channel, PDSCH). In the case where the UE has no data to transmit (i.e., on the UL), the ACK/NACK is signaled on the PUCCH. When the UE has UL data to transmit, the ACK/NACK is signaled on the PUSCH.

SUMMARY:

[0010] In an exemplary aspect of the invention, there is a method comprising determining that an acknowledgment is to be sent, and for the case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource, else placing the acknowledgment in another resource.

[0011] In an exemplary aspect of the invention, there is a computer readable medium encoded with a computer program executable by a processor to perform actions comprising determining that an acknowledgment is to be sent, and for the case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource, else placing the acknowledgment in another resource.

[0012] In an exemplary aspect of the invention, there is an apparatus comprising a processor configured to determinine that an acknowledgment is to be sent, and the processor further configured to, for the case where there is also a scheduling request to be sent, combine the acknowledgment with the scheduling request on a scheduling resource, else placing the acknowledgment in another resource.

[0013] In an exemplary aspect of the invention, there is an apparatus comprising means for determining that an acknowledgment is to be sent, and means for, in the case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource, else placing the acknowledgment in another resource.

[0014] In another exemplary aspect of the invention, there is a method comprising receiving information on a scheduling resource, and determining that the information received on the scheduling resource comprises an acknowledgment.

[0015] In another exemplary aspect of the invention, there is a computer readable medium encoded with a computer program executable by a processor to perform actions

comprising receiving information on a scheduling resource, and determining that the information received on the scheduling resource comprises an acknowledgment.

[0016] In still another exemplary aspect of the invention, there is an apparatus comprising a receiver, the receiver configured to receive information on a scheduling resource, and a processor configured to determine that the information received on the scheduling resource comprises an acknowledgment.

[0017] In yet another exemplary aspect of the invention, there is an apparatus comprising means for receiving information on a scheduling resource, and means for determining that the information received on the scheduling resource comprises an acknowledgment.

[0018] In still another exemplary aspect of the invention there is a method comprising determining that a scheduling request resource and at least one other resource are reserved for a user equipment in a same sub-frame, and based on whether a scheduling request is desired to be transmitted by the user equipment, placing at least one of an acknowledgment/negative acknowledgement and a channel quality indicator that is desired to be transmitted by the user equipment in one of the resources and leaving at least one other resource unused.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0019] In the attached Drawing Figures:

[0020] FIG. 1 shows a length 7 sequence having two constituent orthogonal sequences of lengths 3 and 4;

[0021] FIG. 2 illustrates an example of ACK/NACK and SR resource assignments for UL transmissions on the PUCCH;

[0022] FIG. 3 shows an example of ACK/NACK resources configured for 18 parallel ACK/NACK channels;

[0023] FIG. 4 shows an example of SR resources configured for 72 parallel SR

channels;

[0024] FIG. 5 shows a flowchart illustrating one non-limiting example of a method for practicing the exemplary embodiments of this invention;

[0025] FIG. 6 shows a simplified block diagram of various electronic devices that are suitable for use in practicing the exemplary embodiments of this invention;

[0026] FIG. 7 depicts a flowchart illustrating another non-limiting example of a method for practicing the exemplary embodiments of this invention;

[0027] FIG. 8 depicts a flowchart illustrating another non-limiting example of a method for practicing the exemplary embodiments of this invention; and

[0028] FIG. 9 A, B, and C, depicts a flowchart illustrating yet another example of a method for practicing the exemplary embodiments of the invention.

DETAILED DESCRIPTION:

[0029] Consider a multiplexing case where data-non-associated control signals, such as ACK/NACK (e.g., DL ACK/NACK) and/or periodic CQI, exist simultaneously with an UL SR. Further assume that the UE is not transmitting UL data since separate SR/buffer status reporting principles will be used when the UE has scheduled UL data transmission on the PUSCH. As noted above, in the absence of UL data data-non-associated control signals are transmitted on the PUCCH.

[0030] To date, SR decisions made in 3GPP RAN1 only cover the case where a SR is transmitted standalone. However, it may occur that the SR is transmitted with additional data-non-associated control signals, such as ACK/NACK and/or periodic CQI (e.g., ACK/NACK + SR, periodic CQI + SR, periodic CQI + ACK/NACK + SR). Various complications may arise in such cases.

[0031] FIG. 2 illustrates an example of ACK/NACK and SR resource assignments for UL transmissions on the PUCCH. In FIG. 2, ACK/NACK and SR have been configured for different frequency-hopping radio resources. FIG. 3 shows an example of ACK/NACK resources configured for 18 parallel ACK/NACK channels.

FIG. 4 shows an example of SR resources configured for 72 parallel SR channels.

[0032] Each UE has certain code resources allocated to two different channels: one UE may occupy, for example, the eighth (8th) ACK/NACK resource and the twenty-eighth (28th) SR resource, respectively (see FIGS. 3 and 4).

[0033] One problem with the considered signaling combinations is related to the single-carrier property of LTE UL – it is not possible to transmit signals via multiple frequency bands (see FIG. 2) such that the beneficial low PAR properties of single-carrier transmission are maintained. However, due to the lack of a common pilot in the UL direction, it would not be economical to transmit two low rate control signals (e.g., SR + ACK/NACK and/or CQI) via two separate clusters (or via four clusters if SR and ACK/NACK and/or CQI have been configured into non-overlapping frequency resources).

[0034] There are some prior art techniques being discussed in RAN1 to avoid the multicarrier/multi-cluster transmission in the presence of a SR:

(a) One technique is to prioritize a predetermined signaling type (e.g., ACK/NACK instead of SR or SR instead of CQI). This means that when two signaling types exist in a same subframe, only the signaling type with the higher priority is transmitted whereas the lower priority signaling is not transmitted at all. One problem with this approach is the increased SR (or CQI) delay. This delay may be significant, for example, in a VoIP application.

(b) Periodic CQI + SR: The idea would be to arrange the periodic CQI reporting and SR signaling in such a way that they do not appear in a same subframe. One problem with this approach is that the arrangement will introduce limitations for either SR or CQI signaling. This may also be difficult to arrange as the periodicity of SR and CQI may not be the same.

(c) ACK/NACK + SR: It is possible to avoid this situation by introducing certain scheduler limitations for UEs being allocated for the given SR resource (i.e., do not allocate DL data for a time resource which will cause an ACK/NACK transmission to occur for a TTI in which the UE has simultaneous SR transmission).

(d) It would also be possible to develop a special multiplexing scheme for different alternatives (e.g., different schemes for ACK/NACK + SR, periodic CQI + SR, ACK/NACK + periodic CQI + SR). Problems with this approach are related to link performance (modulation method) and/or resource allocation (multicode method, sequence selection method). Reference with regard to this technique may be made to commonly-owned U.S. provisional patent application no. 60/936,033, "Multiplexing of Scheduling Request and ACK/NACK and/or CQI Transmitted on PUCCH" by Tiirola et al. filed on June 18, 2007 (attorney docket no. 863.0067.P1(US)). Further reference in this regard may be made to R2-074139, 3GPP TSG-RAN WG2#59bis, NEC, "X2 downlink forwarding delay," October 8-12, 2007, Shanghai, China.

[0035] Exemplary embodiments of the invention provide improved techniques for signaling a SR with an ACK/NACK and/or CQI. In some exemplary embodiments, different multiplexing procedures are provided for cases with positive SR than for cases with negative SR. In accordance with the 3GPP TSG-RAN WG1#50bis Shanghai decisions, when the SR is transmitted standalone, only positive SRs are signaled (i.e., there is no transmission for negative SR).

[0036] In one, non-limiting exemplary embodiment of the invention:

(i) For negative SR, the ACK/NACK and/or CQI are signaled using original ACK/NACK (ACK/NACK PUCCH) and/or CQI resources (CQI PUCCH).

(ii) For positive SR, the ACK/NACK signal is transmitted using the SR resources (SR PUCCH). Transmission of the ACK/NACK on the SR resource(s) can be performed in a similar way to when ACK/NACK is transmitted on the ACK/NACK resource (unmodulated sequence 1 and modulated sequence 2 or unmodulated sequence 1 and unmodulated sequence 2). In this case, the ACK/NACK resource (ACK/NACK PUCCH) is left unused.

(iii) For positive SR without a simultaneous ACK/NACK signal, the SR signal is transmitted using the original SR resource(s), SR PUCCH. The simultaneous CQI is dropped (i.e., not transmitted) and the CQI resource(s), (CQI PUCCH)is left unused.

[0037] In such a manner, simultaneous transmission of ACK/NACK and

(positive) SR is supported whereas there is no provision for simultaneous transmission of (positive) SR and CQI.

[0038] It is briefly noted that, as utilized herein, "positive SR" signifies that the UE desires to transmit a SR (e.g., to a Node B). Similarly, "negative SR" indicates that the UE does not desire to transmit a SR (e.g., to a Node B). Any reference to "resource" should be construed as covering a single resource or multiple resources assigned for the specified signaling.

[0039] With a negative SR, it is possible to signal the ACK/NACK and/or CQI using the original resources allocated for ACK/NACK or CQI, respectively. The SR resource(s) is left (SR PUCCH) unused. Thus, the following hold: If there is a negative SR and an ACK/NACK, transmit the ACK/NACK using only the original ACK/NACK resource(s), ACK/NACK PUCCH. If there is a negative SR and a CQI (e.g., periodic CQI), transmit the CQI using only the original CQI resource(s), CQI PUCCH. If there is a negative SR and both ACK/NACK and a CQI, transmit the ACK/NACK and CQI using only the original ACK/NACK and CQI resources, CQI PUCCH respectively.

[0040] As noted above, with a positive SR, simultaneous transmission of ACK/NACK and SR is supported whereas there is no support for simultaneous transmission of CQI and SR. Simultaneous transmission of ACK/NACK and positive SR is performed using the SR resource(s), SR PUCCH. Thus, the following procedures are applied:

[0041] If there is a positive SR and an ACK/NACK, signal the ACK/NACK using the existing SR resource(s), SR PUCCH. The ACK/NACK resource(s), ACK/NACK PUCCH, are left unused. The ACK/NACK can be transmitted similarly to when it is transmitted on its own resource (e.g., unmodulated sequence 1, BPSK/QPSK-modulated sequence 2).

[0042] If there is a positive SR and a CQI (e.g., periodic CQI), the SR is prioritized over the CQI. That is, transmit the SR using only the original SR resource (e.g., on the PUCCH). The CQI resource, CQI PUCCH is left unused.

[0043] If there is a positive SR and both ACK/NACK and CQI, the ACK/NACK

is signaled using only the original SR resource (e.g., on the PUCCH). The CQI resource, CQI PUCCH is left unused and the CQI is not transmitted. The ACK/NACK can be transmitted similarly to when it is transmitted on its own resource (e.g., unmodulated sequence 1, BPSK/QPSK-modulated sequence 2).

[0044] On the Node B side, the Node B is responsible for the UL/DL resource allocation (e.g., for CQI, DL data and ACK/NACK, SR). Therefore, the Node B can receive the ACK/NACK, CQI and SR from the various resources, taking into account the different UE operation in light of positive or negative SR.

[0045] In further exemplary embodiments, the Node B can modify the above-stated prioritizations, for example, using RRC signaling (e.g., cell-specific, UE-specific). In such a manner, and as a non-limiting example, the Node B could modify the prioritization such that CQI is prioritized over ACK/NACK.

[0046] FIG. 5 shows a flowchart illustrating one non-limiting example of a method for practicing the exemplary embodiments of this invention. In box 52, it is determined whether there is a positive SR ("YES") or a negative SR ("NO"). If there is a negative SR, the method proceeds to boxes 54 and 56. In box 54, if there is an ACK/NACK (w/o CQI), the ACK/NACK is transmitted using ACK/NACK resources and the SR resources are unused. In box 56, if there is a CQI (with or without ACK/NACK), the CQI (or CQI+ACK/NACK) is transmitted using CQI resources, CQI PUCCH, and the SR resources (and ACK/NACK PUCCH) are unused. If there is a positive SR ("YES" for box 52), the method proceeds to box 58. In box 58, it is determined whether ACK/NACK is present ("YES") or not ("NO"). If ACK/NACK is not present ("NO" for box 58), then in box 60 the SR is transmitted using the SR resources and the additional resource which may be data-non-associated (DNA) resources, such as ACK/NACK PUCCH and CQI PUCCH are unused. No CQI is transmitted, regardless of whether or not it is present. If ACK/NACK is present ("YES" for box 58), then in box 62 the ACK/NACK is transmitted using the SR resources and the DNA resources, such as ACK/NACK PUCCH and CQI PUCCH are unused. No CQI is transmitted, regardless of whether or not it is present.

[0047] Reference is made to FIG. 6 for illustrating a simplified block diagram of

various electronic devices that are suitable for use in practicing the exemplary embodiments of this invention. In FIG. 6, a wireless network 12 is adapted for communication with a user equipment (UE) 14 via an access node (AN) 16. The UE 14 includes a data processor (DP) 18, a memory (MEM) 20 coupled to the DP 18, and a suitable RF transceiver (TRANS) 22 (having a transmitter (TX) and a receiver (RX)) coupled to the DP 18. The MEM 20 stores a program (PROG) 24. The TRANS 22 is for bidirectional wireless communications with the AN 16. Note that the TRANS 22 has at least one antenna to facilitate communication.

[0048] The AN 16 includes a data processor (DP) 26, a memory (MEM) 28 coupled to the DP 26, and a suitable RF transceiver (TRANS) 30 (having a transmitter (TX) and a receiver (RX)) coupled to the DP 26. The MEM 28 stores a program (PROG) 32. The TRANS 30 is for bidirectional wireless communications with the UE 14. Note that the TRANS 30 has at least one antenna to facilitate communication. The AN 16 is coupled via a data path 34 to one or more external networks or systems, such as the internet 36, for example.

[0049] At least one of the PROGs 24, 32 is assumed to include program instructions that, when executed by the associated DP, enable the electronic device to operate in accordance with the exemplary embodiments of this invention, as discussed herein.

[0050] In general, the various exemplary embodiments of the UE 14 can include, but are not limited to, user equipments, terminals, mobile phones, cellular phones, personal digital assistants (PDAs) having wireless communication capabilities, portable computers having wireless communication capabilities, image capture devices such as digital cameras having wireless communication capabilities, gaming devices having wireless communication capabilities, music storage and playback appliances having wireless communication capabilities, Internet appliances permitting wireless Internet access and browsing, as well as portable units or terminals that incorporate combinations of such functions.

[0051] The embodiments of this invention may be implemented by computer software executable by one or more of the DPs 18, 26 of the UE 14 and the AN 16, or by

hardware, or by a combination of software and hardware.

[0052] The MEMs 20, 28 may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor-based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory, as non-limiting examples. The DPs 18, 26 may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on a multi-core processor architecture, as non-limiting examples.

[0053] By utilizing exemplary embodiments of the invention, unlike with other prior art techniques supporting simultaneous transmission of ACK/NACK and SR, SR, ACK/NACK and CQI performance can be maintained with very little, if any, change.

[0054] In many cases, it may be possible to configure periodic CQI and periodic SR into different subframes. In such cases, the performance degradation caused by dropping CQI is estimated to be very marginal.

[0055] Furthermore, accepted modulation options may be utilized in conjunction with exemplary embodiments of the invention. That is, there is no need to specify separate modulation or multiplexing options for positive SR versus negative SR. Existing data-non-associated signaling can be maintained as similar as possible with both positive SR and negative SR. Furthermore, no changes are needed for CM properties.

[0056] Below are provided further descriptions of non-limiting, exemplary embodiments. The below-described exemplary embodiments are separately numbered for clarity and identification. This numbering should not be construed as wholly separating the below descriptions since various aspects of one or more exemplary embodiments may be practiced in conjunction with one or more other aspects or exemplary embodiments.

[0057] In one non-limiting, exemplary embodiment, and as illustrated in FIG. 7, a method includes: providing that at least one of an acknowledgement and a channel quality indicator (CQI) is to be transmitted, wherein the transmission comprises at least

one scheduling request (SR) resource (SR PUCCH) and at least one additional resource that can be a data-non-associated (DNA) resource, such as ACK/NACK PUCCH or CQI PUCCH (box 71); determining whether a SR is to be transmitted (box 72); determining whether the acknowledgement is to be transmitted (box 73); determining whether the CQI is to be transmitted (box 74); in response to determining that the SR is not to be transmitted and that the acknowledgement is to be transmitted, transmitting the acknowledgement using a corresponding at least one acknowledgement resource of the at least one additional resource such as a DNA resource, wherein the at least one SR resource is unused (box 75); in response to determining that the SR is not to be transmitted and that the CQI (or CQI+ACK/NACK) is to be transmitted, transmitting the CQI (or CQI+ACK/NACK) using a corresponding at least one CQI resource of the at least one additional resource such as a DNA resource, wherein the at least one SR resource is unused (box 76); in response to determining that the SR is to be transmitted and that the acknowledgement is not to be transmitted, transmitting the SR using the at least one SR resource, wherein if the CQI is to be transmitted the CQI is not transmitted and the at least one additional resource such as the DNA resource is unused (box 77); and in response to determining that the SR is to be transmitted and that the acknowledgement is to be transmitted, transmitting the acknowledgement using the at least one SR resource, wherein if the CQI is to be transmitted the CQI is not transmitted and the at least one additional resource such as the DNA resource is unused (box 78).

[0058] A method as above, wherein a periodic CQI transmission and a periodic SR transmission are configured into different subframes. A method as in any above, wherein transmissions are transmitted on a PUCCH. A method as in any above, wherein transmissions are transmitted on an UL. A method as in any above, wherein if transmitted the acknowledgement comprises an unmodulated sequence 1, BPSK/QPSK-modulated sequence 2. A method as in any above, wherein the method is implemented by a UE or terminal. A method as in any above, wherein the method is implemented within a wireless communication network. A method as in any above, wherein the method is implemented within an E-UTRAN. A method as in any above, wherein the method is implemented by a computer program. A method as in any above, wherein the method is implemented by a processor of a user equipment.

[0059] In another non-limiting, exemplary embodiment, a computer program

product comprises program instructions embodied on a tangible computer-readable medium. Execution of the program instructions results in operations comprising: providing that at least one of an acknowledgement and a channel quality indicator (CQI) is to be transmitted, wherein the transmission comprises at least one scheduling request (SR) resource and at least one additional resource such as a data-non-associated (DNA) resource, such as ACK/NACK PUCCH or CQI PUCCH; determining whether a SR is to be transmitted; determining whether the acknowledgement is to be transmitted; determining whether the CQI is to be transmitted; in response to determining that the SR is not to be transmitted and that the acknowledgement is to be transmitted, transmitting the acknowledgement using a corresponding at least one acknowledgement resource of the at least one additional resource such as a DNA resource, wherein the at least one SR resource is unused; in response to determining that the SR is not to be transmitted and that the CQI (or CQI+ACK/NACK) is to be transmitted, transmitting the CQI (or CQI+ACK/NACK) using a corresponding at least one CQI resource of the at least one additional resource such as a DNA resource, wherein the at least one SR resource is unused; in response to determining that the SR is to be transmitted and that the acknowledgement is not to be transmitted, transmitting the SR using the at least one SR resource, wherein if the CQI is to be transmitted the CQI is not transmitted and the at least one additional resource such as a DNA resource is unused; and in response to determining that the SR is to be transmitted and that the acknowledgement is to be transmitted, transmitting the acknowledgement using the at least one SR resource, wherein if the CQI is to be transmitted the CQI is not transmitted and the at least one additional resource such as a DNA resource is unused.

[0060] A computer program as above, wherein a periodic CQI transmission and a periodic SR transmission are configured into different sub-frames. A computer program as in any above, wherein transmissions are transmitted on a PUCCH. A computer program as in any above, wherein transmissions are transmitted on an UL. A computer program as in any above, wherein if transmitted the acknowledgement comprises an unmodulated sequence 1, BPSK/QPSK-modulated sequence 2. A computer program as in any above, wherein the method is implemented by a UE or terminal. A computer program as in any above, wherein the computer program is implemented within a wireless communication network. A computer program as in any above, wherein the

computer program is implemented within an E-UTRAN.

[0061] In another non-limiting, exemplary embodiment, an apparatus comprising: a transceiver configured to transmit at least one of an acknowledgement and a channel quality indicator (CQI), wherein the transmission comprises at least one scheduling request (SR), SR PUCCH resource and at least one additional resource which may be a data-non-associated (DNA) resource, such as ACK/NACK PUCCH or CQI PUCCH; and a processor configured to determine whether a SR is to be transmitted, to determine whether the acknowledgement is to be transmitted, and to determine whether the CQI is to be transmitted, wherein in response to the processor determining that the SR is not to be transmitted and that the acknowledgement is to be transmitted, the transceiver is configured to transmit the acknowledgement using a corresponding at least one acknowledgement resource of the at least one additional resource such as a DNA resource and wherein the at least one SR resource is unused, wherein in response to the processor determining that the SR is not to be transmitted and that the CQI is to be transmitted, the transceiver is configured to transmit the CQI using a corresponding at least one CQI resource of the at least one additional resource such as a DNA resource and wherein the at least one SR resource is unused, wherein in response to the processor determining that the SR is to be transmitted and that the acknowledgement is not to be transmitted, the transceiver is configured to transmit the SR using the at least one SR resource and wherein if the CQI is to be transmitted the CQI is not transmitted and the at least one additional resource such as a DNA resource is unused, wherein in response to the processor determining that the SR is to be transmitted and that the acknowledgement is to be transmitted, the transceiver is configured to transmit the acknowledgement using the at least one SR resource and wherein if the CQI is to be transmitted the CQI is not transmitted and the at least one additional resource such as a DNA resource is unused.

[0062] An apparatus as above, wherein a periodic CQI transmission and a periodic SR transmission are configured by the processor into different sub-frames. An apparatus as in any above, wherein transmissions are transmitted by the transceiver on a PUCCH. An apparatus as in any above, wherein transmissions are transmitted by the transceiver on an UL. An apparatus as in any above, wherein if transmitted by the transceiver the acknowledgement comprises an unmodulated sequence 1, BPSK/QPSK-modulated sequence 2. An apparatus as in any above, wherein the apparatus comprises a

UE or terminal. An apparatus as in any above, wherein the apparatus comprises a node of a wireless communication network. An apparatus as in any above, wherein the apparatus comprises a node of an E-UTRAN.

[0063] In another non-limiting, exemplary embodiment, an apparatus comprising: means for transmitting at least one of an acknowledgement and a channel quality indicator (CQI), wherein the transmission comprises at least one scheduling request (SR) resource and at least one additional resource which may be a data-non-associated (DNA) resource, such as ACK/NACK PUCCH or CQI PUCCH; means for determining whether a SR is to be transmitted; means for determining whether the acknowledgement is to be transmitted; and means for determining whether the CQI is to be transmitted, wherein in response to the processor determining that the SR is not to be transmitted and that the acknowledgement is to be transmitted, the means for transmitting is further for transmitting the acknowledgement using a corresponding at least one acknowledgement resource of the at least one additional resource such as a DNA resource and wherein the at least one SR resource is unused, wherein in response to the processor determining that the SR is not to be transmitted and that the CQI is to be transmitted, the means for transmitting is further for transmitting the CQI using a corresponding at least one CQI resource of the at least one additional resource such as a DNA resource and wherein the at least one SR resource is unused, wherein in response to the processor determining that the SR is to be transmitted and that the acknowledgement is not to be transmitted, the means for transmitting is further for transmitting the SR using the at least one SR resource and wherein if the CQI is to be transmitted the CQI is not transmitted and the at least one additional resource such as a DNA resource is unused, wherein in response to the processor determining that the SR is to be transmitted and that the acknowledgement is to be transmitted, the means for transmitting is further for transmitting the acknowledgement using the at least one SR resource and wherein if the CQI is to be transmitted the CQI is not transmitted and the at least one additional resource such as a DNA resource is unused.

[0064] An apparatus as above, wherein the means for transmitting comprises a transmitter and the means for determining whether the SR is to be transmitted, the means for determining whether the acknowledgement is to be transmitted and the means for

determining whether the CQI is to be transmitted comprise a processor.

[0065] In another non-limiting, exemplary embodiment, and as illustrated in FIG. 8, a method includes: receiving a transmission comprising at least one scheduling request (SR) resource and at least one other resource which may be a data-non-associated (DNA) resource (box 81); such as ACK/NACK PUCCH or CQI PUCCH; in response to determining that the at least one SR resource is unused, determining that the transmission does not comprise a SR (box 82); in response to determining that the at least one SR resource is unused and that at least one acknowledgement resource of the at least one other resource such as a DNA resource is used, determining that the transmission comprises an acknowledgement and obtaining acknowledgement information from the acknowledgement (box 83); in response to determining that the at least one SR resource is unused and that at least one channel quality indicator (CQI) resource of the at least one additional resource such as a DNA resource is used, determining that the transmission comprises a CQI (or CQI+ACK/NACK) and obtaining CQI (or CQI+ACK/NACK) information from the CQI (box 84); in response to determining that the at least one SR resource is used, determining that the transmission comprises a SR (box 85); in response to determining that the at least one SR resource is used by an acknowledgement, determining that the transmission comprises a SR and obtaining acknowledgement information from the acknowledgement (box 86); and responding accordingly to the determination(s) and/or obtained information (box 87).

[0066] A method as above, wherein a periodic CQI transmission and a periodic SR transmission are configured into different sub-frames. A method as in any above, wherein the transmission is received on a PUCCH. A method as in any above, wherein the transmission is received on an UL. A method as in any above, wherein if received the acknowledgement comprises an unmodulated sequence 1, BPSK/QPSK-modulated sequence 2. A method as in any above, wherein the method is implemented by a base station or network element. A method as in any above, wherein the method is implemented within a wireless communication network. A method as in any above, wherein the method is implemented within an E-UTRAN. A method as in any above, wherein the method is implemented by a computer program. A method as in any above, wherein the method is implemented by a processor of a network element.

[0067] In another non-limiting, exemplary embodiment, a computer program product comprises program instructions embodied on a tangible computer-readable medium. Execution of the program instructions results in operations comprising: receiving a transmission comprising at least one scheduling request (SR) resource and at least one additional resource which may be a data-non-associated (DNA) resource, such as ACK/NACK PUCCH or CQI PUCCH; in response to determining that the at least one SR resource is unused, determining that the transmission does not comprise a SR; in response to determining that the at least one SR resource is unused and that at least one acknowledgement resource of the at least one additional resource such as a DNA resource is used, determining that the transmission comprises an acknowledgement and obtaining acknowledgement information from the acknowledgement; in response to determining that the at least one SR resource is unused and that at least one channel quality indicator (CQI) resource of the at least one additional resource such as a DNA resource is used, determining that the transmission comprises a CQI and obtaining CQI information from the CQI; in response to determining that the at least one SR resource is used, determining that the transmission comprises a SR; in response to determining that the at least one SR resource is used by an acknowledgement, determining that the transmission comprises a SR and obtaining acknowledgement information from the acknowledgement; and responding accordingly to the determination(s) and/or obtained information.

[0068] A computer program as above, wherein a periodic CQI transmission and a periodic SR transmission are configured into different sub-frames. A computer program as in any above, wherein the transmission is received on a PUCCH. A computer program as in any above, wherein the transmission is received on an UL. A computer program as in any above, wherein if received the acknowledgement comprises an unmodulated sequence 1, BPSK/QPSK-modulated sequence 2. A computer program as in any above, wherein the method is implemented by a base station or network element. A computer program as in any above, wherein the computer program is implemented within a wireless communication network. A computer program as in any above, wherein the computer program is implemented within an E-UTRAN.

[0069] In another non-limiting, exemplary embodiment, an apparatus comprising: a receiver configured to receive a transmission comprising at least one scheduling request (SR) resource and at least one additional resource which may be a data-non-associated

(DNA) resource, such as ACK/NACK PUCCH or CQI PUCCH; and a processor configured, in response to determining that the at least one SR resource is unused, to determine that the transmission does not comprise a SR, in response to determining that the at least one SR resource is unused and that at least one acknowledgement resource of the at least one additional resource such as a DNA resource is used, to determine that the transmission comprises an acknowledgement and to obtain acknowledgement information from the acknowledgement, in response to determining that the at least one SR resource is unused and that at least one channel quality indicator (CQI) resource of the at least one DNA resource is used, to determine that the transmission comprises a CQI and to obtain CQI information from the CQI, in response to determining that the at least one SR resource is used, to determine that the transmission comprises a SR, in response to determining that the at least one SR resource is used by an acknowledgement, to determine that the transmission comprises a SR and to obtain acknowledgement information from the acknowledgement, and to respond accordingly to the determination(s) and/or obtained information.

[0070] An apparatus as above, wherein a periodic CQI transmission and a periodic SR transmission are configured by the processor into different sub-frames. An apparatus as in any above, wherein transmissions are received by the receiver on a PUCCH. An apparatus as in any above, wherein transmissions are received by the receiver on an UL. An apparatus as in any above, wherein if received by the receiver the acknowledgement comprises an unmodulated sequence 1, BPSK/QPSK-modulated sequence 2. An apparatus as in any above, wherein the apparatus comprises a base station or network element. An apparatus as in any above, wherein the apparatus comprises a node of a wireless communication network. An apparatus as in any above, wherein the apparatus comprises a node of an E-UTRAN.

[0071] In another non-limiting, exemplary embodiment, an apparatus comprising: means for receiving a transmission comprising at least one scheduling request (SR) resource and at least one additional resource which may be a data-non-associated (DNA) resource, such as ACK/NACK PUCCH or CQI PUCCH; means for determining, in response to determining that the at least one SR resource is unused, that the transmission does not comprise a SR, means for determining, in response to determining that the at least one SR resource is unused and that at least one acknowledgement resource of the at

least one additional resource such as a DNA resource is used, that the transmission comprises an acknowledgement and to obtain acknowledgement information from the acknowledgement, means for determining, in response to determining that the at least one SR resource is unused and that at least one channel quality indicator (CQI) resource of the at least one additional resource such as a DNA resource is used, that the transmission comprises a CQI and to obtain CQI information from the CQI, means for determining, in response to determining that the at least one SR resource is used, that the transmission comprises a SR; means for determining, in response to determining that the at least one SR resource is used by an acknowledgement, that the transmission comprises a SR and to obtain acknowledgement information from the acknowledgement, and means for responding accordingly to the determination(s) and/or obtained information.

[0072] An apparatus as above, wherein the means for receiving comprises a receiver and the means for determining/obtaining and the means for responding comprise a processor.

[0073] In accordance with the exemplary embodiments of the invention, and as illustrated in Figures 9A, 9B, and 9C, there is a method, executable computer program, and apparatus configured for operations determining that a scheduling request resource and at least one other resource are reserved for a user equipment in a same sub-frame (box 910); and based on whether a scheduling request is desired to be transmitted by the user equipment, placing at least one of an acknowledgment/negative acknowledgement and a channel quality indicator that is desired to be transmitted by the user equipment in one of the resources and leaving at least one other resource unused (box 920). The method, executable computer program, and apparatus as above where the scheduling request resource and the at least one other resource are physical uplink control channel resources (box 930). Further, as method as in any of the above comprising for the case where the user equipment desires to transmit a scheduling request and transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement with the scheduling request on the scheduling request resource and leaving the at least one other resource unused, or for the case where the user equipment does not desire to transmit a scheduling request and does desire to transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement on the at least one other resource and leaving the scheduling request

resource unused (box 940). The method, executable computer program, and apparatus as above for the case where the user equipment desires to transmit a scheduling request and a channel quality indicator but no acknowledgment/negative acknowledgement, transmitting the scheduling request on the scheduling request resource, not transmitting the channel quality indicator, and leaving the at least one other resource unused (box 950). Further, The method, executable computer program, and apparatus as above for the case where the user equipment desires to transmit a scheduling request, transmit a channel quality indicator, and transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement with the scheduling request on the scheduling request resource, not transmitting the channel quality indicator, and leaving the at least one other resource unused, or for the case where the user equipment does not desire to transmit a scheduling request and does desire to transmit a channel quality indicator and an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement and the channel quality indicator on the at least one other resource and leaving the scheduling request resource unused (box 960).

[0074] The method, executable computer program, and apparatus as above where the scheduling request information is conveyed based on a selected physical uplink control channel selection.

[0075] Further in accordance with the exemplary embodiments of the invention there is a method, executable computer program, and apparatus configured for operations comprising determining the PUCCH resource to be used in the case where at least one of two resources, ACK/NACK resource (ACK/NACK PUCCH) and CQI resource (CQI PUCCH) are reserved by the same UE in the same sub-frame with the scheduling request resource (SR PUCCH). The method, executable computer program, and apparatus as above operational for the case where there is a positive scheduling request, transmitting the acknowledgment with the scheduling request on the scheduling request resource (SR PUCCH) and leaving ACK/NACK PUCCH resource unused and, for the case where there is a negative scheduling request, transmitting the acknowledgment (ACK/NACK) on the original ACK/NACK resource (ACK/NACK PUCCH) and leaving SR PUCCH resource unused. The method, executable computer program, and apparatus as above for a case where a channel quality indicator is also to be sent and the corresponding CQI PUCCH resource is being reserved, and for the case of positive scheduling request with

CQI but without ACK/NACK, transmitting the scheduling request on the SR PUCCH resource and not transmitting the channel quality indicator (CQI PUCCH resource is unused), and for the case of positive scheduling request with CQI and ACK/NACK, transmitting ACK/NACK on the scheduling request resource (SR PUCCH) and not transmitting the channel quality indicator at all (CQI PUCCH and ACK/NACK PUCCH resources are left unused), and for the case of negative scheduling request, transmitting the channel quality indicator and possible ACK/NACK on the original CQI PUCCH resource. The method, executable computer program, and apparatus as above where the scheduling request information is conveyed based on selected PUCCH resource.

[0076] While the exemplary embodiments have been described above in the context of the E-UTRAN (UTRAN-LTE) system, it should be appreciated that the exemplary embodiments of this invention are not limited for use with only this one particular type of wireless communication system, and that they may be used to advantage in other wireless communication systems.

[0077] The exemplary embodiments of the invention, as discussed above and as particularly described with respect to exemplary methods, may be implemented as a computer program product comprising program instructions embodied on a tangible computer-readable medium. Execution of the program instructions results in operations comprising steps of utilizing the exemplary embodiments or steps of the method.

[0078] It should be noted that the terms "connected," "coupled," or any variant thereof, mean any connection or coupling, either direct or indirect, between two or more elements, and may encompass the presence of one or more intermediate elements between two elements that are "connected" or "coupled" together. The coupling or connection between the elements can be physical, logical, or a combination thereof. As employed herein two elements may be considered to be "connected" or "coupled" together by the use of one or more wires, cables and/or printed electrical connections, as well as by the use of electromagnetic energy, such as electromagnetic energy having wavelengths in the radio frequency region, the microwave region and the optical (both visible and invisible) region, as several non-limiting and non-exhaustive examples.

[0079] In general, the various embodiments may be implemented in hardware or

special purpose circuits, software, logic or any combination thereof. For example, some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the invention is not limited thereto. While various aspects of the invention may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[0080] Embodiments of the inventions may be practiced in various components such as integrated circuit modules. The design of integrated circuits is by and large a highly automated process. Complex and powerful software tools are available for converting a logic level design into a semiconductor circuit design ready to be etched and formed on a semiconductor substrate.

[0081] Programs, such as those provided by Synopsys, Inc. of Mountain View, California and Cadence Design, of San Jose, California automatically route conductors and locate components on a semiconductor chip using well established rules of design as well as libraries of pre-stored design modules. Once the design for a semiconductor circuit has been completed, the resultant design, in a standardized electronic format (e.g., Opus, GDSII, or the like) may be transmitted to a semiconductor fabrication facility or "fab" for fabrication.

[0082] The foregoing description has provided by way of exemplary and non-limiting examples a full and informative description of the invention. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims. However, all such and similar modifications of the teachings of this invention will still fall within the scope of this invention.

[0083] Furthermore, some of the features of the preferred embodiments of this invention could be used to advantage without the corresponding use of other features. As such, the foregoing description should be considered as merely illustrative of the

principles of the invention, and not in limitation thereof.

CLAIMS

What is claimed is:

1. A method comprising:

determining that an acknowledgment is to be sent; and

for the case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource,

else placing the acknowledgment in another resource.

2. The method of claim 1, comprising:

for the case where there is also the scheduling request to be sent, transmitting the acknowledgment with the scheduling request on the scheduling resource.

3. The method of any of claims 1 or 2, comprising:

for a case where a channel quality indicator is also to be sent, the channel quality indicator is not sent and the another resource is unused.

4. The method of any one of claims 1 or 2, where the another resource is a data-non-associated resource.

5. The method of claim 2, where the transmitting is on a physical uplink control channel.

6. The method of any one of claims 2 or 5, where the transmitting is on an uplink.

7. The method of any one of claims 1 or 2, where the acknowledgment comprises an unmodulated sequence 1 and a BPSK/QPSK modulated sequence 2.

8. The method of any one of claims 1 or 2 implemented in a user equipment.

9. The method of any one of claims 1 or 2 implemented in a wireless communications network.

10. The method of any one of claims 1, 2, 8, or 9 implemented in an evolved universal terrestrial radio access network.

11. A computer readable medium encoded with a computer program executable by a processor to perform actions comprising:

determining that an acknowledgment is to be sent; and

for the case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource,

else placing the acknowledgment in another resource.

12. The computer readable medium encoded with a computer program of claim 11, comprising:

for the case where there is also the scheduling request to be sent, transmitting the acknowledgment with the scheduling request on the scheduling resource.

13. The computer readable medium encoded with a computer program of any one of claims 11 or 12, comprising:

for a case where a channel quality indicator is also to be sent, the channel quality indicator is not sent and the another resource is unused.

14. The computer readable medium encoded with a computer program of any one of claims 11 or 12, where the another resource is a data-non-associated resource.

15. An apparatus comprising:

a processor configured to determine that an acknowledgment is to be sent; and

the processor further configured to, for the case where there is also a scheduling request to be sent, combine the acknowledgment with the scheduling request on a scheduling resource,

else placing the acknowledgment in another resource.

16. The apparatus of claim 15, comprising:

a transmitter configured to, for the case where there is also the scheduling request to be sent, transmit the acknowledgment with the scheduling request on the scheduling resource.

17. The apparatus of any one of claims 15 or 16, comprising:

the processor further configured to, for a case where a channel quality indicator is also to be sent, drop the channel quality indicator such that it is not sent and the another resource is unused.

18. The apparatus of any one of claims 15 or 16, where the another resource is a data-non-associated resource.

19. The apparatus of claim 16, where the transmitter is configured to transmit the acknowledgment with the scheduling request on a physical uplink control channel.

20. The apparatus of any one of claims 16 or 19, where the transmitter is configured to transmit the acknowledgment with the scheduling request on an uplink.

21. The apparatus of any one of claims 15 or 16, where the acknowledgment

comprises an unmodulated sequence 1 and a BPSK/QPSK modulated sequence 2.

22. The apparatus of any one of claims 15 or 16 embodied in a user equipment.

23. The apparatus of any one of claims 15 or 16 configured to operate in a wireless communications network.

24. The apparatus of any one of claims 15, 16, 22, or 23 configured to operate in an evolved universal terrestrial radio access network.

25. An apparatus comprising:

means for determining that an acknowledgment is to be sent; and

means, in the case where there is also a scheduling request to be sent, for combining the acknowledgment with the scheduling request on a scheduling resource,

else placing the acknowledgment in another resource.

26. The apparatus of claim 25, comprising:

means, in the case where there is also the scheduling request to be sent, for transmitting the acknowledgment with the scheduling request on the scheduling resource.

27. The apparatus of any of claims 25 or 26, comprising:

means, in a case where a channel quality indicator is also to be sent, for dropping the channel quality indicator such that it is not sent and the another resource is unused.

28. The apparatus of any one of claims 25 or 26, where the another resource is a data-non-associated resource.

29. The apparatus of claim 26, where the means for transmitting further comprises

means for transmitting the acknowledgment with the scheduling request on a physical uplink control channel.

30. The apparatus of any of claims 26 or 29, where the means for transmitting further comprises means for transmitting the acknowledgment with the scheduling request on an uplink.

31. The apparatus of any one of claims 25 or 26, where the acknowledgment comprises an unmodulated sequence 1 and a BPSK/QPSK modulated sequence 2.

32. The apparatus of any one of claims 25 or 26 embodied in a user equipment.

33. The apparatus of any one of claims 25 or 26 comprising means for operating in a wireless communications network.

34. The apparatus of any of claims 25, 26, 28, or 29 comprising means for operating in an evolved universal terrestrial radio access network.

35. A method comprising:

receiving information on a scheduling resource; and

determining that the information received on the scheduling resource comprises an acknowledgment.

36. The method of claim 35, comprising

responding accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment.

37. The method of any one of claims 35 or 36 where the information is received on a physical uplink control channel.

38. The method of any one of claims 35 or 36 where the information is received from a wireless communications network.

39. The method of any one of claims 31, 32 or 34 where the information is received from an evolved universal terrestrial radio access network.

40. A computer readable medium encoded with a computer program executable by a processor to perform actions comprising:

receiving information on a scheduling resource; and

determining that the information received on the scheduling resource comprises an acknowledgment.

41. The computer readable medium encoded with a computer program of claim 40, comprising

responding accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment

42. An apparatus comprising:

a receiver;

the receiver configured to receive information on a scheduling resource; and

a processor configured to determine that the information received on the scheduling resource comprises an acknowledgment.

43. The apparatus of claim 42 further comprising:

a transmitter;

the transmitter and the processor responding accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment.

44. The apparatus of any one of claims 42 or 43 where the receiver is further configured to receive the information on a physical uplink control channel.

45. The apparatus of any one of claims 42 or 43 where the receiver is further configured to receive the information from a wireless communications network.

46. The apparatus of any of claims 42, 43, or 45 where the receiver is further configured to receive the information from an evolved universal terrestrial radio access network.

47. An apparatus comprising:

means for receiving information on a scheduling resource; and

means for determining that the information received on the scheduling resource comprises an acknowledgment.

48. The apparatus of claim 47, comprising

means for responding accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment.

49. The apparatus of any one of claims 46 or 47 where the means for receiving comprises a receiver; the means for determining comprises a processor; and the means for responding comprises a transmitter.

50. A method comprising:

determining that a scheduling request resource and at least one other resource are reserved for a user equipment in a same sub-frame; and

based on whether a scheduling request is desired to be transmitted by

the user equipment, placing at least one of an acknowledgment/negative acknowledgement and a channel quality indicator that is desired to be transmitted by the user equipment in one of the resources and leaving at least one other resource unused.

51. The method of claim 50, where the scheduling request resource and the at least one other resource are physical uplink control channel resources.

52. The method of any one of claims 50 or 51 comprising:

for the case where the user equipment desires to transmit a scheduling request and transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement with the scheduling request on the scheduling request resource and leaving the at least one other resource unused; or

for the case where the user equipment does not desire to transmit a scheduling request and does desire to transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement on the at least one other resource and leaving the scheduling request resource unused.

53. The method of any one of claims 50 or 51 comprising:

for the case where the user equipment desires to transmit a scheduling request and a channel quality indicator but no acknowledgment/negative acknowledgement, transmitting the scheduling request on the scheduling request resource and not transmitting the channel quality indicator leaving the at least one other resource unused.

54. The method any one of claims 50 or 51 comprising:

for the case where the user equipment desires to transmit a scheduling request, transmit a channel quality indicator, and transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement with the scheduling request on the scheduling request resource and not transmitting the channel quality indicator leaving the at least one other resource unused; or

for the case where the user equipment does not desire to transmit a scheduling request and does desire to transmit a channel quality indicator and an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement and the channel quality indicator on the at least one other resource and leaving the scheduling request resource unused.

55. The method of any one any one of claims 50 or 51 where the scheduling request information is conveyed based on a selected physical uplink control channel selection.

ABSTRACT

In accordance with the exemplary embodiments of the invention there is a method, executable computer program, and apparatus for determining that an acknowledgment is to be sent, and for the case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource, else placing the acknowledgment in another resource. In accordance with another exemplary embodiment of the invention there is a method, executable computer program, and apparatus for receiving information on a scheduling resource, and determining that the information received on the scheduling resource includes an acknowledgment. Further, in accordance with the exemplary embodiments of the invention there is a method, executable computer program, and apparatus for determining that a scheduling request resource and at least one other resource are reserved for a user equipment in a same sub-frame, and based on whether a scheduling request is desired to be transmitted by the user equipment, placing at least one of an acknowledgment/negative acknowledgement and a channel quality indicator that is desired to be transmitted by the user equipment in one of the resources and leaving at least one other resource unused.

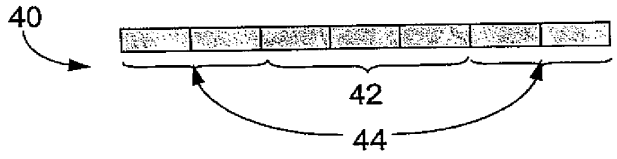


FIG. 1

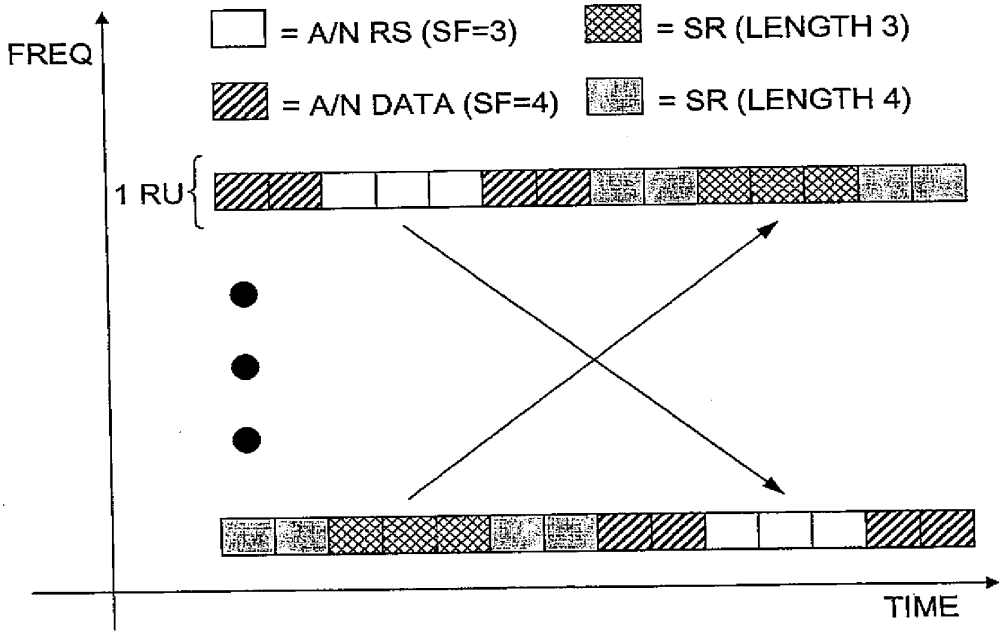


FIG. 2

Cyclic shift inside LB	Block cover code		
	0	1	2
0	0		17
1		6	
2	1		12
3		7	
4	2		13
5		8	
6	3		14
7		9	
8	4		15
9		10	
10	5		16
11		11	

FIG. 3

Cyclic shift inside LB	Additional cove code [1, 1]		
	Block cover code		
	0	1	2
0	0	23	34
1	1	12	35
2	2	13	24
3	3	14	25
4	4	15	26
5	5	16	27
6	6	17	28
7	7	18	29
8	8	19	30
9	9	20	31
10	10	21	32
11	11	22	33

Cyclic shift inside LB	Additional cove code [1, -1]		
	Block cover code		
	0	1	2
0	36	59	70
1	37	48	71
2	38	49	60
3	39	50	61
4	40	51	62
5	41	52	63
6	42	53	64
7	43	54	65
8	44	55	66
9	45	56	67
10	46	57	68
11	47	58	69

FIG. 4

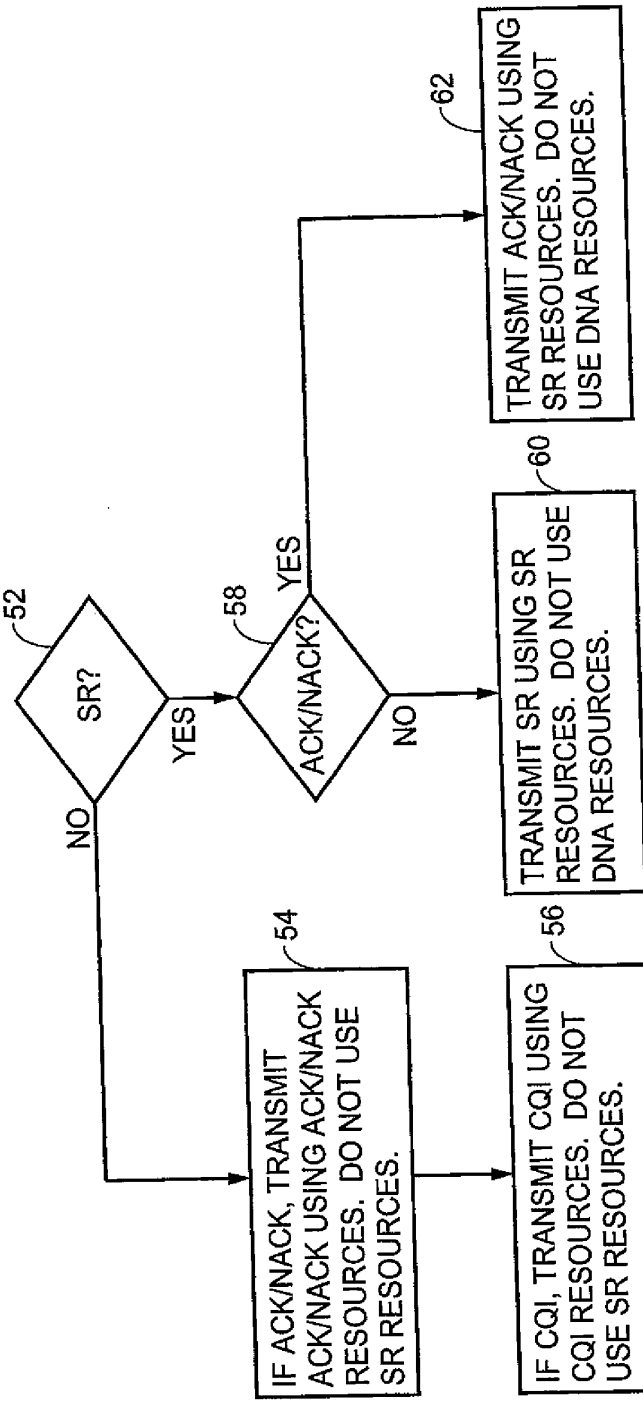

52
SR?
YES
NO
58
ACK/NACK?
YES
NO
62
TRANSMIT ACK/NACK USING SR RESOURCES. DO NOT USE DNA RESOURCES.
60
TRANSMIT SR USING SR RESOURCES. DO NOT USE DNA RESOURCES.
54
IF ACK/NACK, TRANSMIT ACK/NACK USING ACK/NACK RESOURCES. DO NOT USE SR RESOURCES.
56
IF CQI, TRANSMIT CQI USING CQI RESOURCES. DO NOT USE SR RESOURCES.

FIG. 5

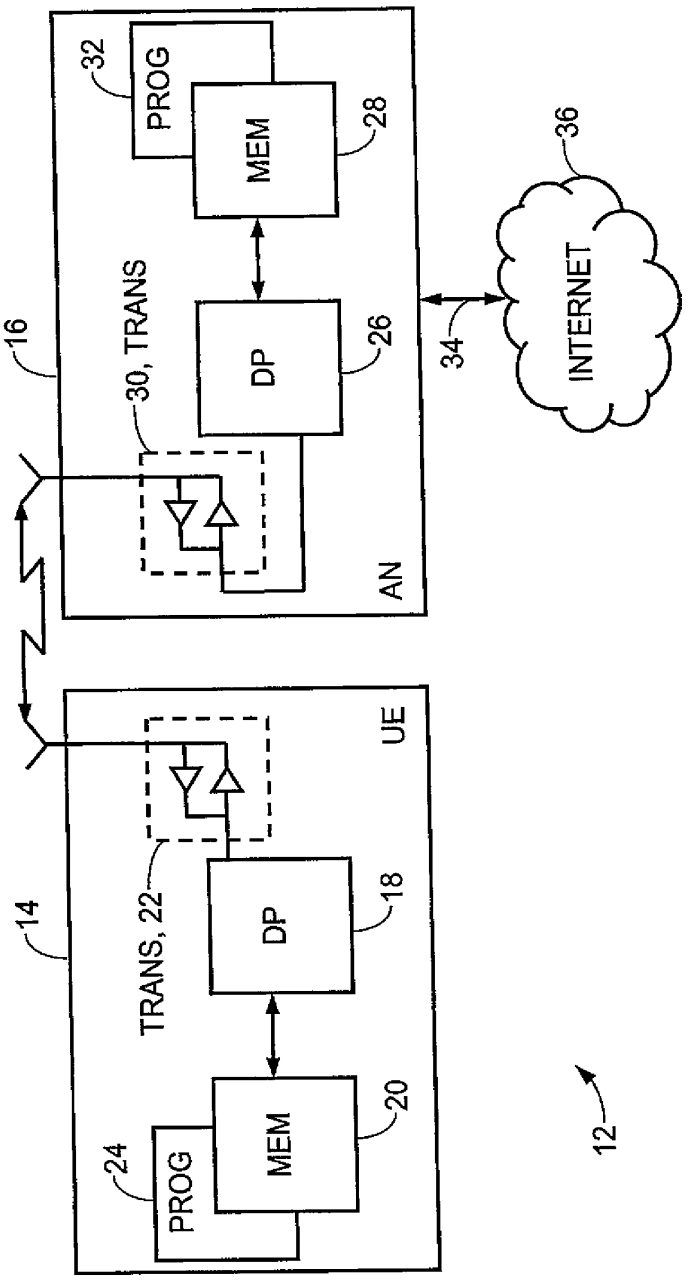

12
14
UE
TRANS, 22
DP
18
MEM
20
PROG
24
16
AN
30, TRANS
DP
26
MEM
28
PROG
32
34
INTERNET
36

FIG. 6

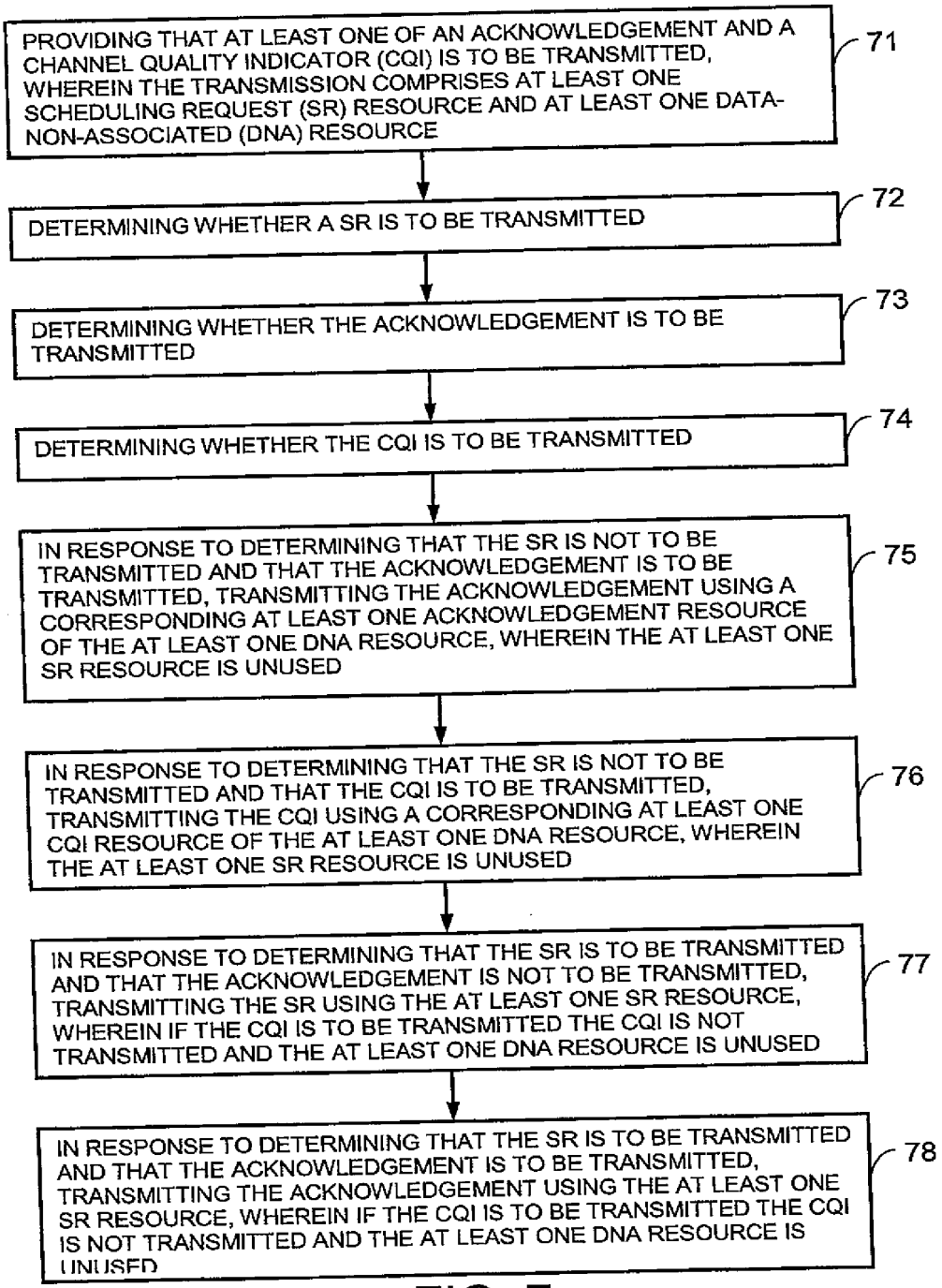

PROVIDING THAT AT LEAST ONE OF AN ACKNOWLEDGEMENT AND A CHANNEL QUALITY INDICATOR (CQI) IS TO BE TRANSMITTED, WHEREIN THE TRANSMISSION COMPRISES AT LEAST ONE SCHEDULING REQUEST (SR) RESOURCE AND AT LEAST ONE DATA-NON-ASSOCIATED (DNA) RESOURCE
71
DETERMINING WHETHER A SR IS TO BE TRANSMITTED
72
DETERMINING WHETHER THE ACKNOWLEDGEMENT IS TO BE TRANSMITTED
73
DETERMINING WHETHER THE CQI IS TO BE TRANSMITTED
74
IN RESPONSE TO DETERMINING THAT THE SR IS NOT TO BE TRANSMITTED AND THAT THE ACKNOWLEDGEMENT IS TO BE TRANSMITTED, TRANSMITTING THE ACKNOWLEDGEMENT USING A CORRESPONDING AT LEAST ONE ACKNOWLEDGEMENT RESOURCE OF THE AT LEAST ONE DNA RESOURCE, WHEREIN THE AT LEAST ONE SR RESOURCE IS UNUSED
75
IN RESPONSE TO DETERMINING THAT THE SR IS NOT TO BE TRANSMITTED AND THAT THE CQI IS TO BE TRANSMITTED, TRANSMITTING THE CQI USING A CORRESPONDING AT LEAST ONE CQI RESOURCE OF THE AT LEAST ONE DNA RESOURCE, WHEREIN THE AT LEAST ONE SR RESOURCE IS UNUSED
76
IN RESPONSE TO DETERMINING THAT THE SR IS TO BE TRANSMITTED AND THAT THE ACKNOWLEDGEMENT IS NOT TO BE TRANSMITTED, TRANSMITTING THE SR USING THE AT LEAST ONE SR RESOURCE, WHEREIN IF THE CQI IS TO BE TRANSMITTED THE CQI IS NOT TRANSMITTED AND THE AT LEAST ONE DNA RESOURCE IS UNUSED
77
IN RESPONSE TO DETERMINING THAT THE SR IS TO BE TRANSMITTED AND THAT THE ACKNOWLEDGEMENT IS TO BE TRANSMITTED, TRANSMITTING THE ACKNOWLEDGEMENT USING THE AT LEAST ONE SR RESOURCE, WHEREIN IF THE CQI IS TO BE TRANSMITTED THE CQI IS NOT TRANSMITTED AND THE AT LEAST ONE DNA RESOURCE IS UNUSED
78

FIG. 7

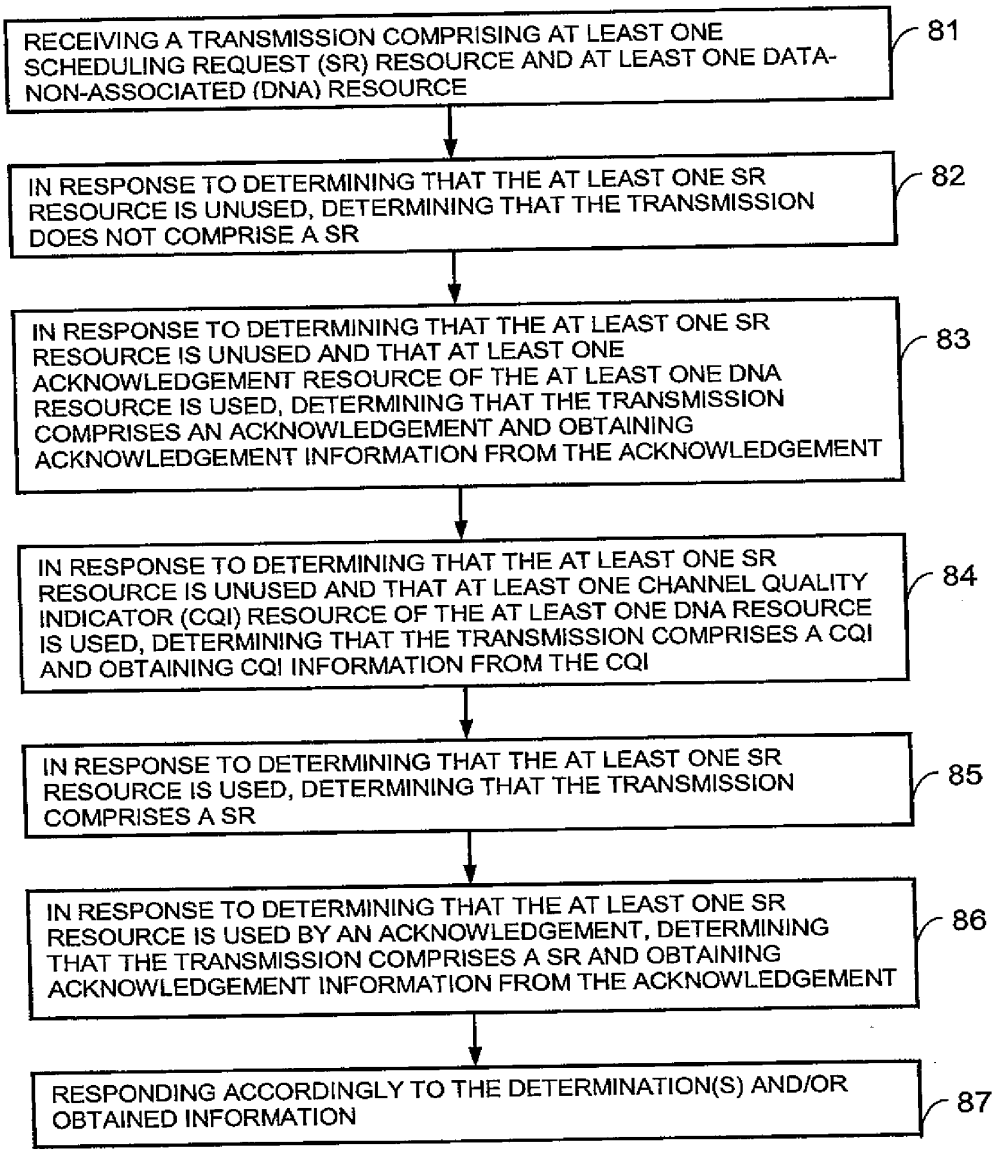
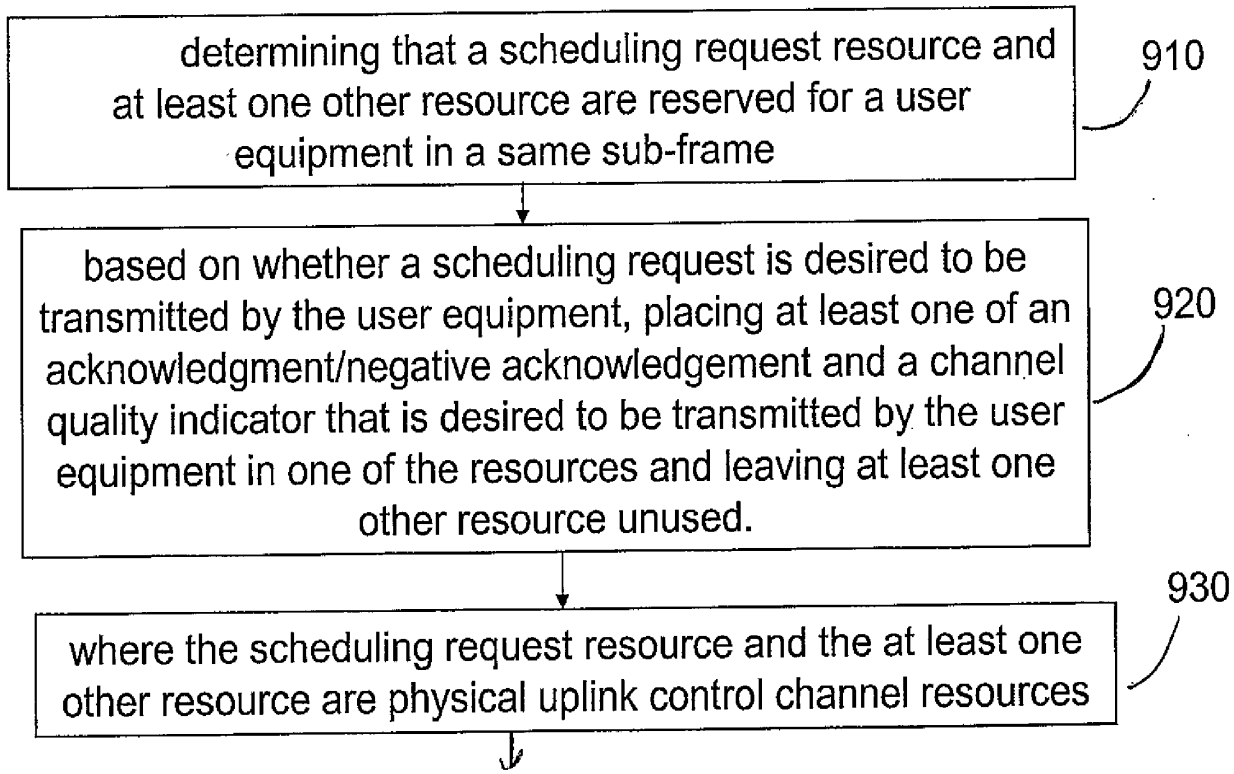
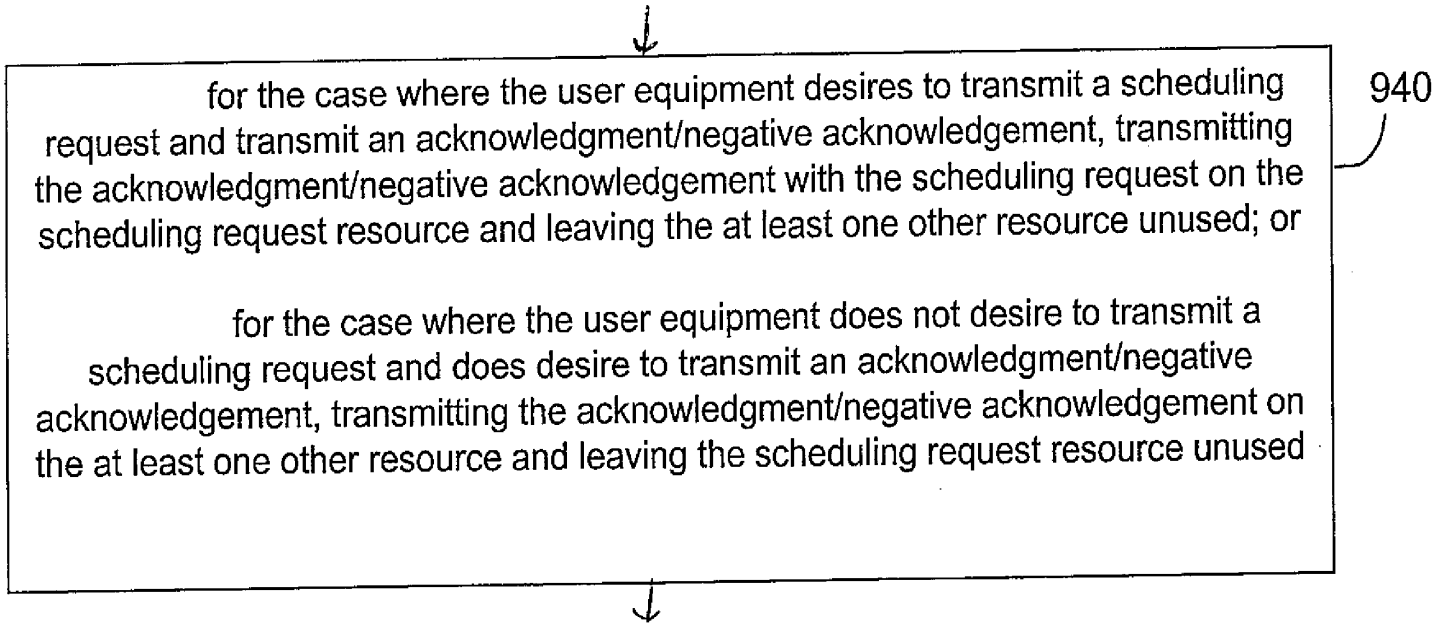

RECEIVING A TRANSMISSION COMPRISING AT LEAST ONE SCHEDULING REQUEST (SR) RESOURCE AND AT LEAST ONE DATA-NON-ASSOCIATED (DNA) RESOURCE
81
IN RESPONSE TO DETERMINING THAT THE AT LEAST ONE SR RESOURCE IS UNUSED, DETERMINING THAT THE TRANSMISSION DOES NOT COMPRISE A SR
82
IN RESPONSE TO DETERMINING THAT THE AT LEAST ONE SR RESOURCE IS UNUSED AND THAT AT LEAST ONE ACKNOWLEDGEMENT RESOURCE OF THE AT LEAST ONE DNA RESOURCE IS USED, DETERMINING THAT THE TRANSMISSION COMPRISES AN ACKNOWLEDGEMENT AND OBTAINING ACKNOWLEDGEMENT INFORMATION FROM THE ACKNOWLEDGEMENT
83
IN RESPONSE TO DETERMINING THAT THE AT LEAST ONE SR RESOURCE IS UNUSED AND THAT AT LEAST ONE CHANNEL QUALITY INDICATOR (CQI) RESOURCE OF THE AT LEAST ONE DNA RESOURCE IS USED, DETERMINING THAT THE TRANSMISSION COMPRISES A CQI AND OBTAINING CQI INFORMATION FROM THE CQI
84
IN RESPONSE TO DETERMINING THAT THE AT LEAST ONE SR RESOURCE IS USED, DETERMINING THAT THE TRANSMISSION COMPRISES A SR
85
IN RESPONSE TO DETERMINING THAT THE AT LEAST ONE SR RESOURCE IS USED BY AN ACKNOWLEDGEMENT, DETERMINING THAT THE TRANSMISSION COMPRISES A SR AND OBTAINING ACKNOWLEDGEMENT INFORMATION FROM THE ACKNOWLEDGEMENT
86
RESPONDING ACCORDINGLY TO THE DETERMINATION(S) AND/OR OBTAINED INFORMATION
87

FIG. 8



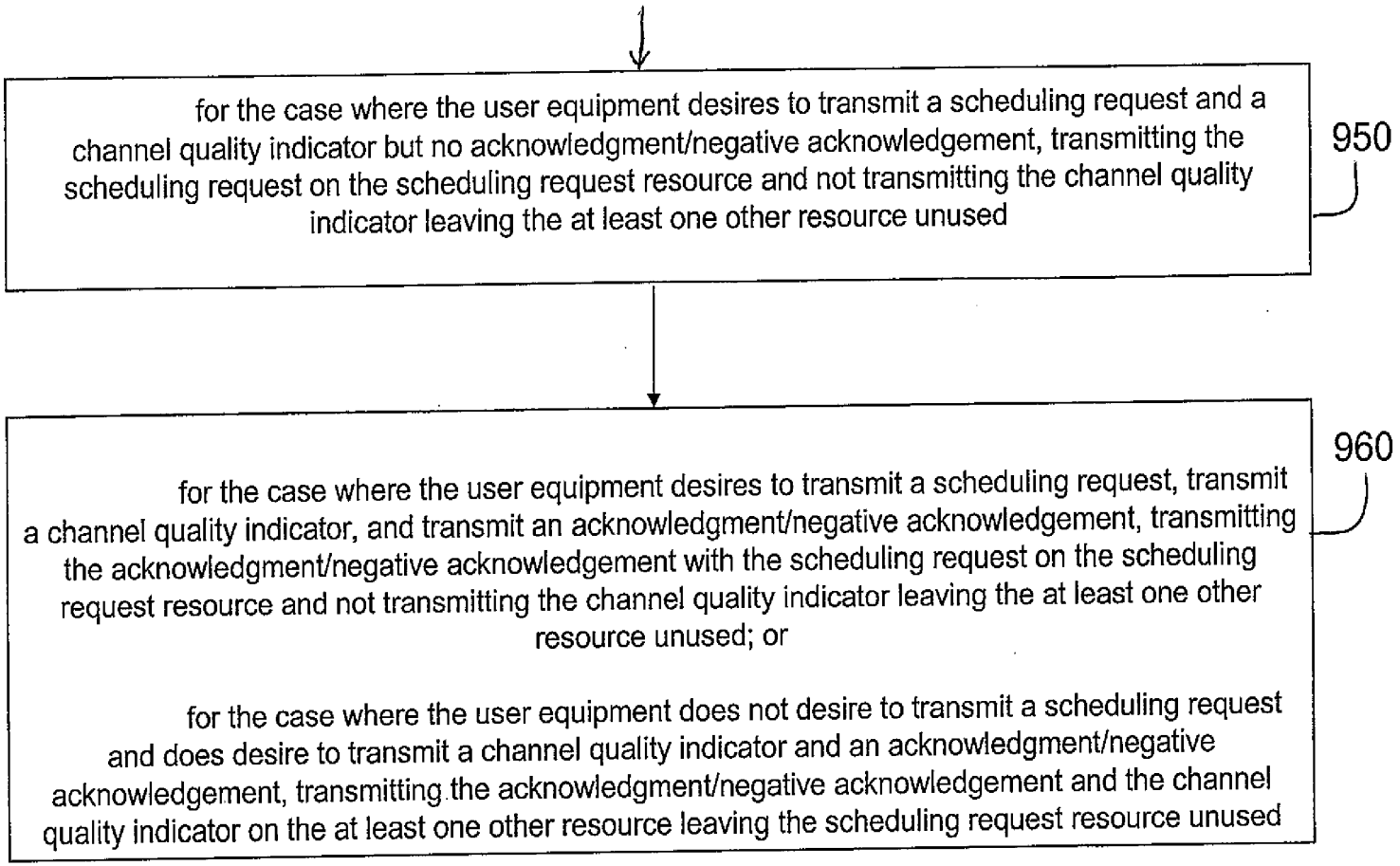
444

Figure 9A



445

Figure 9B



446

Figure 9C

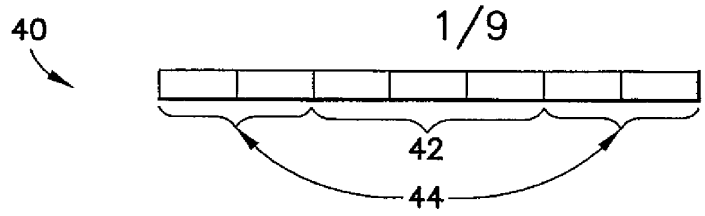


FIG.1

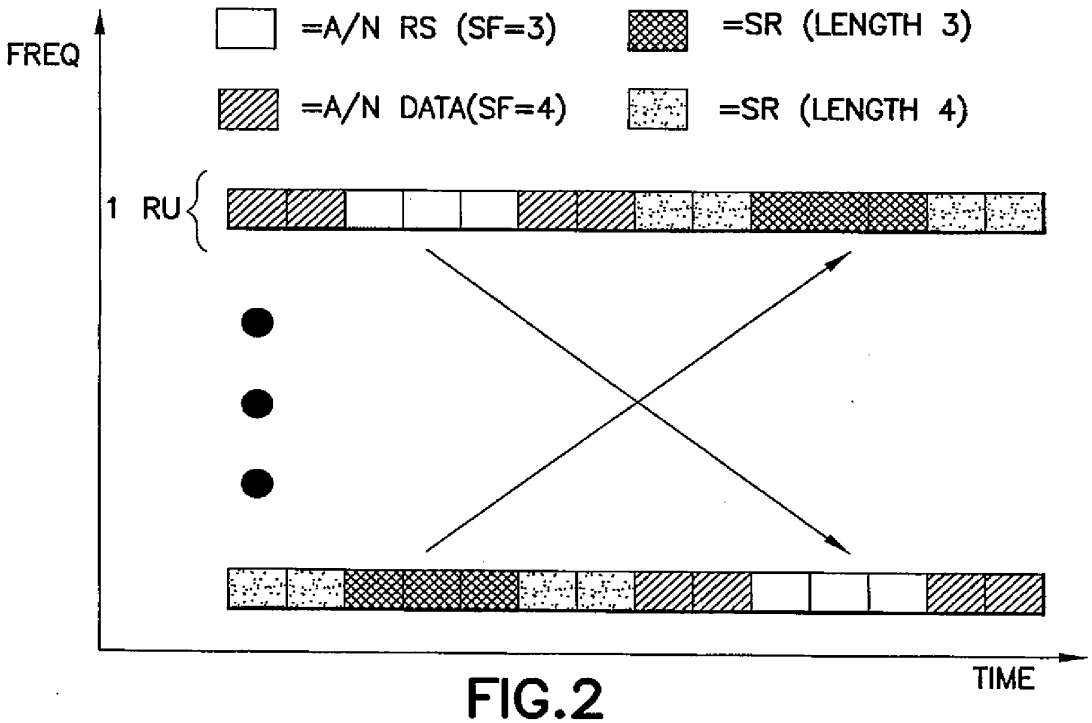


FIG.2

CYCLIC CHIFT INSIDE LB	BLOCK COVER CODE		
	0	1	2
0	0		17
1		6	
2	1		12
3		7	
4	2		13
5		8	
6	3		14
7		9	
8	4		15
9		10	
10	5		16
11		11	

FIG.3

CYCLIC SHIFT INSIDE LB	ADDITIONAL COVE CODE [1,1]		
	BLOCK COVER CODE		
	0	1	2
0	0	23	34
1	1	12	35
2	2	13	24
3	3	14	25
4	4	15	26
5	5	16	27
6	6	17	28
7	7	18	29
8	8	19	30
9	9	20	31
10	10	21	32
11	11	22	33

CYCLIC SHIFT INSIDE LB	ADDITIONAL COVE CODE [1,−1]		
	BLOCK COVER CODE		
	0	1	2
0	36	59	70
1	37	48	71
2	38	49	60
3	39	50	61
4	40	51	62
5	41	52	63
6	42	53	64
7	43	54	65
8	44	55	66
9	45	56	67
10	46	57	68
11	47	58	69

FIG.4

448

2/9

REPLACEMENT SHEET

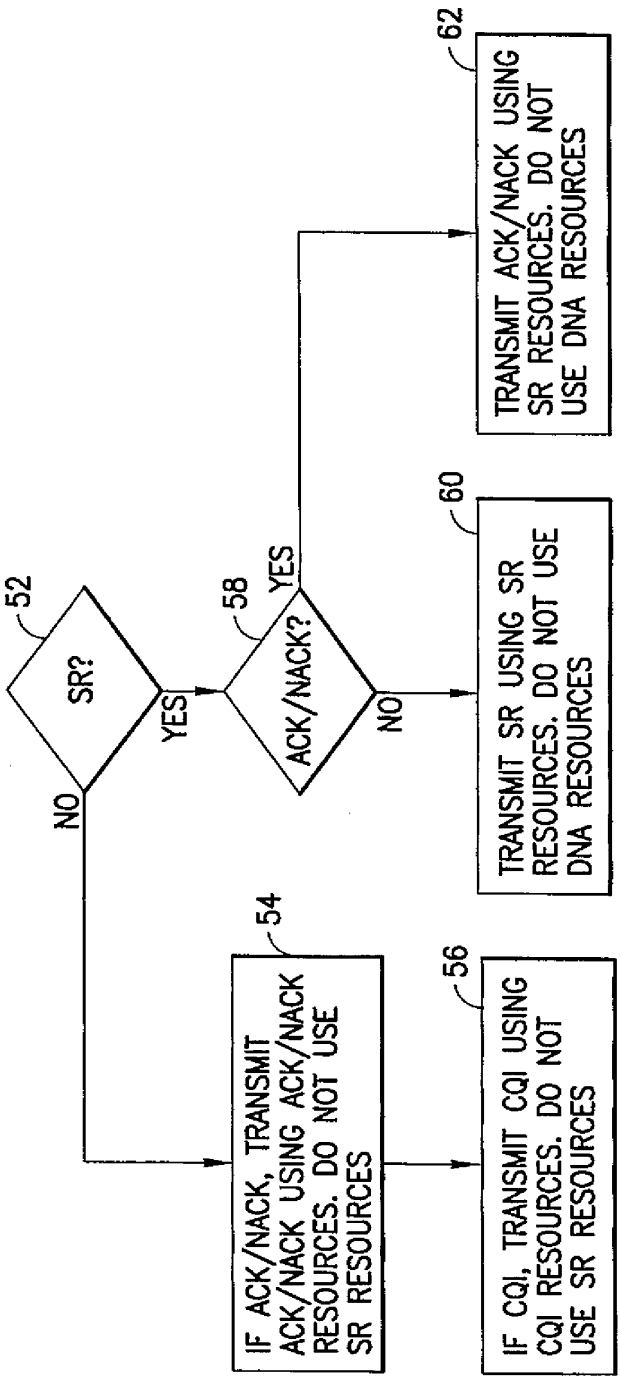

52
SR?
YES
NO
58
ACK/NACK?
YES
NO
62
TRANSMIT ACK/NACK USING SR RESOURCES. DO NOT USE DNA RESOURCES
60
TRANSMIT SR USING SR RESOURCES. DO NOT USE DNA RESOURCES
54
IF ACK/NACK, TRANSMIT ACK/NACK USING ACK/NACK RESOURCES. DO NOT USE SR RESOURCES
56
IF CQI, TRANSMIT CQI USING CQI RESOURCES. DO NOT USE SR RESOURCES

FIG.5

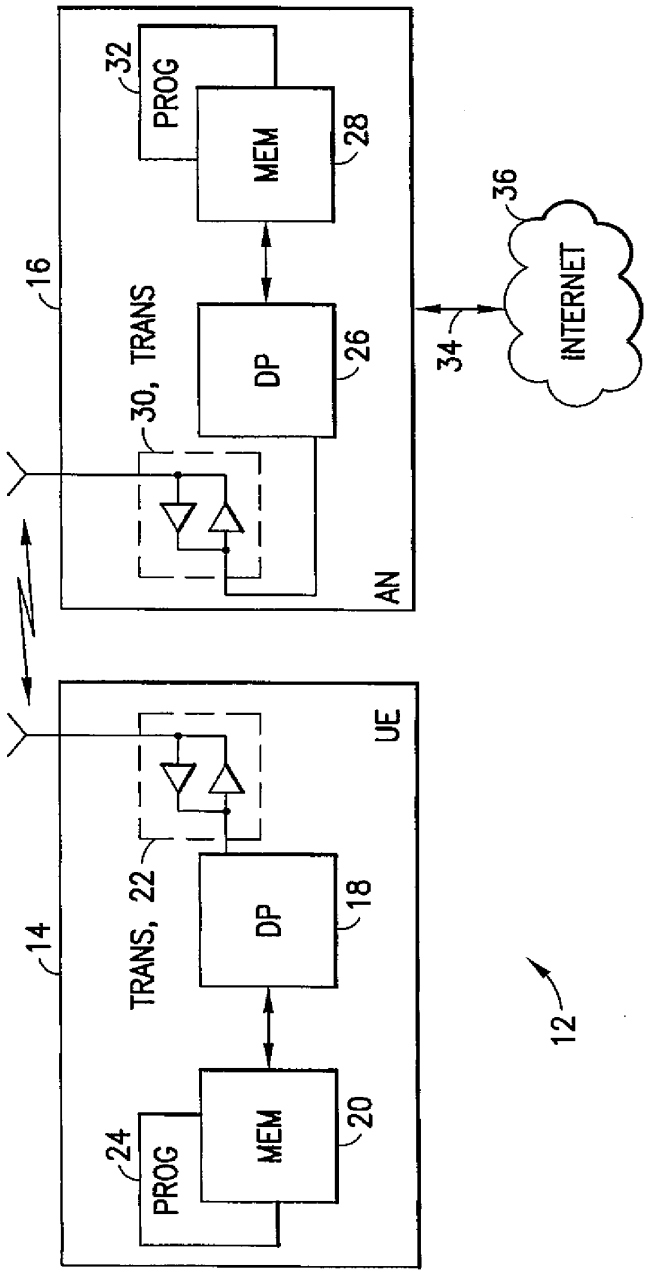

PROG
32
MEM
28
16
30, TRANS
DP
26
AN
36
INTERNET
34
UE
14
TRANS, 22
DP
18
PROG
24
MEM
20
12

FIG.6

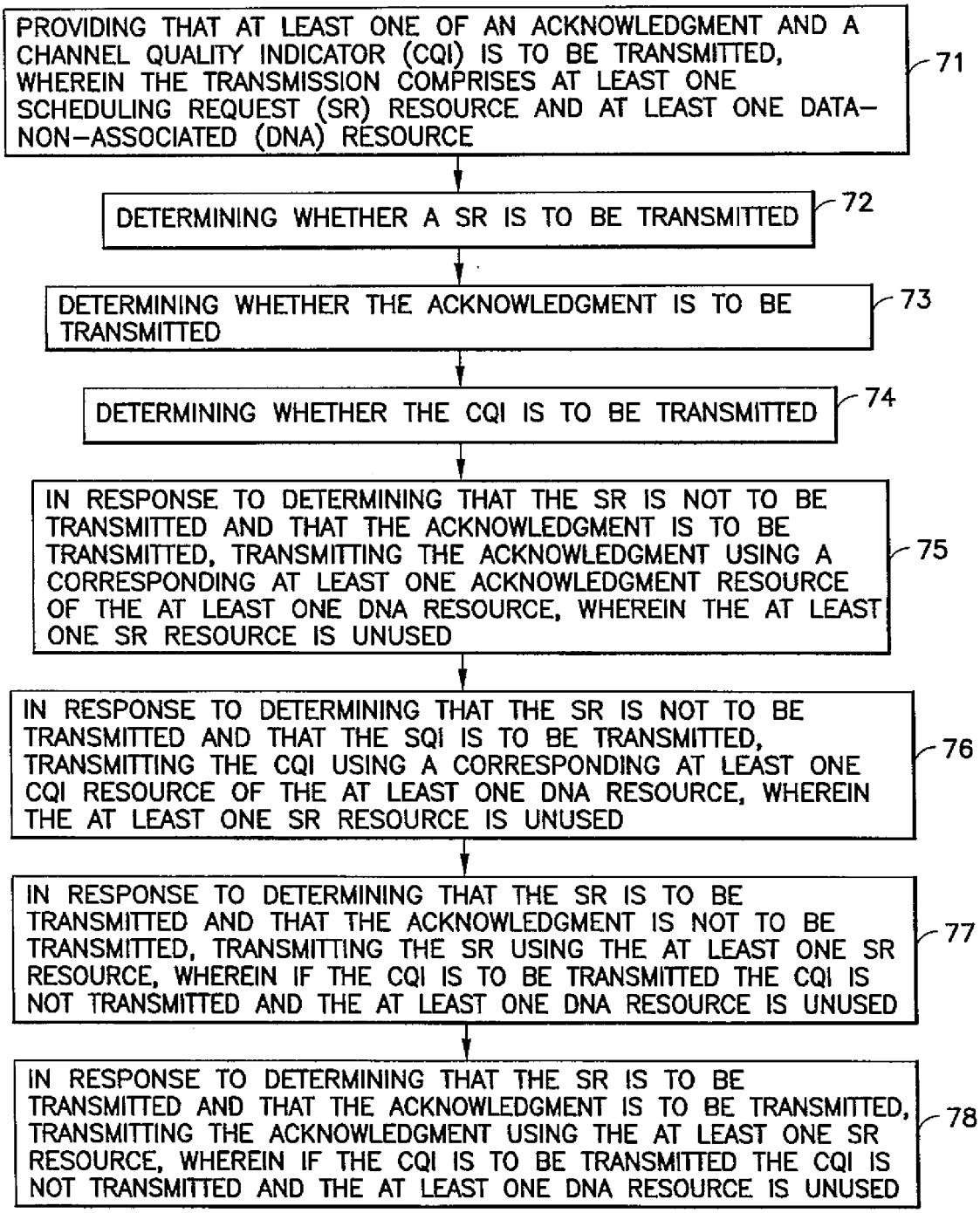

PROVIDING THAT AT LEAST ONE OF AN ACKNOWLEDGMENT AND A CHANNEL QUALITY INDICATOR (CQI) IS TO BE TRANSMITTED, WHEREIN THE TRANSMISSION COMPRISES AT LEAST ONE SCHEDULING REQUEST (SR) RESOURCE AND AT LEAST ONE DATA-NON-ASSOCIATED (DNA) RESOURCE
71
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DETERMINING WHETHER THE CQI IS TO BE TRANSMITTED
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IN RESPONSE TO DETERMINING THAT THE SR IS NOT TO BE TRANSMITTED AND THAT THE ACKNOWLEDGMENT IS TO BE TRANSMITTED, TRANSMITTING THE ACKNOWLEDGMENT USING A CORRESPONDING AT LEAST ONE ACKNOWLEDGMENT RESOURCE OF THE AT LEAST ONE DNA RESOURCE, WHEREIN THE AT LEAST ONE SR RESOURCE IS UNUSED
75
IN RESPONSE TO DETERMINING THAT THE SR IS NOT TO BE TRANSMITTED AND THAT THE SQI IS TO BE TRANSMITTED, TRANSMITTING THE CQI USING A CORRESPONDING AT LEAST ONE CQI RESOURCE OF THE AT LEAST ONE DNA RESOURCE, WHEREIN THE AT LEAST ONE SR RESOURCE IS UNUSED
76
IN RESPONSE TO DETERMINING THAT THE SR IS TO BE TRANSMITTED AND THAT THE ACKNOWLEDGMENT IS NOT TO BE TRANSMITTED, TRANSMITTING THE SR USING THE AT LEAST ONE SR RESOURCE, WHEREIN IF THE CQI IS TO BE TRANSMITTED THE CQI IS NOT TRANSMITTED AND THE AT LEAST ONE DNA RESOURCE IS UNUSED
77
IN RESPONSE TO DETERMINING THAT THE SR IS TO BE TRANSMITTED AND THAT THE ACKNOWLEDGMENT IS TO BE TRANSMITTED, TRANSMITTING THE ACKNOWLEDGMENT USING THE AT LEAST ONE SR RESOURCE, WHEREIN IF THE CQI IS TO BE TRANSMITTED THE CQI IS NOT TRANSMITTED AND THE AT LEAST ONE DNA RESOURCE IS UNUSED
78

FIG.7

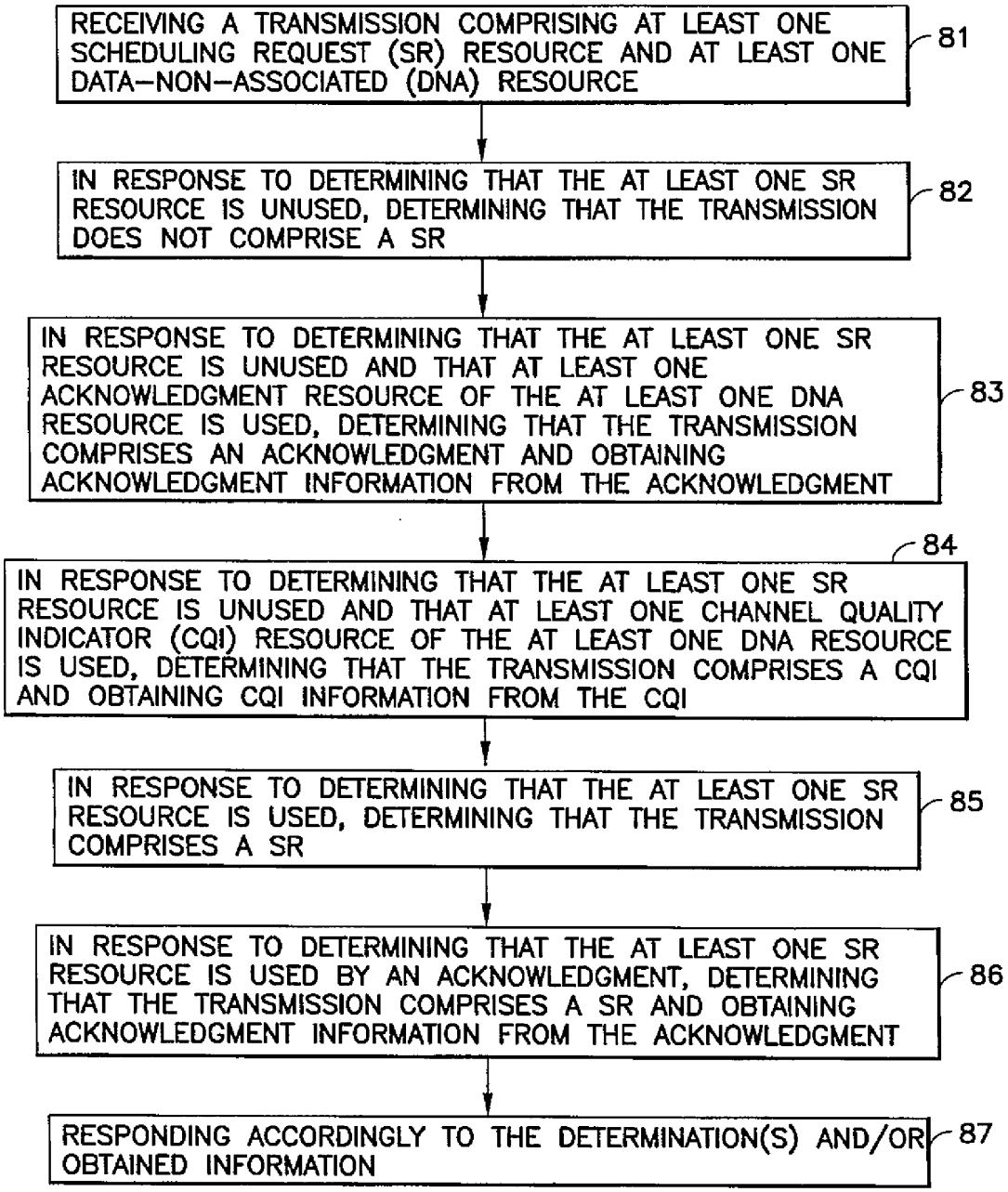

RECEIVING A TRANSMISSION COMPRISING AT LEAST ONE SCHEDULING REQUEST (SR) RESOURCE AND AT LEAST ONE DATA-NON-ASSOCIATED (DNA) RESOURCE
81
IN RESPONSE TO DETERMINING THAT THE AT LEAST ONE SR RESOURCE IS UNUSED, DETERMINING THAT THE TRANSMISSION DOES NOT COMPRISE A SR
82
IN RESPONSE TO DETERMINING THAT THE AT LEAST ONE SR RESOURCE IS UNUSED AND THAT AT LEAST ONE ACKNOWLEDGMENT RESOURCE OF THE AT LEAST ONE DNA RESOURCE IS USED, DETERMINING THAT THE TRANSMISSION COMPRISES AN ACKNOWLEDGMENT AND OBTAINING ACKNOWLEDGMENT INFORMATION FROM THE ACKNOWLEDGMENT
83
84
IN RESPONSE TO DETERMINING THAT THE AT LEAST ONE SR RESOURCE IS UNUSED AND THAT AT LEAST ONE CHANNEL QUALITY INDICATOR (CQI) RESOURCE OF THE AT LEAST ONE DNA RESOURCE IS USED, DETERMINING THAT THE TRANSMISSION COMPRISES A CQI AND OBTAINING CQI INFORMATION FROM THE CQI
IN RESPONSE TO DETERMINING THAT THE AT LEAST ONE SR RESOURCE IS USED, DETERMINING THAT THE TRANSMISSION COMPRISES A SR
85
IN RESPONSE TO DETERMINING THAT THE AT LEAST ONE SR RESOURCE IS USED BY AN ACKNOWLEDGMENT, DETERMINING THAT THE TRANSMISSION COMPRISES A SR AND OBTAINING ACKNOWLEDGMENT INFORMATION FROM THE ACKNOWLEDGMENT
86
RESPONDING ACCORDINGLY TO THE DETERMINATION(S) AND/OR OBTAINED INFORMATION
87

FIG.8

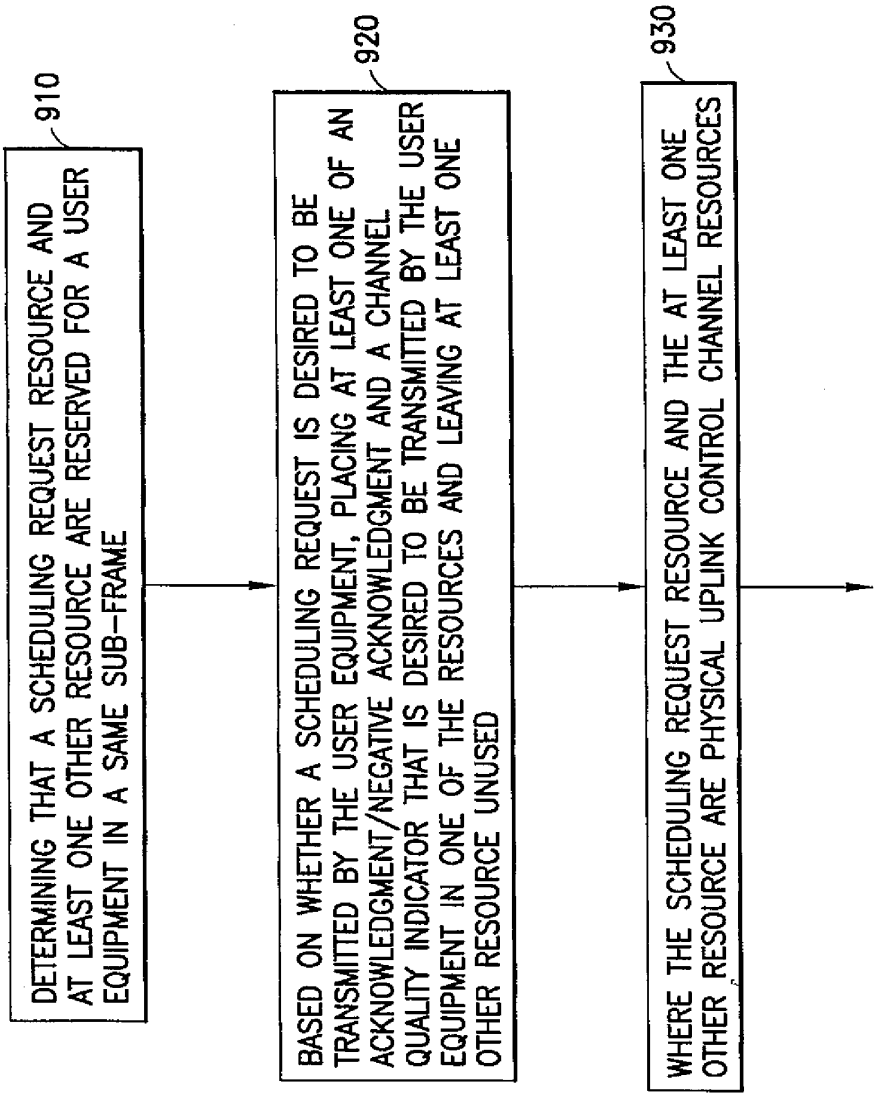

910
DETERMINING THAT A SCHEDULING REQUEST RESOURCE AND AT LEAST ONE OTHER RESOURCE ARE RESERVED FOR A USER EQUIPMENT IN A SAME SUB-FRAME
920
BASED ON WHETHER A SCHEDULING REQUEST IS DESIRED TO BE TRANSMITTED BY THE USER EQUIPMENT, PLACING AT LEAST ONE OF AN ACKNOWLEDGMENT/NEGATIVE ACKNOWLEDGMENT AND A CHANNEL QUALITY INDICATOR THAT IS DESIRED TO BE TRANSMITTED BY THE USER EQUIPMENT IN ONE OF THE RESOURCES AND LEAVING AT LEAST ONE OTHER RESOURCE UNUSED
930
WHERE THE SCHEDULING REQUEST RESOURCE AND THE AT LEAST ONE OTHER RESOURCE ARE PHYSICAL UPLINK CONTROL CHANNEL RESOURCES

FIG.9A

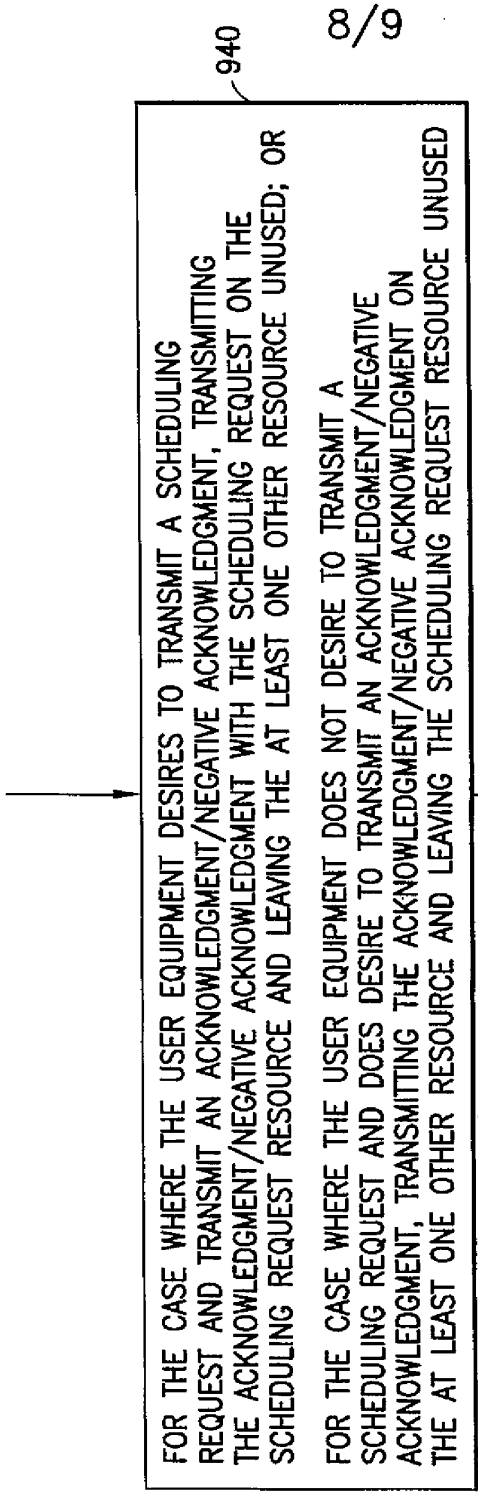
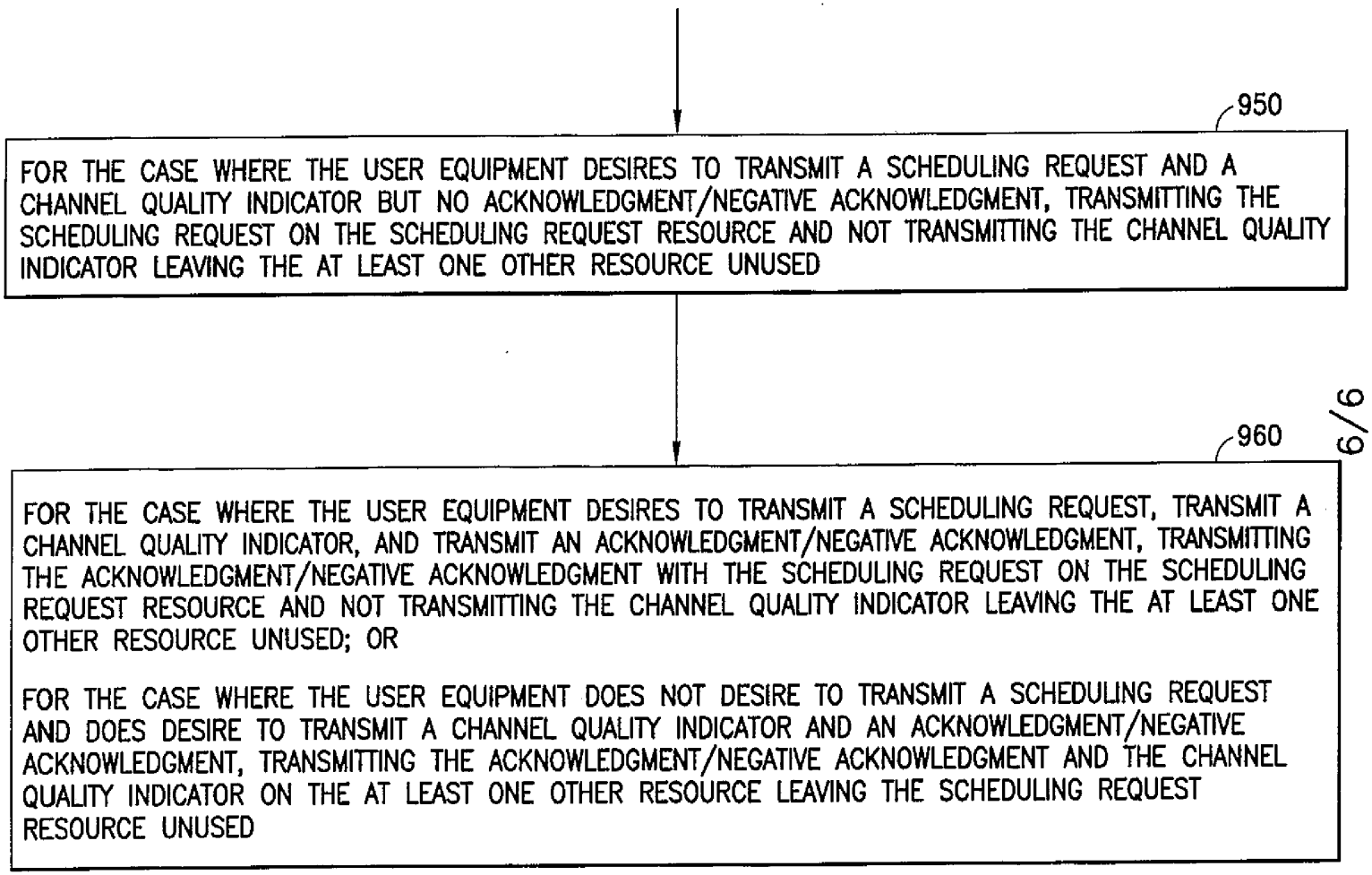

940
FOR THE CASE WHERE THE USER EQUIPMENT DESIRES TO TRANSMIT A SCHEDULING REQUEST AND TRANSMIT AN ACKNOWLEDGMENT/NEGATIVE ACKNOWLEDGMENT, TRANSMITTING THE ACKNOWLEDGMENT/NEGATIVE ACKNOWLEDGMENT WITH THE SCHEDULING REQUEST ON THE SCHEDULING REQUEST RESOURCE AND LEAVING THE AT LEAST ONE OTHER RESOURCE UNUSED; OR
FOR THE CASE WHERE THE USER EQUIPMENT DOES NOT DESIRE TO TRANSMIT A SCHEDULING REQUEST AND DOES DESIRE TO TRANSMIT AN ACKNOWLEDGMENT/NEGATIVE ACKNOWLEDGMENT, TRANSMITTING THE ACKNOWLEDGMENT/NEGATIVE ACKNOWLEDGMENT ON THE AT LEAST ONE OTHER RESOURCE AND LEAVING THE SCHEDULING REQUEST RESOURCE UNUSED

FIG.9B


950
FOR THE CASE WHERE THE USER EQUIPMENT DESIRES TO TRANSMIT A SCHEDULING REQUEST AND A CHANNEL QUALITY INDICATOR BUT NO ACKNOWLEDGMENT/NEGATIVE ACKNOWLEDGMENT, TRANSMITTING THE SCHEDULING REQUEST ON THE SCHEDULING REQUEST RESOURCE AND NOT TRANSMITTING THE CHANNEL QUALITY INDICATOR LEAVING THE AT LEAST ONE OTHER RESOURCE UNUSED
960
FOR THE CASE WHERE THE USER EQUIPMENT DESIRES TO TRANSMIT A SCHEDULING REQUEST, TRANSMIT A CHANNEL QUALITY INDICATOR, AND TRANSMIT AN ACKNOWLEDGMENT/NEGATIVE ACKNOWLEDGMENT, TRANSMITTING THE ACKNOWLEDGMENT/NEGATIVE ACKNOWLEDGMENT WITH THE SCHEDULING REQUEST ON THE SCHEDULING REQUEST RESOURCE AND NOT TRANSMITTING THE CHANNEL QUALITY INDICATOR LEAVING THE AT LEAST ONE OTHER RESOURCE UNUSED; OR
FOR THE CASE WHERE THE USER EQUIPMENT DOES NOT DESIRE TO TRANSMIT A SCHEDULING REQUEST AND DOES DESIRE TO TRANSMIT A CHANNEL QUALITY INDICATOR AND AN ACKNOWLEDGMENT/NEGATIVE ACKNOWLEDGMENT, TRANSMITTING THE ACKNOWLEDGMENT/NEGATIVE ACKNOWLEDGMENT AND THE CHANNEL QUALITY INDICATOR ON THE AT LEAST ONE OTHER RESOURCE LEAVING THE SCHEDULING REQUEST RESOURCE UNUSED

455

FIG.9C

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	863.0076.U2(US)
	Application Number	
Title of Invention	Providing Improved Scheduling Request Signaling with ACK/NACK or CQI	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

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☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Kari	P.	Pajukoski	

Residence Information (Select One) ○ US Residency ◉ Non US Residency ○ Active US Military Service

City	Oulu	Country of Residence [i]	FI

Mailing Address of Inventor:

Address 1	Purantie 3		
Address 2			
City	Oulu	State/Province	
Postal Code	90240	Country [i]	FI

Inventor 2 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Esa	T.	Tiirola	

Residence Information (Select One) ○ US Residency ◉ Non US Residency ○ Active US Military Service

City	Kempele	Country of Residence [i]	FI

Mailing Address of Inventor:

Address 1	Porttikellonkuja 12		
Address 2			
City	Kempele	State/Province	
Postal Code	90450	Country [i]	FI

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

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U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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	Application Number	
Title of Invention	Providing Improved Scheduling Request Signaling with ACK/NACK or CQI	

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).			
☐ An Address is being provided for the correspondence Information of this application.			
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Email Address	patent@hspatent.com	Add Email	Remove Email

Application Information:

Title of the Invention	Providing Improved Scheduling Request Signaling with ACK/NACK or CQI		
Attorney Docket Number	863.0076.U2(US)	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	9	Suggested Figure for Publication (if any)	

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)
☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

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Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	29683		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

Prior Application Status			Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	12/290547	2008-10-30
Prior Application Status			Remove

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	863.0076.U2(US)
	Application Number	
Title of Invention	Providing Improved Scheduling Request Signaling with ACK/NACK or CQI	

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	provisional	61/001207	2007-10-30

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.

Authorization to Permit Access:

☒ Authorization to Permit Access to the Instant Application by the Participating Offices

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If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

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Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

◉ Assignee	○ Legal Representative under 35 U.S.C. 117	○ Joint Inventor
○ Person to whom the inventor is obligated to assign.	○ Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. ☒

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	863.0076.U2(US)
	Application Number	
Title of Invention	Providing Improved Scheduling Request Signaling with ACK/NACK or CQI	

Email Address	

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Complete this section only if non-applicant assignee information is desired to be included on the patent application publication in accordance with 37 CFR 1.215(b). Do not include in this section an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest), as the patent application publication will include the name of the applicant(s).

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Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Non-Applicant Assignee:

Address 1	
Address 2	

City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

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Signature:

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Signature				Date (YYYY-MM-DD)	2013-10-11
First Name	John A.	Last Name	Garrity	Registration Number	60470

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This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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IN THE U.S. PATENT AND TRADEMARK OFFICE

In re U.S. Patent Application of:

APPLICANTS: Kari P. Pajukoski et al.

SERIAL NO.: to be assigned FILING DATE: Herewith

EXAMINER: ART UNIT:

ATTORNEY'S DOCKET NO.: 062A.0002.U2(US)

TITLE: PROVIDING IMPROVED SCHEDULING REQUEST SIGNALLING WITH ACK/NACK OR CQI

Commissioner for Patents

Alexandria, VA 22313

PRELIMINARY AMENDMENT

Sir:

The present paper is filed contemporaneously with a continuation application filed under 37 C.F.R. §1.53(b). The continuation application is a continuation of application No. 12/290,547, filed on October 30, 2008, which claims benefit of U.S. provisional application no. 61/001,207 that has a priority date of October 30, 2007.

Please amend the continuation application as shown below:

AMENDMENTS TO THE SPECIFICATION:

At page 1, line 1, please amend paragraph [0001] to recite:

This patent application is a continuation of U.S. Patent Application Serial Number 12/290,547, filed on October 30, 2008, which claims priority under 35 U.S.C. §119(e) from Provisional Patent Application No.: 61/001,207, filed October 30, 2007, the disclosure of which is incorporated by reference herein in its entirety

AMENDMENTS TO THE CLAIMS:

This listing of the claims will replace all prior versions, and listings, of the claims in this application.

Listing of Claims:

1. (Original) A method comprising:

determining that an acknowledgment is to be sent; and

for the case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource,

else placing the acknowledgment in another resource.

2. (Original) The method of claim 1, comprising:

for the case where there is also the scheduling request to be sent, transmitting the acknowledgment with the scheduling request on the scheduling resource.

3. (Currently Amended) The method of ~~any of claims 1 or 2~~claim 1, comprising:

for a case where a channel quality indicator is also to be sent, the channel quality indicator is not sent and the another resource is unused.

4. (Currently Amended) The method of ~~any one of claims 1 or 2~~claim 1, where the another resource is a data-non-associated resource.

5. (Original) The method of claim 2, where the transmitting is on a physical uplink control channel.

6. (Currently Amended) The method of ~~any one of claims 2 or 5~~claim 2, where the transmitting is on an uplink.

7. (Currently Amended) The method of ~~any one of claims 1 or 2~~claim 1, where the acknowledgment comprises an unmodulated sequence 1 and a BPSK/QPSK modulated sequence 2.

8. (Currently Amended) The method of ~~any one of claims 1 or 2~~claim 1 implemented in a user equipment.

9. (Currently Amended) The method of ~~any one of claims 1 or 2~~claim 1 implemented in a wireless communications network.

10. (Currently Amended) The method of ~~any one of claims 1, 2, 8, or 9~~claim 1 implemented in an evolved universal terrestrial radio access network.

11. (Original) A computer readable medium encoded with a computer program executable by a processor to perform actions comprising:

determining that an acknowledgment is to be sent; and

for the case where there is also a scheduling request to be sent, combining the acknowledgment with the scheduling request on a scheduling resource,

else placing the acknowledgment in another resource.

12. (Original) The computer readable medium encoded with a computer program of claim 11, comprising:

for the case where there is also the scheduling request to be sent, transmitting the acknowledgment with the scheduling request on the scheduling resource.

13. (Currently Amended) The computer readable medium encoded with a computer program of ~~any one of claims 11 or 12~~claim 11,comprising:

for a case where a channel quality indicator is also to be sent, the channel quality indicator is not sent and the another resource is unused.

14. (Currently Amended) The computer readable medium encoded with a computer program of ~~any one of claims 11 or 12~~claim 11, where the another resource is a data-non-associated resource.

15. (Original) An apparatus comprising:

a processor configured to determine that an acknowledgment is to be sent; and

the processor further configured to, for the case where there is also a scheduling request to be sent, combine the acknowledgment with the scheduling request on a scheduling resource,

else placing the acknowledgment in another resource.

16. (Original) The apparatus of claim 15, comprising:

a transmitter configured to, for the case where there is also the scheduling request to be sent, transmit the acknowledgment with the scheduling request on the scheduling resource.

17. (Currently Amended) The apparatus of ~~any one of claims 15 or 16~~claim 15 comprising:

the processor further configured to, for a case where a channel quality indicator is also to be sent, drop the channel quality indicator such that it is not sent and the another resource is unused.

18. (Currently Amended) The apparatus of ~~any one of claims 15 or 16~~claim 15, where the another resource is a data-non-associated resource.

19. (Original) The apparatus of claim 16, where the transmitter is configured to transmit the acknowledgment with the scheduling request on a physical uplink control channel.

20. (Currently Amended) The apparatus of ~~any one of claims 16 or 19~~claim 16, where the transmitter is configured to transmit the acknowledgment with the scheduling request on an uplink.

21. (Currently Amended) The apparatus of ~~any one of claims 15 or 16~~claim 15, where the acknowledgment comprises an unmodulated sequence 1 and a BPSK/QPSK modulated sequence 2.

22. (Currently Amended) The apparatus of ~~any one of claims 15 or 16~~claim 15, embodied in a user equipment.

23. (Currently Amended) The apparatus of ~~any one of claims 15 or 16~~claim 15, configured to operate in a wireless communications network.

24. (Currently Amended) The apparatus of ~~any one of claims 15, 16, 22, or 23~~claim 15 configured to operate in an evolved universal terrestrial radio access network.

25. (Original) An apparatus comprising:

means for determining that an acknowledgment is to be sent; and

means, in the case where there is also a scheduling request to be sent, for combining the acknowledgment with the scheduling request on a scheduling resource,

else placing the acknowledgment in another resource.

26. (Original) The apparatus of claim 25, comprising:

means, in the case where there is also the scheduling request to be sent, for transmitting the acknowledgment with the scheduling request on the scheduling resource.

27. (Currently Amended) The apparatus of ~~any of claims 25 or 26~~claim 25,comprising:

means, in a case where a channel quality indicator is also to be sent, for dropping the channel quality indicator such that it is not sent and the another resource is unused.

28. (Currently Amended) The apparatus of ~~any one of claims 25 or 26~~claim 25, where the another resource is a data-non-associated resource.

29. (Original) The apparatus of claim 26, where the means for transmitting further comprises means for transmitting the acknowledgment with the scheduling request on a physical uplink control channel.

30. (Currently Amended) The apparatus of ~~any of claims 26 or 29~~claim 26, where the means for transmitting further comprises means for transmitting the acknowledgment with the scheduling request on an uplink.

31. (Currently Amended) The apparatus of ~~any one of claims 25 or 26~~claim 25, where the acknowledgment comprises an unmodulated sequence 1 and a BPSK/QPSK modulated sequence 2.

32. (Currently Amended) The apparatus of ~~any one of claims 25 or 26~~claim 25 embodied in a user equipment.

33. (Currently Amended) The apparatus of ~~any one of claims 25 or 26~~claim 25 comprising means for operating in a wireless communications network.

34. (Currently Amended) The apparatus of ~~any of claims 25, 26, 28, or 29~~claim 25 comprising means for operating in an evolved universal terrestrial radio access network.

35. (Original) A method comprising:

receiving information on a scheduling resource; and

determining that the information received on the scheduling resource comprises an acknowledgment.

36. (Original) The method of claim 35, comprising

responding accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment.

37. (Currently Amended) The method of ~~any one of claims 35 or 36~~claim 35 where the information is received on a physical uplink control channel.

38. (Currently Amended) The method of ~~any one of claims 35 or 36~~claim 35 where the information is received from a wireless communications network.

39. (Currently Amended) The method of ~~any one of claims 31, 32 or 34~~claim 31 where the information is received from an evolved universal terrestrial radio access network.

40. (Original) A computer readable medium encoded with a computer program executable by a processor to perform actions comprising:

receiving information on a scheduling resource; and

determining that the information received on the scheduling resource comprises an acknowledgment.

41. (Original) The computer readable medium encoded with a computer program of claim 40, comprising

responding accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment

42. (Original) An apparatus comprising:

a receiver;

the receiver configured to receive information on a scheduling resource; and

a processor configured to determine that the information received on the scheduling resource comprises an acknowledgment.

43. (Original) The apparatus of claim 42 further comprising:

a transmitter;

the transmitter and the processor responding accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment.

44. (Currrently Amended) The apparatus of ~~any one of claims 42 or 43~~claim 42 where the receiver is further configured to receive the information on a physical uplink control channel.

45. (Currently Amended) The apparatus of ~~any one of claims 42 or 43~~claim 42 where the receiver is further configured to receive the information from a wireless communications network.

46. (Currently Amended) The apparatus of ~~any of claims 42, 43, or 45~~claim 42 where the receiver is further configured to receive the information from an evolved universal terrestrial radio access network.

47. (Original) An apparatus comprising:

means for receiving information on a scheduling resource; and

means for determining that the information received on the scheduling resource comprises an acknowledgment.

48. (Original) The apparatus of claim 47, comprising

means for responding accordingly to the determining that the information received on the scheduling resource comprises the acknowledgment.

49. (Currently Amended) The apparatus of ~~any one of claims 46 or 47~~claim 46 where the means for receiving comprises a receiver; the means for determining comprises a processor; and the means for responding comprises a transmitter.

50. (Original) A method comprising:

determining that a scheduling request resource and at least one other resource are reserved for a user equipment in a same sub-frame; and

based on whether a scheduling request is desired to be transmitted by the user equipment, placing at least one of an acknowledgment/negative acknowledgement and a channel quality indicator that is desired to be transmitted by the user equipment in one of the resources and leaving at least one other resource unused.

51. (Original) The method of claim 50, where the scheduling request resource and the at least one other resource are physical uplink control channel resources.

52. (Currently Amended) The method of ~~any one of claims 50 or 51~~claim 50 comprising:

for the case where the user equipment desires to transmit a scheduling request and transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement with the scheduling request on the scheduling request resource and leaving the at least one other resource unused; or

for the case where the user equipment does not desire to transmit a scheduling request and does desire to transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement on the at least one other resource and leaving the scheduling request resource unused.

53. (Currently Amended) The method of ~~any one of claims 50 or 51~~claim 50 comprising:

for the case where the user equipment desires to transmit a scheduling request and a channel quality indicator but no acknowledgment/negative acknowledgement, transmitting the scheduling request on the scheduling request resource and not transmitting the channel quality indicator leaving the at least one other resource unused.

54. (Currently Amended) The method ~~any one of claims 50 or 51~~of claim 50 comprising:

for the case where the user equipment desires to transmit a scheduling request, transmit a channel quality indicator, and transmit an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement with the scheduling request on the scheduling request resource and not transmitting the channel quality indicator leaving the at least one other resource unused; or

for the case where the user equipment does not desire to transmit a scheduling request and does desire to transmit a channel quality indicator and an acknowledgment/negative acknowledgement, transmitting the acknowledgment/negative acknowledgement and the channel quality indicator on the at least one other resource and leaving the scheduling request resource unused.

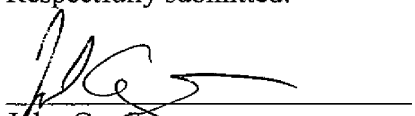
55. (Currently Amended) The method of ~~any one any one of claims 50 or 51~~claim 50 where the scheduling request information is conveyed based on a selected physical uplink control channel selection.

REMARKS

This amendment removes the multiple dependencies from the claims. The amendment was not made for reasons related to patentability, and the full range of equivalents for all of the elements of the amended claims, as well as for all of the other claims, should remain intact.

A favorable consideration that results in the allowance of all of the pending claims is earnestly solicited.

Respectfully submitted:



10/11/2013

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