



APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/203,391	05/28/2019	10306669	P73334-US2	3937

27045 7590 05/08/2019
ERICSSON INC.
6300 LEGACY DRIVE
M/S EVR 1-C-11
PLANO, TX 75024

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):

TELEFONAKTIEBOLAGET L M ERICSSON (PUBL), Stockholm, SWEDEN;
Havish Koorapaty, SARATOGA, CA;
Sorour Falahati, STOCKHOLM, SWEDEN;
Robert Baldemair, SOLNA, SWEDEN;
Daniel Larsson, LUND, SWEDEN;

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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
16/203,391	11/28/2018	Havish Koorapaty	P73334-US2

CONFIRMATION NO. 3937

27045
ERICSSON INC.
6300 LEGACY DRIVE
M/S EVR 1-C-11
PLANO, TX 75024

PUBLICATION NOTICE



Title:PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION

Publication No.US-2019-0132861-A1

Publication Date:05/02/2019

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/>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently <https://portal.uspto.gov/pair/PublicPair>. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/203,391	11/28/2018	Havish Koorapaty	P73334-US2	3937
27045	7590	04/08/2019	EXAMINER	
ERICSSON INC. 6300 LEGACY DRIVE M/S EVR 1-C-11 PLANO, TX 75024			CHOI, EUNSOOK	
			ART UNIT	PAPER NUMBER
			2467	
			NOTIFICATION DATE	DELIVERY MODE
			04/08/2019	ELECTRONIC

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.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

michelle.sanderson@ericsson.com
pam.ewing@ericsson.com

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APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR/ PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.
16/203,391	11/28/2018	Koorapaty et al.	P73334-US2

ERICSSON INC. 6300 LEGACY DRIVE M/S EVR 1-C-11 PLANO, TX 75024		EXAMINER	
		EUNSOOK CHOI	
		ART UNIT	PAPER
		2467	20190402

DATE MAILED: _____

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner for Patents

Considered IDS dated 3/21/2019.

/EUNSOOK CHOI/
Primary Examiner, Art Unit 2467

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	16203391
	Filing Date	2018-11-18
	First Named Inventor	Havish Koorapaty
	Art Unit	2467
	Examiner Name	Eynsook Choi
	Attorney Docket Number	P73334-US2

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Examiner Initial*	Cite No	Patent Number	Kind Code ¹	Issue Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear		
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Examiner Initial*	Cite No	Publication Number	Kind Code ¹	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear		
	1	20140126491	A1	2014-05-08	EKPENYONG et al.			
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Examiner Initial*	Cite No	Foreign Document Number ³	Country Code ²ⁱ	Kind Code ⁴	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear	T ⁵
	1	2012/050389	WO	A1	2012-04-19	PANTECH CO., LTD.		
	2	2014/051508	WO	A1	2014-04-03	TELEFONAKTIEBOLAG ET L M Ericsson (PUBL)		
	3	2497468	GB	A	2013-06-12	LG ELECTRONICS INC.		

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /E.C/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number		16203391
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	Art Unit	2467	
	Examiner Name	Eynsook Choi	
	Attorney Docket Number	P73334-US2	

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Examiner Signature	/EUNSOOK CHOI/		Date Considered 04/02/2019
*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.			
<small> ¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached. </small>			

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /E.C/

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	16203391
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	First Named Inventor	Havish Koorapaty
	Art Unit	2467
	Examiner Name	Eynsook Choi
	Attorney Docket Number	P73334-US2

CERTIFICATION STATEMENT

Please see 37 CFR 1.97 and 1.98 to make the appropriate selection(s):

☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

OR

☐ That no item of information contained in the information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of information contained in the information disclosure statement was known to any individual designated in 37 CFR 1.56(c) more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(2).

See attached certification statement.

☒ The fee set forth in 37 CFR 1.17 (p) has been submitted herewith.

A certification statement is not submitted herewith.

SIGNATURE

A signature of the applicant or representative is required in accordance with CFR 1.33, 10.18. Please see CFR 1.4(d) for the form of the signature.

Signature	/Ben Westover/	Date (YYYY-MM-DD)	2019-03-21
Name/Print	Ben Westover	Registration Number	56612

This collection of information is required by 37 CFR 1.97 and 1.98. 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 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: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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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 the Freedom of Information Act requires disclosure of these records.
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 inspections 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.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (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)

27045 7590 03/13/2019
ERICSSON INC.
6300 LEGACY DRIVE
M/S EVR 1-C-11
PLANO, TX 75024

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 transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/203,391	11/28/2018	Havish Koorapaty	P73334-US2	3937

TITLE OF INVENTION: PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1000	\$0.00	\$0.00	\$1000	06/13/2019

EXAMINER	ART UNIT	CLASS-SUBCLASS
CHOI, EUNSOOK	2467	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 03-09 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, _____ 1
- (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. _____ 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 must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)

STOCKHOLM, SWEDEN

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

4a. Fees submitted: ☒ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

- ☒ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)
- ☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. 50-1379

5. Change in Entity Status (from status indicated above)

- ☐ Applicant certifying micro entity status. See 37 CFR 1.29
- ☐ Applicant asserting small entity status. See 37 CFR 1.27
- ☐ Applicant changing to regular undiscounted fee status.

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.

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.

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 /Ben Westover/ Date April 8, 2019

Typed or printed name Ben Westover Registration No. 56,612

Electronic Patent Application Fee Transmittal				
Application Number:		16203391		
Filing Date:		28-Nov-2018		
Title of Invention:		PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION		
First Named Inventor/Applicant Name:		Havish Koorapaty		
Filer:		Taylor Merritt Meacham/Akiko Cline		
Attorney Docket Number:		P73334-US2		
Filed as Large Entity				
Filing Fees for Utility under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	1501	1	1000	1000

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				1000

Electronic Acknowledgement Receipt	
EFS ID:	35664345
Application Number:	16203391
International Application Number:	
Confirmation Number:	3937
Title of Invention:	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION
First Named Inventor/Applicant Name:	Havish Koorapaty
Customer Number:	27045
Filer:	Taylor Merritt Meacham/Akiko Cline
Filer Authorized By:	Taylor Merritt Meacham
Attorney Docket Number:	P73334-US2
Receipt Date:	08-APR-2019
Filing Date:	28-NOV-2018
Time Stamp:	21:21:48
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$1000
RAM confirmation Number	040919INTEFSW00007143501379
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	P73334_US2_2019-04-08_195344_Issue_Fee.pdf	70107	no	1
			4e7dce562b9c7e0e397197bab9a695915f0cdeae		
Warnings:					
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2	Fee Worksheet (SB06)	fee-info.pdf	30365	no	2
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Total Files Size (in bytes):			100472		
<p>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.</p> <p><u>New Applications Under 35 U.S.C. 111</u> 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.</p> <p><u>National Stage of an International Application under 35 U.S.C. 371</u> 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.</p> <p><u>New International Application Filed with the USPTO as a Receiving Office</u> 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.</p>					

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	16203391
	Filing Date	2018-11-18
	First Named Inventor	Havish Koorapaty
	Art Unit	2467
	Examiner Name	Eynsook Choi
	Attorney Docket Number	P73334-US2

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Examiner Initial*	Cite No	Foreign Document Number ³	Country Code ² i	Kind Code ⁴	Publication Date	Name of Patentee or Applicant of cited Document	Pages, Columns, Lines where Relevant Passages or Relevant Figures Appear	T ⁵
	1	2012/050389	WO	A1	2012-04-19	PANTECH CO., LTD.		
	2	2014/051508	WO	A1	2014-04-03	TELEFONAKTIEBOLAG ET L M Ericsson (PUBL)		
	3	2497468	GB	A	2013-06-12	LG ELECTRONICS INC.		

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	Examiner Name	Eynsook Choi
	Attorney Docket Number	P73334-US2

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Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.	T ⁵
	1		
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Examiner Signature			Date Considered
*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.			
<small> ¹ See Kind Codes of USPTO Patent Documents at www.USPTO.GOV or MPEP 901.04. ² Enter office that issued the document, by the two-letter code (WIPO Standard ST.3). ³ For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. ⁴ Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. ⁵ Applicant is to place a check mark here if English language translation is attached. </small>			

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☒ That each item of information contained in the information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of the information disclosure statement. See 37 CFR 1.97(e)(1).

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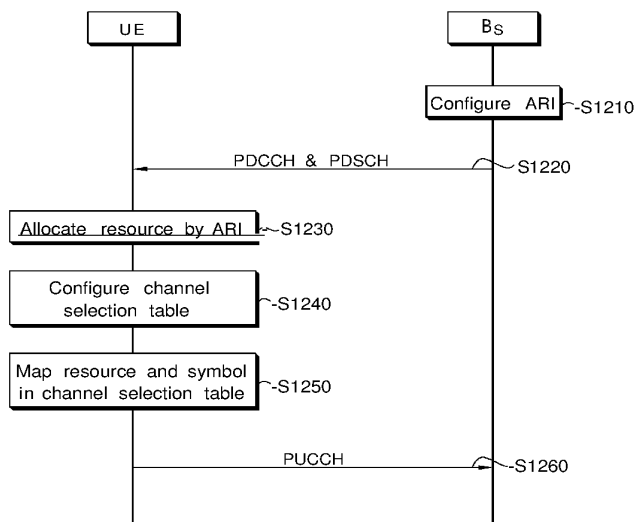
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(54) **Title:** METHOD OF TRANSMITTING AND RECEIVING ACK/NACK SIGNAL AND APPARATUS THEREOF

[Fig. 4]



(57) **Abstract:** Disclosed is a method for transmitting an ACK/NACK signal for an HARQ (Hybrid Automatic Repeat reQuest) in a CA (Carrier Aggregation) system, the method including obtaining at least one transmission resource among first and second transmission resources; configuring a first table showing a relationship in which a combination of at least one of the first and second transmission resources and modulation symbols is mapped to an ACK/NACK signal, and transmitting modulation symbols corresponding to a transmission target ACK/NACK signal in the first table by using transmission resource corresponding to the transmission target ACK/NACK signal in the first table, wherein the first transmission resource is indicated by a control element used for a first downlink control channel, the second transmission resource is at least one transmission resource among sets of transmission resources in a second table indicated by a resource allocation indicator transmitted on a second downlink control channel, and the second table shows a correspondence relationship between indication values of the resource allocation indicators and sets of transmission resources transmitted to the UE through higher layer signaling.

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Description

Title of Invention: METHOD OF TRANSMITTING AND RECEIVING ACK/NACK SIGNAL AND APPARATUS THEREOF

Technical Field

[0001] The present invention relates to wireless communication and, more particularly, to a wireless communication system supporting multiple carriers.

Background Art

[0002] A wireless communication system generally uses a single bandwidth for data transmission, and respective mobile communication generation use different bandwidths. For example, a 2nd-generation wireless communication system uses a bandwidth of 200 KHz to 1.25 MHz, a 3rd-wierless communication system uses a bandwidth of 5 MHz to 10 MHz. In order to support an increasing transmission capacity, recently, LTE (Long Term Evolution) or IEEE 802.16m continue to extend their bandwidth to 20 MHz or even higher. It may be requisite to increase the bandwidth to enhance transmission capacity, but it is not easy to allocate frequency of a large bandwidth, except for some areas globally.

[0003] A carrier aggregation (CA) technique for binding (or grouping) a plurality of physically non-continuous bands in a frequency domain to obtain an effect of using a logically large band has been developed in order to effectively use fragmented small bands. Individual unit carriers bound through carrier aggregation are called component carriers (CCs). Each of the component carriers (CCs) is defined by a single bandwidth and central frequency.

[0004] A system for transmitting and/or receiving data in a broadband through a plurality of component carriers is called a CA (Carrier Aggregation) system or a carrier aggregation environment. The CA system supports both a narrowband and a broadband by using one or more carriers. For example, when one carrier corresponds to a bandwidth of 5 MHz, a bandwidth of a maximum of 20 MHz is supported by using four carriers.

[0005] In order to operate the CA system, various control signaling is required between a base station (BS) and a user equipment (UE). For example, exchanging of ACK (ACKnowledgement)/NACK (Not-ACKnowledgement) information to perform HARQ (Hybrid Automatic Repeat reQuest), exchanging of CQI (Channel Quality Indicator) indicating downlink channel quality, and the like, are required.

[0006] In this connection, however, since a plurality of uplink CCs and a plurality of downlink CCs are used in the multi-CC system, an apparatus and method for ex-

changing various control signaling between a BS and a UE in such a communication environment are required.

Summary of Invention

Technical Problem

- [0007] Therefore, an object of the present invention is to provide an apparatus and method for effectively allocating transmission resources for transmitting an ACK/NACK signal with respect to a plurality of component carriers (CCs) in a CA system.
- [0008] Another object of the present invention is to provide an apparatus and method for effectively using radio resources by using resources allocated for repeatedly transferred control signals in a CA system.
- [0009] Another object of the present invention is to provide a resource allocation method for preventing a collision of radio resources and smoothly performing communication in a CA system.

Solution to Problem

- [0010] According to an aspect of the present invention, there is provided a method for transmitting an ACK/NACK signal for an HARQ (Hybrid Automatic Repeat reQuest) in a CA system, including: obtaining at least one transmission resource through a resource allocation indicator transmitted on a downlink control channel; and obtaining at least one second transmission resource based on at least one of resources used for the downlink control channel, wherein the transmission of the ACK/NACK signal is performed through a transmission and a modulation symbol mapped by a first table comprised of combinations of the obtained first and/or second transmission resources and modulation symbols of the ACK/NACK signal.
- [0011] The number of first and/or second transmission resources may be allocated according to the number of transmission bits of the ACK/NACK signal.
- [0012] The resource allocation indicator may be transferred by using resource allocated to control information repeatedly transmitted through a plurality of CCs.
- [0013] The first transmission resource may be a transmission resource mapped by a resource allocation indicator on a second table comprised of a certain transmission resource group.
- [0014] The transmission of the ACK/NACK signal may be performed through a multi-antenna system, and the method may further include obtaining a third transmission resource different from the first and second transmission resources, wherein a transmission resource mapped in the first table may be allocated to a first antenna, a third transmission resource may be allocated to a second antenna, and modulation symbols mapped in the first table may be transmitted through the first and second antennas.

- [0015] According to another aspect of the present invention, there is provided a method for receiving an ACK/NACK signal for an HARQ (Hybrid Automatic Repeat reQuest) in a CA system, including: allocating at least one first transmission resource to be used for transmission of an uplink ACK/NACK signal through a resource allocation indicator transmitted on a downlink control channel; and transmitting a resource allocation indicator on a downlink control channel, wherein the resource allocation indicator may indicate a transmission resource to be used for transmission of the ACK/NACK signal in a table comprised of a certain transmission resource group.
- [0016] The resource allocation indicator may be transferred by using resource allocated to control information repeatedly transmitted through a plurality of CCs.
- [0017] According to another aspect of the present invention, there is provided an apparatus for transmitting an ACK/NACK signal for an HARQ (Hybrid Automatic Repeat reQuest) in a CA system, including: an RF unit receiving a downlink transport block through a downlink allocation indicated by a downlink control channel and transmitting an ACK/NACK signal with respect to the downlink transport block; and a signal processing unit processing a signal received from the RF unit and a signal transmitted via the RF unit, wherein the signal processing unit obtains at least one first transmission resource through a resource allocation indicator transmitted on the downlink control channel, obtains at least one second transmission resource based on at least one of resources used for the downlink control channel, and maps modulation symbols and a transmission resource to be used for transmission of the ACK/NACK in a table comprised of combinations of first and/or second transmission resources and modulation symbols of ACK/NACK transmission, and the RF unit transmits an ACK/NACK signal by using the mapped transmission resource and modulation symbols.
- [0018] The RF unit may include a plurality of antennas, a transmission resource mapped in the table may be allocated to a first antenna among the plurality of antennas, a transmission resource different from the first and second transmission resources may be allocated to a second antenna among the plurality of antennas, and symbols mapped in the table may be transmitted through the first and second antennas.
- [0019] According to another aspect of the present invention, there is provided an apparatus for receiving an ACK/NACK signal for an HARQ (Hybrid Automatic Repeat reQuest) in a CA system, including: an RF unit transmitting a downlink transport block through a downlink allocation indicated by a downlink control channel and receiving an ACK/NACK signal with respect to the downlink transport block; and a signal processing unit processing a signal transmitted from the RF unit and a signal received through the RF unit, wherein the signal processing unit allocates at least one transmission resource to be used for transmission of an ACK/NACK signal through a resource allocation indicator transmitted on the downlink control channel, the RF unit transmits a resource

allocation indicator on the downlink control channel, and the resource allocation indicator indicates a transmission resource to be used for transmission of the ACK/NACK signal in a table comprised of a certain transmission resource group.

- [0020] According to another aspect of the present invention, there is provided a method for transmitting an ACK/NACK signal for an HARQ (Hybrid Automatic Repeat reQuest) by a user equipment (UE) in a CA system, including: obtaining at least one transmission resource among first and second transmission resources; and transmitting modulation symbols corresponding to a transmission target ACK/NACK signal in a first table, which shows a relationship in which a combination of at least one of the first and second transmission resources and modulation symbols is mapped to an ACK/NACK signal, by using

$$n_{PUCCH}^{(1)}$$

corresponding to the transmission target ACK/NACK signal in the first table, wherein the first transmission resource is indicated by a control element used for a first downlink control channel, the second transmission resource is at least one transmission resource among sets of transmission resources in a second table indicated by a resource allocation indicator transmitted on a second downlink control channel, and the second table may show a correspondence relationship between indication values of the resource allocation indicators and sets of transmission resources transmitted to the UE through higher layer signaling.

- [0021] The number of first and/or second transmission resources may be allocated according to the number of transmission bits of the ACK/NACK signal, and the resource allocation indicator may be transferred by using resource allocated to control information repeatedly transmitted through a plurality of CCs.
- [0022] The sets of transmission resources may include transmission resources corresponding to the number of transport blocks transmitted on a data channel indicated by a control signal transmitted on the second downlink control channel.
- [0023] The second transmission resource may be allocated according to the number of transport blocks transmitted on the data channel indicated by the control signal transmitted on the second downlink control channel.
- [0024] The resource allocation indicator may be comprised of N-bit information, the second table may be comprised of 2^N number of resource groups, the resource groups may be comprised of the resource sets or elements of the resource sets, and the resource groups may be comprised of the same number of transmission resources as that of transport blocks transmitted on the data channel indicated by the second downlink control channel.
- [0025] The method may further include: obtaining a third transmission resource different

from the first and second transmission resources, wherein a transmission resource mapped in the first table may be allocated to a first antenna, a third transmission resource may be allocated to a second antenna, and modulation symbols mapped to the ACK/NACK signal in the first table may be transmitted through the first and second antennas.

- [0026] According to another aspect of the present invention, there is provided a method for receiving an ACK/NACK signal for an HARQ (Hybrid Automatic Repeat reQuest) in a CA system, including: allocating at least one transmission resource to be used for reception of an uplink ACK/NACK signal through a resource allocation indicator transmitted on a downlink control channel; and transmitting a resource allocation indicator on a downlink control channel, wherein the resource allocation indicator may indicate at least one transmission resource in a resource allocation table, and the resource allocation table may show a correspondence relationship between indication values of the resource allocation indicators and sets of transmission resources transmitted to the UE through higher layer signaling.
- [0027] The resource allocation indicator may be transferred by using resource allocated to control information repeatedly transmitted through a plurality of CCs, and may be comprised of N-bit information. When the resource allocation indicator is comprised of N-bit information, the resource allocation table may be comprised of 2^N number of resource groups, and the resource groups may be comprised of resource sets or elements of the resource sets.
- [0028] The resource groups may be comprised of the same number of transmission resources as that of transport blocks transmitted on the data channel indicated by the downlink control channel.
- [0029] According to another aspect of the present invention, there is provided an apparatus for transmitting an ACK/NACK signal for an HARQ (Hybrid Automatic Repeat reQuest) in a CA system, including: an RF unit receiving a downlink transport block through a downlink allocation indicated by a downlink control channel and transmitting an ACK/NACK signal with respect to the downlink transport block; and a signal processing unit processing a signal received from the RF unit and a signal transmitted via the RF unit, wherein the signal processing unit obtains at least one of first and second transmission resources and determines transmission symbols and transmission resource mapped to the ACK/NACK signal to be transmitted, and the RF unit transmits the transmission symbols by using the transmission resource, the transmission symbols and the transmission resource are determined correspondingly according to an ACK/NACK to be transmitted in a first table, which shows a relationship in which a combination of at least one of the first and second transmission resources and modulation symbols is mapped to an ACK/NACK signal, the first

transmission resource is indicated by a control element used for a first downlink control channel, the second transmission resource is at least one transmission resource among sets of transmission resources in a second table indicated by a resource allocation indicator transmitted on a second downlink control channel, and the second table may show a correspondence relationship between indication values of the resource allocation indicators and sets of transmission resources configured based on transmission resources transmitted to the UE through higher layer signaling.

[0030] The resource allocation indicator may be comprised of N-bit information, the second table may be comprised of 2^N number of resource groups, and the resource groups may be comprised of the resource sets or elements of the resource sets.

[0031] According to another aspect of the present invention, there is provided an apparatus for receiving an ACK/NACK signal for an HARQ (Hybrid Automatic Repeat reQuest) in a CA system, including: an RF unit transmitting a downlink transport block through a downlink allocation indicated by a downlink control channel and receiving an ACK/NACK signal with respect to the downlink transport block; and a signal processing unit processing a signal transmitted from the RF unit and a signal received via the RF unit, wherein the signal processing unit allocates at least one transmission resource to be used for transmission of an ACK/NACK signal through a resource allocation indicator transmitted on the downlink control channel, the RF unit transmits a resource allocation indicator on the downlink control channel, the resource allocation indicator indicates at least one transmission resource in a resource transmission table, and the resource allocation table shows a correspondence relationship between indication values of the resource allocation indicators and sets of transmission resources transmitted to a user equipment (UE) through higher layer signaling.

[0032] The number of transmission resources mapped to the value of the resource allocation indicator may correspond to the number of transport blocks transmitted on a data channel indicated by the downlink control channel.

Advantageous Effects of Invention

[0033] According to an embodiment of the present invention, in a CA system, transmission resources for transmitting an ACK/NACK signal with respect to a plurality of component carriers can be effectively allocated.

[0034] According to an embodiment of the present invention, in a CA system, radio resources can be effectively used by using resource allocated to repeatedly transferred control signals.

[0035] According to an embodiment of the present invention, in a CA system, a collision of radio resources can be prevented and smooth communication can be performed.

Brief Description of Drawings

- [0036] FIG. 1 is a conceptual view for schematically explaining a downlink HARQ and CQI transmission.
- [0037] FIG. 2 is a view for schematically explaining a method for transmitting downlink control information in a CA system.
- [0038] FIG. 3 is a view schematically showing a transmission and reception relationship between a base station and a user equipment in the CA system.
- [0039] FIG. 4 is a view schematically explaining using resource allocated to repeated TPC (Transmission Power Control) fields in the CA system.
- [0040] FIG. 5 is a flow chart illustrating the process of a method for transmitting an ACK/NACK signal by a user equipment in a multi-antenna system.
- [0041] FIG. 6 is a schematic block diagram showing an example of an apparatus for transmitting an HARQ ACK/NACK signal in the multi-antenna system.
- [0042] FIG. 7 is a schematic block diagram of a wireless communication system implemented by an embodiment of the present invention.

Mode for the Invention

- [0043] Embodiments of the present invention will now be described in detail with reference to the accompanying drawings. It should be understood that, in applying reference numerals to constituents of each drawing, although the same constituents are shown on different drawings, they are denoted by the same reference numbers as possible. In describing the present invention, if a detailed explanation for a related known function or construction is considered to unnecessarily divert the gist of the present invention, such explanation will be omitted but would be understood by those skilled in the art.
- [0044] In describing the elements of the present invention, terms such as first, second, A, B, (a), (b), etc., may be used. Such terms are used for merely discriminating the corresponding elements from other elements and the corresponding elements are not limited in their essence, sequence, or precedence by the terms. It will be understood that when an element or layer is referred to as being "on" or "connected to" another element or layer, it can be directly on or directly connected to the other element or layer, or intervening elements or layers may be present.
- [0045] In the present disclosure, a wireless communication network will be described, and an operation performed in the wireless communication network may be performed in a process of controlling a network and transmitting data by a system (e.g., a base station (BS)) administering the corresponding wireless communication network or may be performed in a mobile station (MS) connected to the corresponding wireless network.
- [0046] A wireless communication system is widely disposed to provide various communication services such as voice and packet data, or the like. The wireless communication system includes at least one base station (BS). A BS generally refers to a fixed

station that communicates with a mobile station (MS) and may be called by other names such as evolved-node B (eNB), base transceiver system (BTS), access point (AP), etc. Each BS provides a communication service to particular geographical areas (which are generally called cells). Cells may be construed to have comprehensive meanings indicating partial areas covered by a BS, and may include various coverage areas such as a mega-cell, a macro-cell, a micro-cell, a pico-cell, a femto-cell, and the like.

[0047] A mobile station (MS) may be fixed or mobile and may be referred to by other names such as user equipment (UE), mobile terminal (MT), user terminal (UT), subscriber station (SS), wireless device, personal digital assistant (PDA), wireless modem, handheld device, etc.

[0048] Multi-access schemes applied to the wireless communication system are not limited. Namely, various multi-access schemes such as CDMA Code Division Multiple Access), TDMA (Time Division Multiple Access), FDMA (Frequency Division Multiple Access), OFDMA (Orthogonal Frequency Division Multiple Access), SC-FDMA (Single Carrier-FDMA), OFDM-FDMA, OFDM-TDMA, OFDM-CDMA, or the like, may be used. A TDD (Time Division Duplex) scheme in which transmission is made by using a different time or an FDD (Frequency Division Duplex) scheme in which transmission is made by using different frequencies may be applied to an uplink transmission or a downlink transmission.

[0049] A carrier aggregation (CA) supports a plurality of carriers, which is also called a spectrum aggregation or a bandwidth aggregation.

[0050] Sizes (i.e., bandwidths) of component carriers constituting a CA may vary.

[0051] Hereinafter, a multi-carrier system refers to a system supporting the carrier aggregation.

[0052] Component carriers may be divided into a primary component carrier and a secondary component carrier depending on whether or not they are activated. The primary component carrier is a carrier which is activated all the time, and the secondary carrier is a carrier which is activated or deactivated according to particular conditions. Here, activation refers to a state in which traffic data is transmitted or received or a state in which traffic data is ready to be transmitted or received. Deactivation refers to a state in which traffic data cannot be transmitted or received and measurement or transmission or reception of minimum information is available. A UE may use only one primary component carrier or one or more secondary component carriers along with a primary component carrier.

[0053] FIG. 1 shows a downlink HARQ and CQI transmission.

[0054] With reference to FIG. 1, when a UE receives downlink data from a BS, it transmits ACK (ACKnowledgement)/NACK (Not-ACKnowledgement) information after the

lapse of a certain time. The downlink data may be transmitted on a PDSCH indicated by a PDCCH. The ACK/NACK signal may be ACK information when the downlink data is successfully decoded, and may be NACK information when the downlink data fails to be decoded. When the NACK information received, the BS may retransmit the downlink data up to a maximum retransmission number.

[0055] A transmission time of the ACK/NACK signal with respect to the downlink data or a resource allocation may be dynamically informed by the BS, or may be previously agreed according to a transmission time of the downlink data or a resource allocation.

[0056] The UE may measure a downlink channel state and report a CQI to the BS periodically and/or aperiodically. The BS may inform the UE about a transmission time of the CQI or a resource allocation.

[0057] Meanwhile, the PUCCH may support multiple formats. Namely, it may transmit uplink control information having different number of bits per subframe according to a modulation scheme and a PUCH transmission format. Table 1 below shows modulation schemes and number of bits according to various PUCCH formats.

[0058]

[0059] [Table 1]

PUCCH format	Modulation scheme	Number of bits per subframe
1	N/A	N/A
1a	BPSK	1
1b	QPSK	2
2	QPSK	20
2a	QPSK+BPSK	21
2b	QPSK+QPSK	22
3	QPSK	48

[0060] PUCCH format 1 may be used for transmitting a scheduling request (SR). PUCCH format 1a/1b may be used for transmitting an HARQ ACK/NACK signal. PUCCH format 2 may be used for transmitting a CQI, and PUCCH format 2a/2b may be used for transmitting HARQ ACK/NACK. When the HARQ ACK/NACK signal is transmitted alone, PUCCH format 1a/1b/3 may be used, and when SR is transmitted alone, PUCCH format 1 may be used.

[0061] Resource index $n_{PUCCH}^{(1)}$, resource for transmission of PUCCH format 1/1a/1b is used to determine the amount of CS $\alpha(n_s, l)$ of a basic sequence and an orthogonal sequence index $n_0 c(n_s)$, as well as the position of a physical resource block in which the ACK/

NACK signal is transmitted. The resource index $n^{(1)}_{\text{PUCCH}}$ for the HARQ ACK/NACK may be obtained as shown in Table 2 below. The resource index $n^{(1)}_{\text{PUCCH}}$ may be used as a parameter for determining a physical RB index n_{PRB} , the amount of CS $\alpha(n_s, l)$ of the basic sequence, the orthogonal sequence index $n_{\text{OC}}(n_s)$, and the like.

[0062] [Table 2]

	Dynamic scheduling	Semi-persistent scheduling
Resource index	$n^{(1)}_{\text{PUCCH}} = n_{\text{CCE}} + N^{(1)}_{\text{PUCCH}}$	Signaled by higher layer or a control channel
Higher Layer Signaling value	$N^{(1)}_{\text{PUCCH}}$	$n^{(1)}_{\text{PUCCH}}$

[0063] Namely, the HARQ ACK/NACK signal with respect to the PDCCH transmitted at an n th subframe is transmitted at a $(n+4)$ th subframe by using resource index $n^{(1)}_{\text{PUCCH}}$, the sum of a first CCE (Control Channel Element) index n_{CCE} of the PDCCH transmitted in the n th subframe and the value $N^{(1)}_{\text{PUCCH}}$ obtained through higher layer signaling or a separate control channel. For example, $N^{(1)}_{\text{PUCCH}}$ may be a total number of PUCCH format 1/la/lb resources required for semi-persistent scheduling (SPS) transmission and service request (SR) transmission. As for the semi-persistent scheduling (SPS) transmission and service request (SR) transmission, since there is no PDCCH indicating the corresponding PDSCH transmission, the BS may explicitly inform the UE about $n^{(1)}_{\text{PUCCH}}$.

[0064] When the HARQ ACK/NACK signal and/or the SR are transmitted through PUCCH format 1/la/lb, the physical RB index n_{PRB} is determined by the resource index $n^{(1)}_{\text{PUCCH}}$. This is shown as expressed by Equation 1 below.

[0065] [Math.1]

$$m = \begin{cases} N_{\text{RB}}^{(2)} & \text{if } n^{(1)}_{\text{PUCCH}} < c \cdot N_{\text{cs}}^{(V)} / \text{"shift"}^{*\text{PUCCH}} \\ \left\lfloor \frac{n^{(1)}_{\text{PUCCH}} - c \cdot N_{\text{cs}}^{(1)} / \Delta_{\text{shift}}^{\text{PUCCH}}}{c \cdot N_{\text{sc}}^{\text{RB}} / \Delta_{\text{shift}}^{\text{PUCCH}}} \right\rfloor + N_{\text{RB}}^{(2)} + \left\lceil \frac{N_{\text{cs}}^{(1)}}{8} \right\rceil & \text{otherwise} \end{cases}$$

$$c = \begin{cases} 3 & \text{normal cyclic prefix} \\ 2 & \text{extended cyclic prefix} \end{cases}$$

$$n_{\text{PRB}} = \begin{cases} \left\lfloor \frac{m}{2} \right\rfloor & \text{if } (m + n_s \bmod 2) \bmod 2 = 0 \\ N_{\text{RB}}^{\text{UL}} - 1 - \left\lfloor \frac{m}{2} \right\rfloor & \text{if } (m + n_s \bmod 2) \bmod 2 = 1 \end{cases}$$

[0066] PUCCH format 3 is a PUCCH format employing DFT-S-OFDM(Discrete Fourier

Transform - Spreading - Orthogonal Frequency-Division Multiplexing), which uses DFT-IFFT and block-spreading. When the HARQ ACK/NACK signal is transmitted by using PUCCH format 3, information of up to maximum 10 bits in case of FDD and information of up to maximum 20 bits may be transmitted in the HARQ ACK/NACK signal by using one ACK/NACK resource.

[0067] Meanwhile, when the ACK/NACK signal is transmitted through the PUCCH by using multiple antennas in uplink, diversity can be obtained by transmitting the same ACK/NACK symbols through different resources by using different resources. In this case, however, since the same ACK/NACK signal is transmitted through different antennas, different ACK/NACK transmission resources should be allocated to the respective antennas in order to prevent a collision of resources.

[0068] For example, an ACK/NACK transmission resource may be allocated to a first antenna according to a signal transmission table, and an ACK/NACK transmission resource may be allocated to a second antenna from a resource domain not designated by the signal transmission table to transmit the same ACK/NACK signal through the different antennas, thereby preventing a collision of resources and obtaining transmission diversity.

[0069] In a carrier aggregation environment, the HARQ ACK/NACK signal may be transmitted through PUCCH format 1/1a/1b using the signal transmission table. The signal transmission table is a table for mapping a message to be transmitted, resource to be used for transmitting the corresponding message and modulation symbols. The signal transmission table may be configured in various manners. For example, the signal transmission table may be comprised of combinations of a plurality of resource indexes and modulation symbols of an ACK/NACK signal, may be implemented differently according to the number (M) of bits used for transmitting an ACK/NACK signal, or may be configured as a single table including the number (M) of every bit. Thus, when a signal transmission table is used with respect to ACK/NACK information having 4 bits or smaller in the carrier aggregation environment, the signal transmission table may be configured when the M values are 2, 3, and 4, and utilized for an ACK/NACK transmission resource allocation. An example of the method for allocating transmission resources and mapping transmission resources and modulation symbols by using the signal transmission table is channel selection. In the following description, channel selection will be taken as an example of a method of using the signal transmission table according to an embodiment of the present invention for the sake of brevity.

[0070] The format of a table used for channel selection (referred to as a 'channel selection table', hereinafter) may be transferred to the UE and the BS in advance by higher layer signaling or may be a table already owned by the UE and the BS. The UE may obtain

resource indexes for configuring the channel selection table through separate signaling, a transport channel, or the like, from a higher channel.

- [0071] In order to allocate resource for transmitting the ACK/NACK signal in the PUCCH format 1/1a/1b using channel selection, the BS may allocate resource indexes according to an implicit resource allocation scheme. The implicit allocating of a resource index by the BS refers to allocating a calculated resource index by using n_{CCE} indicating the number of a CCE, among the at least one CCE constituting the PDCCH of CC#a, as a parameter.
- [0072] The BS may allocate resource indexes according to an explicit resource allocation scheme. The explicit allocating of resource indexes by the BS refers to allocating a resource index of a PUCCH dedicated to a particular UE to the UE through a separate resource allocation indicator, or the like, without relying on n_{CCE} . Here, the separate resource allocation indicator includes signaling, or the like, from an upper layer or a physical layer. Also, the resource allocation indicator may be included as control information or system information in the PDCCH.
- [0073] In order to explicitly allocate a resource index, the BS may utilize an indicator used for transferring different control information, as a resource allocation indicator. For example, the BS may utilize a power indicator (PI) with respect to uplink transmission power, as a resource allocation indicator.
- [0074] The PI is an indicator for controlling and adjusting uplink transmission power. In general, a DCI format indicating a downlink grant includes 2-bit PI field for controlling power with respect to the PUCCH, and a DCI format indicating an uplink grant includes 2-bit PI field for controlling power with respect to the PUSCH. One example of the PI may be a transmission power control (TPC). Hereinafter, for content related to the PI in an embodiment of the present invention, the TPC will be described as an example for the sake of brevity.
- [0075] When cross-carrier scheduling is applied in the carrier aggregation environment, downlink grants regarding one or more target control carriers (i.e., carriers to be controlled) may be transmitted through control carriers. The control carriers may be carriers transmitting the PDCCH indicating the PDSCH of the target control carriers in cross-carrier scheduling, which may be primary component carriers (CC) or secondary component carriers. The target control carriers may be carriers whose PDSCH is indicated by the PDCCH of control carriers, which may be secondary CCs. All of the downlink grants transmit a TPC with respect to the PUCCH of the uplink CCs linked to the control carriers. In this case, one or more of the same TPCs for controlling power of the same uplink PUCCH are transmitted. These act as overhead of the downlink control information resultantly. Thus, when a plurality of TPCs with respect to one PUCCH exist due to transmission of a plurality of downlink grants, the bits

allocated to the repeated TPC fields may be diverted to be used for transmitting different control information to effectively use the limited radio resource.

- [0076] FIG. 2 is a view for schematically explaining a method for transmitting downlink control information and cross-carrier scheduling in a CA system.
- [0077] In the example of FIG. 2, the multi-CC system provides three CCs, i.e., CCI, CC2, and CC3 through carrier aggregation (CA) to the UE. Among them, one may be a primary CC and the others may be secondary CCs. It is assumed that CCI is a primary CC for the sake of brevity.
- [0078] A downlink subframe of each CC may include a control region including a PDCCH and a data region including a PDSCH. For example, CCI includes a data region 1070 and a control region 1040, CC2 includes a data region 1080 and a control region 1050, and CC3 includes a data region 1090 and a control region 1060.
- [0079] When CCI, CC2, and CC3 are operated according to cross-carrier scheduling, CCI may include PDCCHs regarding the PDSCHs 1020 and 1030 of carriers CC2 and CC3, as well as a PDCCH with respect to its PDSCH 1010. For example, the control region 1040 of CCI may include PDCCH1 1001 with respect to the PDSCH of CCI, PDCCH2 1002 with respect to the PDSCH of CC2, and PDCCH 3 1003 with respect to the PDSCH of CC3.
- [0080] Control information transmitted through the PDCCH is called downlink control information (DCI). A usage purpose of the DCI is different according to its format and a field defined in the DCI is different. The DCI includes uplink resource allocation information and downlink resource allocation information. The uplink resource allocation information may be called an uplink grant and the downlink resource allocation information may be called a downlink grant. For example, DCI format 0 may indicate uplink resource allocation information, and DCI formats 1 to 2C may indicate downlink resource allocation information, and DCI formats 3 and 3A may indicate an uplink TPC (Transmit Power Control) command with respect to certain UE groups. Respective fields of a DCI may be sequentially mapped to information bits. PDCCH 1 1001 with respect to the PDSCH of CCI, PDCCH2 1002 with respect to the PDSCH of CC2, and PDCCH3 1003 with respect to the PDSCH of CC3 may transmit a DCI of any one format among DCI 1/1A/1B/1C/1D/2/2A/2B/2C. A resource allocation field included in the DCI may indicate a PDSCH of a particular CC. For example, the DCI of the PDCCH1 1001 may indicate the PDSCH1 1010, the DCI of the PDCCH2 1002 may indicate the PDSCH2 1020, and the DCI of PDCCH3 1003 may indicate the PDSCH3 1030.
- [0081] In this manner, in the carrier aggregation, the DCI information of the PDCCH may transmit resource allocation information with respect to a different carrier, as well as resource allocation within the carrier to which the corresponding PDCCH belongs.

This is called cross-carrier scheduling. According to the cross-carrier scheduling, control information regarding a secondary CC can be transmitted through a primary CC, so scheduling becomes flexible.

- [0082] Meanwhile, the DCI may further include various fields besides the resource allocation field. For example, the respective DCIs may include a transmission field TPC.
- [0083] The UE may monitor a plurality of PDCCHs transmitted in the CA environment. For example, the UE may monitor the plurality of PDCCHs in a blind decoding manner by using a particular RNTI (Radio Network Temporary Identifier) allocated to the UE itself, and extract a transmission field.
- [0084] FIG. 3 is a view schematically showing a transmission and reception relationship between a BS 1120 and a UE 1110 in the CA system.
- [0085] The BS 1120 aggregates three CCs of CC1 1130, CC2 1140, and CC3 1150, and transmits the same to the UE 1110.
- [0086] Required information is included in the respective CCs CC1 1130, CC2 1140, and CC3 1150 and transferred on the PDCCH and the PDSCH, respectively (SI 110, SI 120, and SI 130). Here, the PDCCHs of the respective CCs CC1 1130, CC2 1140, and CC3 1150 include a TPC for controlling uplink power.
- [0087] Upon receiving the respective CCs CC1 1130, CC2 1140, and CC3 1150, the UE 1110 transfers required information on a PUCCH to the BS 1120 in response (SI 140). The PUCCH includes an HARQ ACK/NACK signal with respect to whether or not the PDSCHs of the respective CCs CC1 1130, CC2 1140, and CC3 1150 have been received without an error.
- [0088] When one PUCCH is transmitted to the BS with respect to a downlink transmission, as described above, the repeated information of the power indicators TPC1, TPC2, and TPC3 with respect to the same PUCCH may be included and transmitted on the PDCCH of the respective CCs CC1, CC2, and CC3 to the UE. Thus, a method for utilizing the bits allocated to the repeatedly transmitted TPC fields with respect to the same PUCCH in order to transmit different control information may be considered.
- [0089] In FIG. 3, when CC1 is a primary CC (PCC) and CC2 and CC3 are secondary CCs (SCC1 and SCC2), the TPC field included in the PDCCH of the PCC may be used to transfer information for controlling uplink PUCCH power and bits allocated to the TPC fields included in the PDCCHs of SCC1 and SCC2 may be used to transfer different control information.
- [0090] For example, resource may be allocated by using two bits allocated to the TPC fields included in the PDCCHs of the SCC1 and/or SCC2 to obtain resources constituting a channel selection table for transmitting 2-4 bit ACK/NACK signal through the PUCCH.
- [0091] FIG. 4 is a view schematically explaining using resource allocated to the repeated

TPC fields in the CA system.

- [0092] In the CA environment, in order to allocate resource to be used for an uplink signal transmission, the BS configures a resource allocation indicator (S1210). For example, an ACK/NACK resource indicator (ARI) may be configured for an uplink HARQ ACK/NACK signal. The ARI is an indicator explicitly allocating PUCCH resource(s) to be used for the UE to transmit the HARQ ACK/NACK signal. In the following description, the ARI will be taken as an example of the PUCCH resource allocation indicator according to the present embodiment.
- [0093] The BS transmits required information on the PDCCH and the PDSCH to the UE through CCs (S1220). When a plurality of CCs are transmitted, e.g., when SCCs are transmitted together with a PCC in the multi-CC system, the TPC fields included in the PDCCHs of the SCCs are repeated with the TPC with respect to the PUCCH included in the PDCCH of the PCC. The BS may transmit the ARI by using the bits allocated to the repeated TPC fields on the SCCs.
- [0094] The UE checks the PDCCHs of the CCs received from the BS, and is allocated resource from the ARI transmitted by using the bits allocated to the TPC fields on the SCCs according to the explicit resource allocation method (S1230).
- [0095] The UE may configure a channel selection with the transmission resource obtained through the ARI and the implicitly allocated transmission resource (to be described) (S1240).
- [0096] The UE maps PUCCH resource to be used for HARQ ACK/NACK transmission and modulated symbols according to HARQ ACK/NACK information received by UE in the channel selection table (S1250). Mapping in the channel selection table may be simply matching transmission resource to be used for transmission with respect to a message/signal to be transmitted and/or matching resource to be used for the transmission and symbols according to a type of a message and/or a signal to be transmitted. For example, in case of transmission of the HARQ ACK/NACK signal, transmission resource to be used for the transmission and symbols to be transmitted may be mapped.
- [0097] The UE may transmit symbols and/or a message on the PUCCH by using the transmission resource determined through mapping in the channel selection table (S1260).
- [0098] In general, ACK/NACK information regarding PDSCH of a plurality of downlink CCs are transmitted through a single UL PCC, e.g., a single PUCCH. Thus, when a plurality of CCs are used for downlink transmission, as mentioned above, the TPC fields with respect to the PUCCH of the PDCCHs of the respective CCs are repeated.
- [0099] In particular, when an HARQ ACK/NACK signal with respect to the PDSCHs transferred according to the PUCCH format 1b using channel selection in the CA en-

vironment, namely, transferred by downlink SCCs has 1 to 4 bits, 2-bit TPC field within the PDCCHs is diverted to be used to configure a channel selection table for transmitting the uplink HARQ ACK/NACK signal.

- [0100] Hereinafter, the exclusive use of the 2-bit TPC field within the PDCCHs to configure a channel selection table for transmitting the uplink HARQ ACK/NACK signal when the HARQ ACK/NACK signal with respect to the PDSCHs transferred via downlink SCCs has 1 to 4 bits according to an embodiment to which the technical concept of the present invention is applied will be described. Here, a case in which a plurality of CCs are transmitted from the BS to the UE in order to divert the 2-bit TPC field to be used for an ARI (ACK/NACK Resource Indicator) will be considered.
- [0101] For the sake of brevity, the case in which the 2-bit TPC field is diverted to be used to transmit the ARI and a channel selection table is configured by using the 2-bit TPC field will be described, but the technical concept of the present invention is not limited thereto.
- [0102] An ARI resource mapping table for allocating resource to the ARI may be transmitted in advance to the UE through higher layer signaling. The ARI resource mapping table is comprised of values of the ARI and HARQ ACK/NACK transmission resources allocated according to the ARI values. The number of ACK/NACK transmission resources required for configuring the ARI resource mapping table is determined by the number of SCCs configured through an RRC and a transmission mode. Here, the transmission mode is related to whether to transmit one transport block for each CC or whether to transmit two transport blocks for each CC within the subframe, but the present invention is not limited thereto, and the transmission mode may reflect various transmission formats, and the ACK/NACK transmission resource may be determined by various transmission modes. Here, the transport block is also called a codeword.
- [0103] As described above, the ARI resource mapping table is differently configured according to the number of ACK/NACK transmission resources. The ARI resource mapping table may be previously transferred to the UE through higher layer signaling. In the PUCCH format 1b using channel selection in the CA environment, as for ACK/NACK transmission resources required for transmitting an ACK/NACK signal with respect to the PDSCHs transmitted through SCCs, 1 to 4 resources are required to be designated as an ARI table.
- [0104] One ACK/NACK transmission resource may be required, for example, when a PDSCH including one transport block is transmitted through an SCC.
- [0105] Two ACK/NACK transmission resources may be required, for example, when PDSCHs including two transport blocks are transmitted through an SCC, or when a PDSCH including one transport block is transmitted through two SCCs, respectively,

- [0106] Three ACK/NACK transmission resources may be required, for example, when a PDSCH including one transport block is transmitted through one SCC and PDSCH and a PDSCH including two transport blocks is transmitted through different SCCs, or when a PDSCH including one transport block is transmitted through three SCCs, respectively.
- [0107] Four ACK/NACK transmission resources may be required, for example, when a PDSCH including two transport blocks is transmitted through two SCCs, respectively, when a PDSCH including two transport blocks through one SCC and a PDSCH including one transport block is transmitted through two different SCCs, or when a PDSCH including one transport block is transmitted through four SCCs, respectively.
- [0108] The ACK/NACK transmission resources with respect to a PDSCH indicated by the PDCCH transmitted through the PCC are allocated according to an implicit resource allocation scheme, so transmission resource may not be allocated explicitly through an ARI.
- [0109] Each case according to the number of ACK/NACK transmission resources required for transmitting an ACK/NACK signal with respect to the PDSCHs transmitted through SCCs will be described.
- [0110] (1) When one ACK/NACK transmission resource is required
- [0111] Since one ACK/NACK transmission resource is required, respective resource sets for configuring an ARI resource mapping table have elements corresponding to one ACK/NACK transmission resource, respectively.
- [0112] For example, when resource sets transferred in advance through higher layer signaling are {n1}, {n2}, {n3}, and {n4}, the ARI resource mapping table may be configured as shown in Table 3 below.
- [0113]
- [0114] [Table 3]

ACK/NACK resource indicator	Mapped ACK/NACK transmission resource
00	First resource set, i.e., {n1}
01	Second resource set, i.e., {n2}
10	Third resource set, i.e., {n3}
11	Fourth resource set, i.e., {n4}

- [0115] Table 3 is an ARI resource mapping table configured for the sake of convenience in order to easily explain the present invention, and the specific values in the ARI resource mapping table according to an embodiment of the present invention are not limited thereto. For example, a table may not be configured with the sets having one element but a table may be configured with respective elements of one set {n1, n2, n3,

n4}.

[0116] Here, a 2-bit TPC on the PDCCHs with respect to the PDSCHs of the SCCs, among a plurality of CCs transmitted to downlink, may be used for the ARI. The ACK/NACK transmission resource is allocated according to the ARI value on the PDCCHs with respect to the PDSCHs of the received SCCs. For example, when the ARI is '00', a resource set {n1} is allocated.

[0117] (2) When two ACK/NACK transmission resources are required

[0118] Since two ACK/NACK transmission resources are required, respective resource sets for configuring an ARI resource mapping table may be four sets having elements corresponding to two ACK/NACK transmission resources or two sets having elements corresponding to four ACK/NACK transmission resources.

[0119] When resource sets previously transferred through higher layer signaling are four sets, e.g., {n1, n2}, {n3, n4}, {n5, n6}, {n7, n8}, having elements corresponding to two ACK/NACK transmission resources, the ARI resource mapping table may be configured as shown in Table 4 below.

[0120]

[0121] [Table 4]

ACK/NACK resource indicator	Mapped ACK/NACK transmission resource
00	First resource set, i.e., {n1, n2}
01	Second resource set, i.e., {n3, n4}
10	Third resource set, i.e., {n5, n6}
11	Fourth resource set, i.e., {n7, n8}

[0122] When resource sets previously transferred through higher layer signaling are two sets, e.g., {n1, n2, n3, n4}, {n5, n6, n7, n8}, having elements corresponding to four ACK/NACK transmission resources, the ARI resource mapping table may also be configured as shown in Table 5 below.

[0123]

[0124] [Table 5]

ACK/NACK resource indicator	Mapped ACK/NACK transmission resource
00	First resource set, i.e., {n1, n5}
01	Second resource set, i.e., {n2, n6}
10	Third resource set, i.e., {n3, n7}
11	Fourth resource set, i.e., {n4, n8}

[0125] Table 4 and Table 5 are ARI resource mapping tables configured for the sake of con-

venience to easily explain the present invention, and the specific values in the ARI resource mapping table according to an embodiment of the present invention are not limited thereto.

[0126] When the ARI is 00, a resource set {n1, n2} is allocated in the example of Table 4. Also, when the ARI is '00', a resource set {n1, n5} is allocated in the example of Table 5.

[0127] (3) When three ACK/NACK transmission resources are required

[0128] Since three ACK/NACK transmission resources are required, respective resource sets for configuring an ARI resource mapping table may be four sets having elements corresponding to three ACK/NACK transmission resources or three sets having elements corresponding to four ACK/NACK transmission resources.

[0129] When resource sets previously transferred through higher layer signaling are four sets, e.g., {n1, n2, n3}, {n4, n5, n6}, {n7, n8, n9}, {n10, n11, n12}, having elements corresponding to three ACK/NACK transmission resources, the ARI resource mapping table may be configured as shown in Table 6 below.

[0130]

[0131] [Table 6]

ACK/NACK resource indicator	Mapped ACK/NACK transmission resource
00	First resource set, i.e., {n1, n2, n3}
01	Second resource set, i.e., {n4, n5, n6}
10	Third resource set, i.e., {n7, n8, n9}
11	Fourth resource set, i.e., {n10, n11, n12}

[0132] When resource sets previously transferred through higher layer signaling are three sets, e.g., {n1, n2, n3, n4}, {n5, n6, n7, n8}, {n9, n10, n11, n12}, having elements corresponding to four ACK/NACK transmission resources, the ARI resource mapping table may also be configured as shown in Table 7 below.

[0133]

[0134] [Table 7]

ACK/NACK resource indicator	Mapped ACK/NACK transmission resource
00	First resources of each set, i.e., {n1, n5, n9}
01	Second resources of each set, i.e., {n2, n6, n10}
10	Third resources of each set, i.e., {n3, n7, n11}
11	Fourth resources of each set, i.e., {n4, n8, n12}

[0135] Table 6 and Table 7 are ARI resource mapping tables configured for the sake of con-

venience to easily explain the present invention, and the specific values in the ARI resource mapping table according to an embodiment of the present invention are not limited thereto.

[0136] When the ARI is '00', a resource set {n1, n2, n3} is allocated in the example of Table 6. Also, when the ARI is '01', a resource set {n1, n5, n9} is allocated in the example of Table 7.

[0137] (4) When four ACK/NACK transmission resources are required

[0138] Since four ACK/NACK transmission resources are required, respective resource sets for configuring an ARI resource mapping table may be four sets having elements corresponding to four ACK/NACK transmission resources.

[0139] When resource sets previously transferred through higher layer signaling are four sets, e.g., {n1, n2, n3, n4}, {n5, n6, n7, n8}, {n9, n10, n11, n12}, {n13, n14, n15, n16}, having elements corresponding to four ACK/NACK transmission resources, the ARI resource mapping table may be configured as shown in Table 8 below.

[0140]

[0141] [Table 8]

ACK/NACK resource indicator	Mapped ACK/NACK transmission resource
00	First resource set, i.e., {n1, n2, n3, n4}
01	Second resource set, i.e., {n5, n6, n7, n8}
10	Third resource set, i.e., {n9, n10, n11, n12}
11	Fourth resource set, i.e., {n13, n14, n15, n16}

[0142] When resource sets previously transferred through higher layer signaling are {n1, n2, n3, n4}, {n5, n6, n7, n8}, {n9, n10, n11, n12}, {n13, n14, n15, n16}, the ARI resource mapping table may also be configured as shown in Table 9 below.

[0143]

[0144] [Table 9]

ACK/NACK resource indicator	Mapped ACK/NACK transmission resource
00	First resources of each set, i.e., {n1, n5, n9, n13}
01	Second resources of each set, i.e., {n2, n6, n10, n14}
10	Third resources of each set, i.e., {n3, n7, n11, n15}
11	Fourth resources of each set, i.e., {n4, n8, n12, n16}

[0145] Table 8 and Table 9 are ARI resource mapping tables configured for the sake of convenience to easily explain the present invention, and the specific values in the ARI

resource mapping table according to an embodiment of the present invention are not limited thereto.

- [0146] When the ARI is '00', a resource set {n1, n2, n3, n4} is allocated in the example of Table 8. Also, when the ARI is '00', a resource set {n1, n5, n9, n13} is allocated in the example of Table 9.
- [0147] Meanwhile, as described above, in the CA environment, HARQ ACK/NACK information having less than 4 bits may be transmitted according to PUCCH format 1b using channel selection.
- [0148] The format of the channel selection table is previously transferred to the UE and the BS through higher layer signaling.
- [0149] The UE may be allocated ACK/NACK transmission resource for configuring a channel selection table according to a implicit resource allocation scheme or according to an explicit resource allocation scheme.
- [0150] In the multi-CC system, an ACK/NACK transmission resource with respect to the PDSCH indicated by the PDCCH transmitted through a PCC may be allocated according to the implicit resource allocation scheme. An ACK/NACK transmission resource with respect to a PDSCH indicated by the PDCCH transmitted through an SCC may be allocated according to the explicit or implicit resource allocation scheme. Here, as the explicit resource allocation scheme in which the ACK/NACK transmission resource with respect to the PDSCH indicated by the PDCCH transmitted through an SCC is allocated, the foregoing resource allocation scheme using the ARI may be used.
- [0151] FIG. 5 is a flow chart illustrating the process of a method for transmitting an ACK/NACK signal by the UE in a multi-antenna system.
- [0152] The UE receives a plurality of CCs from the BS and receives information on the PDCCH and the PDSCH (S1310).
- [0153] Transmission resource may be allocated to the PDSCH indicated by the PDCCH transmitted through a PCC among the received CCs according to the implicit resource allocation scheme. The UE may obtain a resource index ($n_{PUCCH,0}$) for allocation of the ACK/NACK resource on the PUCCH through an indicator of a first CCE among CCEs on the PDCCH received through the PCC. Also, the UE may obtain an additional resource index according to the implicit resource allocation scheme. For example, the UE may select any one of the remaining CCEs, excluding the first CCE, among the CCEs on the received PDCCH and obtain an additional resource index ($n_{PUCCH,i}$) from the index of the corresponding CCE.
- [0154] An ARI (ACK/NACK Resource Indicator) for allocating an ACK/NACK transmission resource is transferred on the PDCCH transmitted through the SCC among the received CCs. As described above, 2 bits allocated to the repeatedly

transferred TPC (Transmission Power Control) with respect to the PUCCH may be used for the ARI. The UE may be allocated ACK/NACK transmission resource explicitly through the ARI.

- [0155] The UE configures a signal transmission table with the resources allocated according to the implicit/explicit resource allocation schemes (S1330).
- [0156] As described above, the channel selection table is differently configured according to the M value (the number of bits used to transmit an ACK/NACK signal), and the number of resource indexes for configuring the channel selection table differs according to the M value. For example, when the number of indexes of the ACK/NACK transmission resources for configuring the channel selection table is 2, one ACK/NACK transmission resource, which is related to the PDSCH indicated by the PDCCH of a PCC, may be allocated according to the implicit resource allocation scheme and the other remaining ACK/NACK transmission resource, which is related to the PDSCH indicated by the PDCCH of an SSC, may be allocated according to the explicit resource allocation scheme by using the ARI.
- [0157] The UE allocates the ACK/NACK transmission resources in the channel selection table to a first antenna (S1340). The UE allocates a transmission resource, rather than the ACK/NACK transmission resource in the channel selection table, to a second antenna according to the explicit resource allocation scheme (S1350). Accordingly, the transmission resources of the first and second antennas can be prevented from colliding.
- [0158] The UE transmits the ACK/NACK signal to the first and second antennas by using the allocated ACK/NACK transmission resource (S1360).
- [0159] Here, the multiple antenna transmission using two antennas is described, but the present invention is not limited thereto and may be applicable to a multiple antenna transmission using two or more antennas.
- [0160] Table 10 shows an example of a channel selection table in case of M=2.
- [0161] [Table 10]

HARQ-ACK(0), HARQ-ACK(1)	$n_{\text{PUCCH}}^{(1)}$	$b(0), b(1)$
ACK, ACK	$n_{\text{PUCCH},1}^{(1)}$	1, 1
ACK, NACK/DTX	$n_{\text{PUCCH},0}^{(1)}$	0, 1
NACK/DTX, ACK	$n_{\text{PUCCH},1}^{(1)}$	0, 0
NACK/DTX, NACK	$n_{\text{PUCCH},1}^{(1)}$	1, 0
NACK, DTX	$n_{\text{PUCCH},0}^{(1)}$	1, 0
DTX, DTX	N/A	N/A

- [0162] Table 11 shows an example of a channel selection table in case of M=3.
- [0163]

[Table 11]

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2)	$n_{\text{PUCCH}}^{(1)}$	$b(0), b(1)$
ACK, ACK, ACK	$n_{\text{PUCCH},2}^{(1)}$	1, 1
ACK, ACK, NACK/DTX	$n_{\text{PUCCH},1}^{(1)}$	1, 1
ACK, NACK/DTX, ACK	$n_{\text{PUCCH},0}^{(1)}$	1, 1
ACK, NACK/DTX, NACK/DTX	$n_{\text{PUCCH},0}^{(1)}$	0, 1
NACK/DTX, ACK, ACK	$n_{\text{PUCCH},2}^{(1)}$	1, 0
NACK/DTX, ACK, NACK/DTX	$n_{\text{PUCCH},1}^{(1)}$	0, 0
NACK/DTX, NACK/DTX, ACK	$n_{\text{PUCCH},2}^{(1)}$	0, 0
DTX, DTX, NACK	$n_{\text{PUCCH},2}^{(1)}$	0, 1
DTX, NACK, NACK/DTX	$n_{\text{PUCCH},1}^{(1)}$	1, 0
NACK, NACK/DTX, NACK/DTX	$n_{\text{PUCCH},0}^{(1)}$	1, 0
DTX, DTX, DTX	N/A	N/A

[0164] Table 12 shows an example of a channel selection table in case of M=4.

[0165] [Table 12]

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	$n_{\text{PUCCH}}^{(1)}$	$b(0), b(1)$
ACK, ACK, ACK, ACK	$n_{\text{PUCCH},1}^{(1)}$	1, 1
ACK, ACK, ACK, NACK/DTX	$n_{\text{PUCCH},1}^{(1)}$	1, 0
NACK/DTX, NACK/DTX, NACK, DTX	$n_{\text{PUCCH},2}^{(1)}$	1, 1
ACK, ACK, NACK/DTX, ACK	$n_{\text{PUCCH},1}^{(1)}$	1, 0
NACK, DTX, DTX, DTX	$n_{\text{PUCCH},0}^{(1)}$	1, 0
ACK, ACK, NACK/DTX, NACK/DTX	$n_{\text{PUCCH},1}^{(1)}$	1, 0
ACK, NACK/DTX, ACK, ACK	$n_{\text{PUCCH},3}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, NACK/DTX, NACK	$n_{\text{PUCCH},3}^{(1)}$	1, 1
ACK, NACK/DTX, ACK, NACK/DTX	$n_{\text{PUCCH},2}^{(1)}$	0, 1
ACK, NACK/DTX, NACK/DTX, ACK	$n_{\text{PUCCH},0}^{(1)}$	0, 1
ACK, NACK/DTX, NACK/DTX, NACK/DTX	$n_{\text{PUCCH},0}^{(1)}$	1, 1
NACK/DTX, ACK, ACK, ACK	$n_{\text{PUCCH},3}^{(1)}$	0, 1
NACK/DTX, NACK, DTX, DTX	$n_{\text{PUCCH},1}^{(1)}$	0, 0
NACK/DTX, ACK, ACK, NACK/DTX	$n_{\text{PUCCH},2}^{(1)}$	1, 0
NACK/DTX, ACK, NACK/DTX, ACK	$n_{\text{PUCCH},3}^{(1)}$	1, 0
NACK/DTX, ACK, NACK/DTX, NACK/DTX	$n_{\text{PUCCH},1}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, ACK, ACK	$n_{\text{PUCCH},3}^{(1)}$	0, 1
NACK/DTX, NACK/DTX, ACK, NACK/DTX	$n_{\text{PUCCH},2}^{(1)}$	0, 0
NACK/DTX, NACK/DTX, NACK/DTX, ACK	$n_{\text{PUCCH},3}^{(1)}$	0, 0
DTX, DTX, DTX, DTX	N/A	N/A

[0166] Here, HARQ-ACK(0)~HARQ-ACK(3) are ACK/NACK types with respect to transport blocks to be determined whether or not they have been normally received (decoded).

[0167] $n_{\text{PUCCH}}^{(1)}$ is an ACK/NACK transmission resource to be used for transmission. Here, the respective transmission resources, e.g., $\{n_{\text{PUCCH},0}^{(1)}, n_{\text{PUCCH},1}^{(1)}\}$ in case of M=2, $\{n_{\text{PUCCH},0}^{(1)}, n_{\text{PUCCH},1}^{(1)}, n_{\text{PUCCH},2}^{(1)}\}$ in case of M=3, and $\{n_{\text{PUCCH},0}^{(1)}, n_{\text{PUCCH},1}^{(1)}, n_{\text{PUCCH},2}^{(1)}, n_{\text{PUCCH},3}^{(1)}\}$ in case of M=4, constituting the channel selection are the transmission resource, related to the PDSCH indicated by the PDCCH of the PCC, which has been allocated according to the implicit resource allocation scheme and the transmission resource, related to the PDSCH indicated by the PDCCH of the SCC, which has been allocated according to the explicit resource allocation.

[0168] $b(0)b(1)$ is a QPSK symbol of an ACK/NACK signal to be transmitted. When the value of $b(0), b(1)$ is mapped to N/A, namely, in case of DTX (Discontinuous

Transmission), since it corresponds to, for example, a case in which the UE has not received the PDCCH, so the UE does not transmit an ACK/NACK in a subframe n .

- [0169] As described above, when the UE allocates resource to the first antenna, by using the signal transmission table, e.g., the channel selection table, the UE transmits the corresponding transmission symbols ($b(0)$, $b(1)$) on the PUCCH by using the ACK/NACK transmission resource ($n_{\text{PUCCH}}^{(1)}$) mapped according to an ACK/NACK type corresponding to the decoding results of the received PDSCHs. For example, in case of $M=3$, when the types of ACK/NACK signals to be transmitted are all ACK, the UE transmits the value (1, 1) of the corresponding symbols ($b(0)$, $b(1)$) on the PUCCH by using the ACK/NACK transmission resource $n_{\text{PUCCH},2}^{(1)}$.
- [0170] The foregoing channel selection table is an example for explaining the technical concept of the present invention, so the present invention is not limited thereto and may be configured in various manners within the scope of the technical concept of the present invention.
- [0171] FIG. 6 is a schematic block diagram showing an example of an apparatus for transmitting an HARQ ACK/NACK signal in the multi-antenna system. FIG. 6 illustrates multi-antenna transmission using two antennas, but the present invention is not limited thereto, and the present invention may also be applicable to a multi-antenna transmission using two or more antennas. Also, for the sake of brevity, some of a configuration such as an encoder, a mapper, a multiplexing unit, and the like, will be omitted in the following description.
- [0172] A symbol modulation unit 1410 modulates an ACK/NACK signal and outputs modulation symbols. A resource determining unit 1420 allocates ACK/NACK resource to be used for transmitting the ACK/NACK modulation symbols to a first antenna 1440a and a second antenna 1440b. The results of resource allocation are transmitted, for example, in the form of a resource index, or the like, to first and second spreading units 1430a and 1430b.
- [0173] The first resource spreading unit 1430a spreads ACK/NACK modulation symbols according to the resource allocation results of the resource determining unit 1420 with respect to the first antenna 1440a and transmits the same through the second antenna 1440b.
- [0174] When the ACK/NACK signal is transmitted by using multiple antennas, since the same ACK/NACK symbols are transmitted by using different resources through the different antennas, diversity can be obtained.
- [0175] As described above, the ACK/NACK transmission resource is allocated with respect to the first antenna according to a channel selection table and different resource not mapped in the channel selection table is allocated with respect to the second antenna, and the same ACK/NACK signal is transmitted, whereby a collision of resources is

prevented and transmission diversity is obtained.

[0176] FIG. 7 is a schematic block diagram of a wireless communication system implemented by an embodiment of the present invention.

[0177] A BS 1510 includes a signal processing unit 1511, a memory 1512, and an RF unit 1513.

[0178] The signal processing unit 1511 implements the proposed functions, procedures and/or methods. The signal processing unit 1511 may configure a downlink physical channel and perform HARQ. Also, the signal processing unit 1511 may include resource indexes constituting a channel selection table for a resource allocation of an ACK/NACK signal in a downlink transport block or process an ARI, or the like, explicitly indicating the resource indexes. In this case, signal processing is processing in a broad sense including a signal creation, modulation, allocation of signal content, determining of a signal transmission, and the like. For example, how many resource indexes among the resource indexes constituting the channel selection table for an ACK/NACK resource allocation are to be allocated according to an explicit resource allocation scheme, how many resource indexes among the resource indexes constituting the channel selection table are to be allocated according to an implicit resource allocation scheme, which resources are to be based on in order to be allocated resource indexes according to the implicit resource allocation scheme, and the like, may be determined by the signal processing unit 1511 and transmitted to a UE 1520. Also, when a plurality of component carriers are transmitted, the signal processing unit 1511 may transmit an ARI for allocating ACK/NACK transmission resource by using bits allocated to a repeated TPC with respect to the same PUCCH.

[0179] The memory 1512, connected to the signal processing unit 1511, stores protocols or parameters for an HARQ operation. Also, the memory 1512 may store the channel selection table and/or the ARI mapping table. The formats of the channel selection table and/or the ARI mapping table are previously determined by a higher layer, so the same formats of channel selection table and/or the ARI mapping table exist in the UE and the BS. The BS 1510 may use the channel selection table and/or the ARI mapping table stored in the memory 1512 in order to process an ACK/NACK signal transmitted from the UE 1520.

[0180] The RF unit 1513, connected to the signal processing unit 1511, transmits and/or receives a radio signal, and may include a plurality of antennas.

[0181] The UE 1520 may include a signal processing unit 1521, a memory 1522, and an RF unit 1523.

[0182] The signal processing unit 1521 implements the proposed functions, procedures and/or methods. The signal processing unit 1521 may obtain a plurality of resources and transmit an HARQ ACK/NACK signal through multiple antennas by using the

plurality of resources. Also, the signal processing unit 1521 may also serve to modulate symbols and spread the modulation symbols for an ACK/NACK signal transmission. Also, the signal processing unit 1521 may allocate transmission resource according to an implicit or explicit resource allocation scheme through a radio signal received from the BS. Also, the signal processing unit 1521 may allocate an ACK/NACK transmission resource by using a channel selection table and/or an ARI mapping table and process an ACK/NACK signal.

- [0183] The memory 1522, connected to the signal processing unit 1521, may store protocols or parameter for an HARQ operation and the same channel selection table and/or ARI mapping table as that of the BS 1510. The RF unit 1523, connected to the signal processing unit 1521, may transmit and/or receive a radio signal, and may include a plurality of antennas.
- [0184] The signal processing units 1511 and 1521 may include an ASIC (Application-Specific Integrated Circuit), a chip-set, a logical circuit and/or a data processor. The memories 1512 and 1522 may include a ROM (Read-Only Memory), a RAM (Random Access Memory), a flash memory, a memory card, a storage medium, and/or any other storage devices. The RF units 1513 and 1523 may include a baseband circuit for processing a radio signal. When the embodiments are implemented by software, the foregoing techniques may be implemented by modules (processes, functions, or the like) performing the foregoing functions. The modules may be stored in the memories 1512 and 1522 and executed by the signal processing units 1511 and 1521. The memories 1512 and 1522 may be provided within or outside signal processing units 1511 and 1512, respectively, or may be connected to the signal processing units 1511 and 1521 through a well-known unit, respectively.
- [0185] Control information transferred from a higher layer described in the present disclosure may also be transmitted via a physical control channel, and may be periodically or aperiodically updated according to a request from a BS or a UE or according to a predetermined certain rule or instruction.
- [0186] In the exemplary system as described above, the methods are described based on the flow chart by sequential steps or blocks, but the present invention is not limited to the order of the steps, and a step may be performed in different order from another step as described above or simultaneously performed. It would be understood by a skilled person in the art that the steps are not exclusive, a different step may be included, or one or more of the steps of the flow chart may be deleted without affecting the scope of the present invention.
- [0187] The preferred embodiments of the present invention have been described with reference to the accompanying drawings, and it will be apparent to those skilled in the art that various modifications and variations can be made in the present invention

without departing from the scope of the invention. Thus, the technical idea of the present invention should be interpreted to embrace all such alterations, modifications, and variations in addition to the accompanying drawings.

[0188]

[0189]

Claims

- [Claim 1] A method for transmitting an ACK/NACK signal for an HARQ (Hybrid Automatic Repeat reQuest) by a user equipment (UE) in a CA (Carrier Aggregation) system, the method comprising:
obtaining at least one transmission resource among first and second transmission resources; and
transmitting modulation symbols corresponding to a ACK/NACK signal to be transmitted in a first table, which shows a relationship in which a combination of at least one of the first and second transmission resources and modulation symbols is mapped to an ACK/NACK signal, by using
 $n^{(1)}_{PUCCH}$
corresponding to the transmission target ACK/NACK signal in the first table,
wherein the first transmission resource is indicated by a control element used for a first downlink control channel, the second transmission resource is at least one transmission resource among sets of transmission resources in a second table indicated by a resource allocation indicator transmitted on a second downlink control channel, and the second table shows a correspondence relationship between indication values of the resource allocation indicators and sets of transmission resources transmitted to the UE through higher layer signaling.
- [Claim 2] The method of claim 1, wherein the number of first and/or second transmission resources are allocated according to the number of transmission bits of the ACK/NACK signal.
- [Claim 3] The method of claim 1, wherein the resource allocation indicator is transferred by using resource allocated to control information repeatedly transmitted through a plurality of CCs.
- [Claim 4] The method of claim 1, wherein the sets of transmission resources include transmission resources corresponding to the number of transport blocks transmitted on a data channel indicated by a control signal transmitted on the second downlink control channel.
- [Claim 5] The method of claim 1, wherein the second transmission resource is allocated according to the number of transport blocks transmitted on the data channel indicated by the control signal transmitted on the second downlink control channel.

- [Claim 6] The method of claim 1, wherein the resource allocation indicator is comprised of N-bit information, the second table is comprised of 2^N number of resource groups, the resource groups are comprised of the resource sets or elements of the resource sets, and the resource groups are comprised of the same number of transmission resources as that of transport blocks transmitted on the data channel indicated by the second downlink control channel.
- [Claim 7] The method of claim 1, further comprising:
obtaining a third transmission resource different from the first and second transmission resources,
wherein a transmission resource mapped in the first table is allocated to a first antenna, a third transmission resource is allocated to a second antenna, and modulation symbols mapped to the ACK/NACK signal in the first table are transmitted through the first and second antennas.
- [Claim 8] A method for receiving an ACK/NACK signal for an HARQ in a CA system, the method comprising:
allocating at least one transmission resource to be used for reception of an uplink ACK/NACK signal through a resource allocation indicator transmitted on a downlink control channel; and
transmitting a resource allocation indicator on a downlink control channel,
wherein the resource allocation indicator indicates at least one transmission resource in a resource allocation table, and the resource allocation table shows a correspondence relationship between indication values of the resource allocation indicators and sets of transmission resources transmitted to the UE through higher layer signaling.
- [Claim 9] The method of claim 8, wherein the resource allocation indicator is transferred by using resource allocated to control information repeatedly transmitted through a plurality of CCs.
- [Claim 10] The method of claim 8, wherein the resource allocation indicator is comprised of N-bit information, the resource allocation table is comprised of 2^N number of resource groups, and the resource groups are comprised of resource sets or elements of the resource sets.
- [Claim 11] The method of claim 8, wherein the resource groups are comprised of the same number of transmission resources as that of transport blocks transmitted on the data channel indicated by the downlink control channel.
- [Claim 12] An apparatus for transmitting an ACK/NACK signal for an HARQ

(Hybrid Automatic Repeat reQuest) in a CA (Carrier Aggregation) system, the apparatus comprising:

an RF unit receiving a downlink transport block through a downlink channel indicated by a downlink control channel and transmitting an ACK/NACK signal with respect to the downlink transport block; and

a signal processing unit processing a signal received from the RF unit and a signal transmitted via the RF unit,

wherein the signal processing unit obtains at least one of first and second transmission resources and determines transmission symbols and transmission resource mapped to the ACK/NACK signal to be transmitted, and the RF unit transmits the transmission symbols by using the transmission resource, the transmission symbols and the transmission resource are determined correspondingly according to an ACK/NACK to be transmitted in a first table, which shows a relationship in which a combination of at least one of the first and second transmission resources and modulation symbols is mapped to an ACK/NACK signal, the first transmission resource is indicated by a control element used for a first downlink control channel, the second transmission resource is at least one transmission resource among sets of transmission resources in a second table indicated by a resource allocation indicator transmitted on a second downlink control channel, and the second table shows a correspondence relationship between indication values of the resource allocation indicators and sets of transmission resources configured based on transmission resources transmitted to the UE through higher layer signaling.

[Claim 13] The apparatus of claim 12, wherein the resource allocation indicator is comprised of N-bit information, the second table is comprised of 2^N number of resource groups, and the resource groups are comprised of the resource sets or elements of the resource sets.

[Claim 14] An apparatus for receiving an ACK/NACK signal for an HARQ in a CA system, the apparatus comprising:

an RF unit transmitting a downlink transport block through a downlink resource indicated by a downlink control channel and receiving an ACK/NACK signal with respect to the downlink transport block; and

a signal processing unit processing a signal transmitted from the RF unit and a signal received via the RF unit,

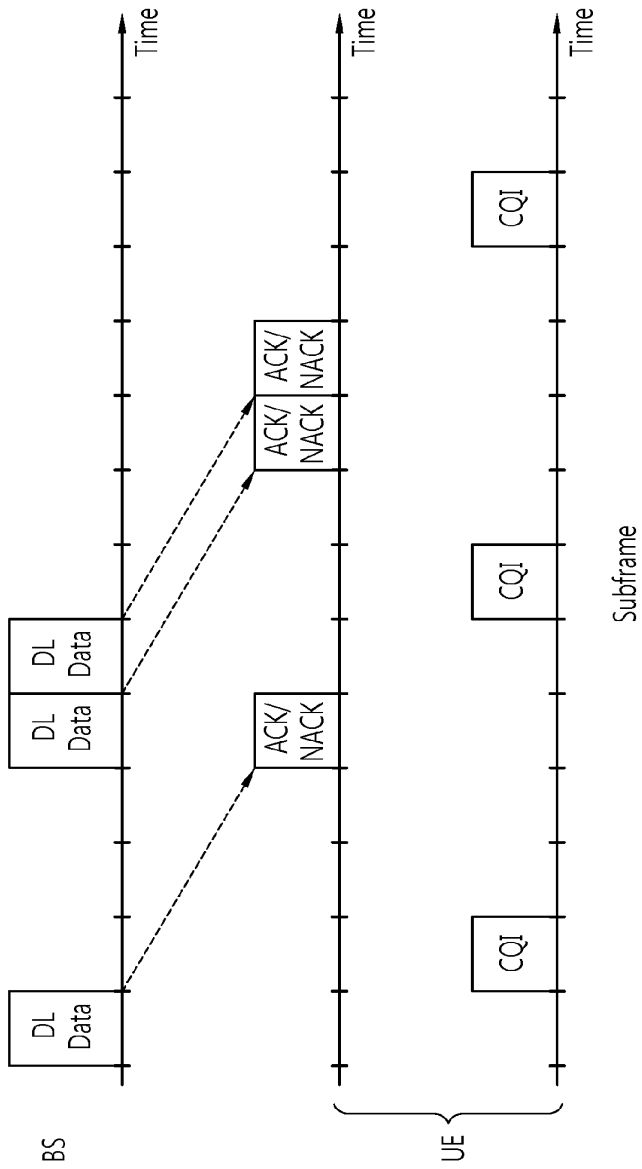
wherein the signal processing unit allocates at least one transmission resource to be used for transmission of an ACK/NACK signal through

a resource allocation indicator transmitted on the downlink control channel, the RF unit transmits a resource allocation indicator on the downlink control channel, the resource allocation indicator indicates at last one transmission resource in a resource transmission table, and the resource allocation table shows a correspondence relationship between indication values of the resource allocation indicators and sets of transmission resources transmitted to a (UE) through higher layer signaling.

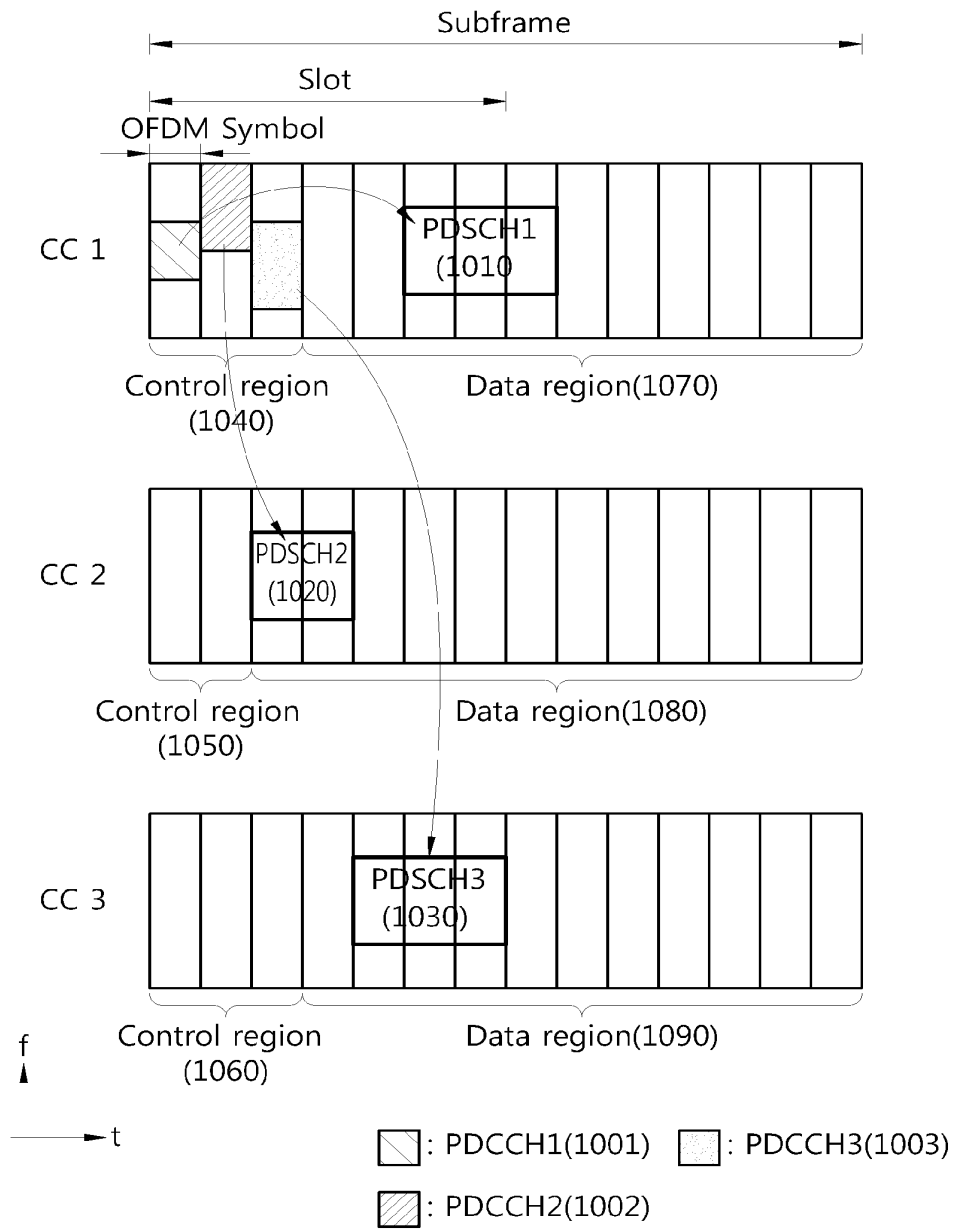
[Claim 15]

The apparatus of claim 14, wherein the number of transmission resources mapped to the value of the resource allocation indicator corresponds to the number of transport blocks transmitted on a data channel indicated by the downlink control channel.

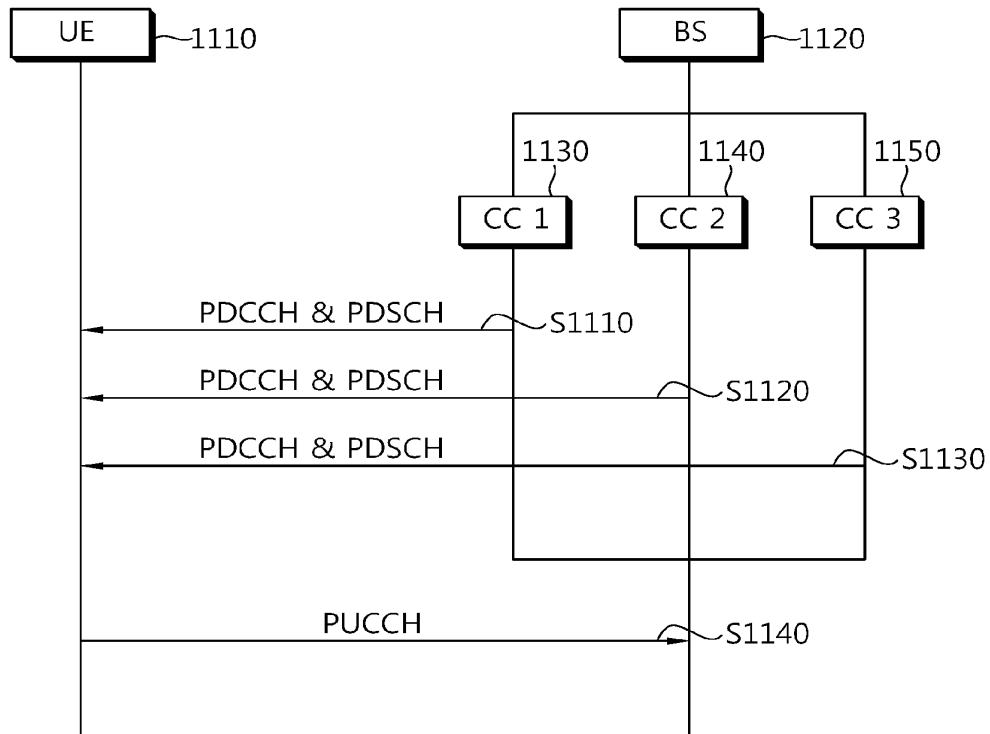
[Fig. 1]



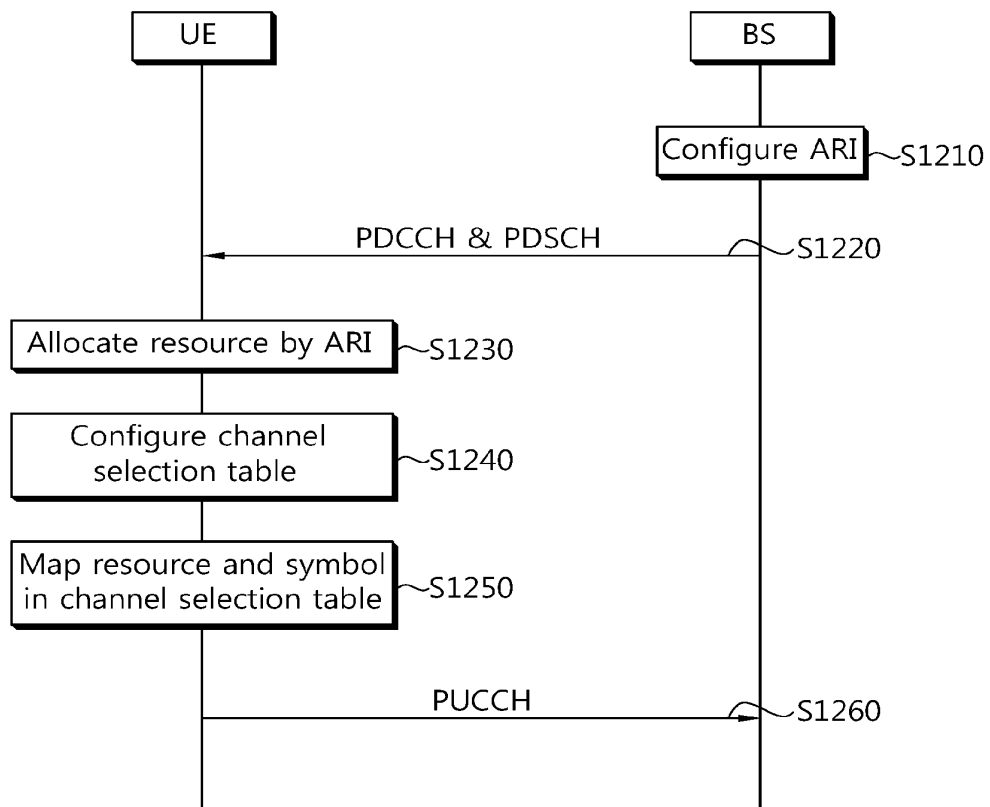
[Fig. 2]



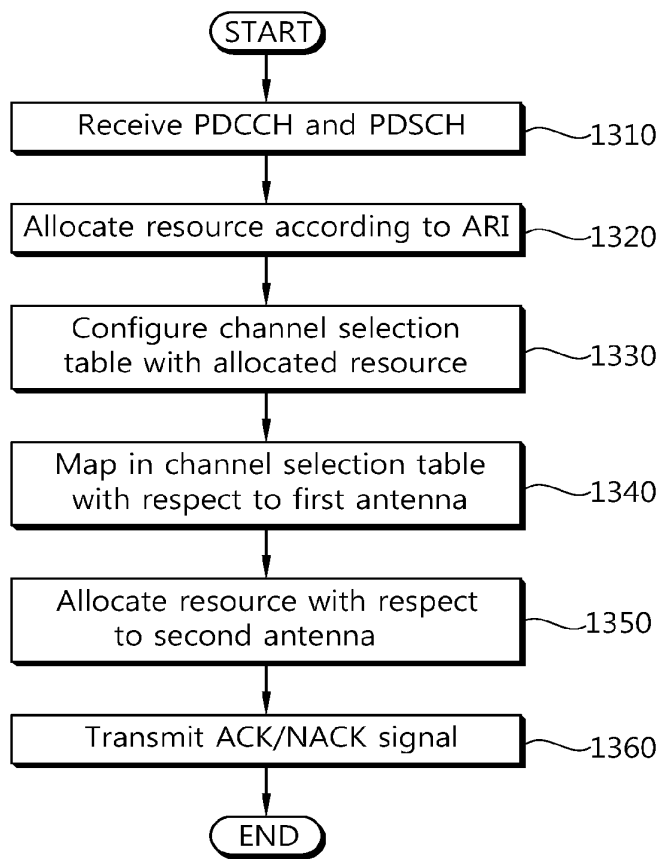
[Fig. 3]



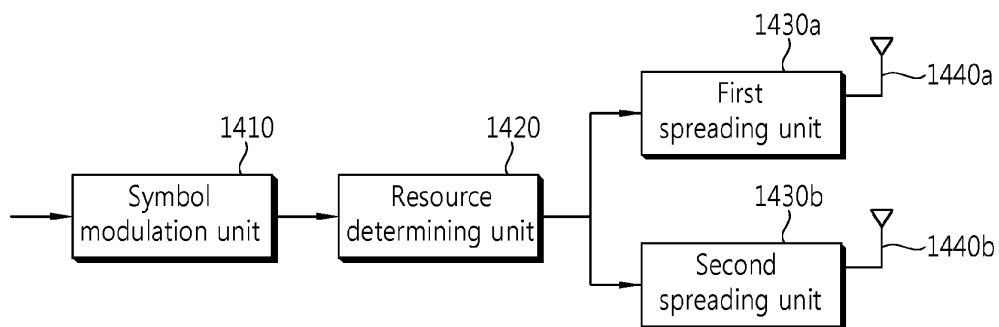
[Fig. 4]



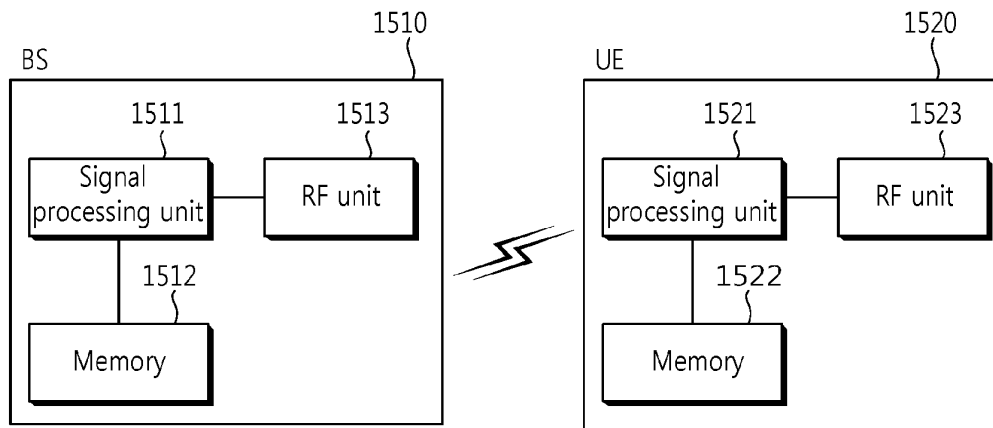
[Fig. 5]



[Fig. 6]



[Fig. 7]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2011/007659**A. CLASSIFICATION OF SUBJECT MATTER****H04L 1/18(2006.01)i, H04J 11/00(2006.01)1**

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 1/18

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

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: PUCCH, HARQ, carrier aggregation, ARI(ACK/NACK Resource indicator), PDSCH, resource allocation;

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Samsung, "PUCCH HARQ-ACK Resource Mapping for DL CA", 3GPP TSG RAN WG1 #61bis, R1-103637, June 28 - July 2, 2010. See section 2 and Figure 1.	1-15
Y	Fujitsu, "Channel Selection for A/N feedback in CA", 3GPP TSG RAN WG1 #62, R1-104875, 23-27 August, 2010. See section 2 and Tables 1-2.	1-15
A	Huawei, "Resource allocation for uplink ACK/NACK multiplexing", 3GPP TSG RAN WG1 #62, R1-104282, 23-27 August, 2010. See sections 2-3 and Figure 3.	1-15
A	CATT, "ACK/NACK resource allocation for CA", 3GPP TSG RAN WG1 #62, R1-104312, 23-27 August, 2010. See section 2 and Figures 2-3.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
None			



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H04L 5/00 (2006.01) **H04L 1/18** (2006.01)

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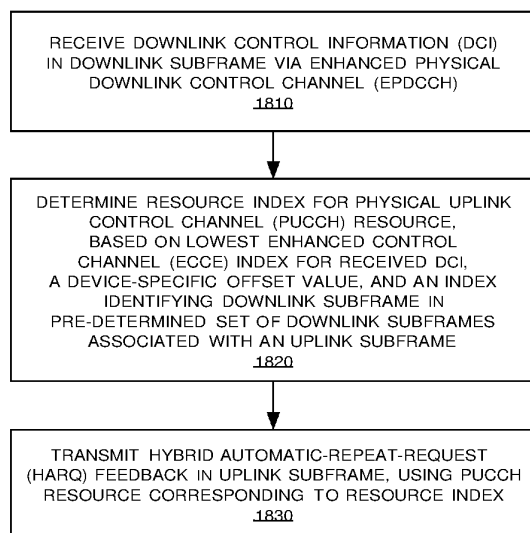
(74) Agent: BOU FAICAL, Roger; Ericsson AB, Patent Unit Kista RAN 1, S-164 80 Stockholm (SE).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, 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, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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[Continued on nextpage]

(54) Title: METHODS AND SYSTEMS FOR TDD PUCCH HARQ RESOURCE ALLOCATION FOR ENHANCED PHYSICAL DOWNLINK CONTROL CHANNEL (EPDCCH)



(57) Abstract: PUCCH resource determination for HARQ-ACK transmission in response to ePDCCH-scheduled PDSCH or ePDCCH-indicated SPS release in a TDD radio communication system. Downlink control information (DCI) is received in a downlink subframe via an Enhanced Physical Downlink Control Channel (ePDCCH). A resource index for a Physical Uplink Control Channel (PUCCH) resource is determined, based on the lowest enhanced Control Channel Element (eCCE) index of the received DCI, a device-specific offset value, and an index that identifies the downlink subframe in a pre-determined set of one or more downlink subframes associated with an uplink subframe. The PUCCH resource is determined according to a formula that results in a sequential allocation of PUCCH resources in the uplink subframe with respect to the downlink subframes associated with the uplink subframe, for each of a plurality of sets of ePDCCH resources. HARQ feedback is transmitted in the uplink subframe, in the indexed PUCCH resource.

FIG. 18

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**METHODS AND SYSTEMS FOR TDD PUCCH HARQ RESOURCE
ALLOCATION FOR ENHANCED PHYSICAL DOWNLINK CONTROL CHANNEL
(EPDCCH)**

TECHNICAL FIELD

5 The present invention generally relates to wireless communication networks, and particularly relates to the allocation of uplink control channel resources within such networks.

BACKGROUND

 The 3rd-Generation Partnership Project (3GPP) has developed specifications for a fourth-generation wireless communications technology known as "Long Term Evolution," or "LTE."
10 LTE uses Orthogonal Frequency Division Multiplexing (OFDM) in the downlink and DFT-spread OFDM in the uplink, where DFT denotes "Discrete Fourier Transform". The basic LTE physical resources can thus be seen as a time-frequency grid, as illustrated in Figure 1, where each resource element corresponds to one subcarrier during one OFDM symbol interval on a particular antenna port. An antenna port is defined such that the channel over which a symbol on
15 the antenna port is conveyed can be inferred from the channel over which another symbol on the same antenna port is conveyed. There is one resource grid per antenna port.

 In the time domain, LTE downlink transmissions are organized into radio frames of ten milliseconds. Each radio frame includes ten equally sized subframes of one millisecond. Figure 2
20 illustrates this arrangement - one sees from the diagram that each subframe is divided into two slots, with each slot having a duration of 0.5 milliseconds.

 Resource allocation in LTE is described in terms of "Physical Resource Blocks," or "PRBs." As shown in Figure 3, a PRB corresponds to one slot in the time domain and twelve contiguous 15-kHz subcarriers in the frequency domain. The bandwidth, N_{BW} , of the overall system determines the number of PRBs in each slot, and each PRB spans six or seven OFDM
25 symbols, depending upon the length of the cyclic prefix (CP) used. Two consecutive PRBs in time represent a PRB pair. User scheduling by the LTE base station, referred to as an "eNodeB" or "eNB", is generally performed using the PRB pair as the smallest unit of resource allocation.

 Transmissions in LTE are dynamically scheduled based on transmitting downlink assignments and uplink grants to targeted mobile terminals (referred to as "user equipment," or
30 "UEs," in 3GPP terminology). According to Release 8 of the 3GPP standards, which was the first release to include specifications for LTE, the downlink assignments and uplink grants are transmitted in a defined control region using Physical Downlink Control Channels (PDCCHs) targeted to specific UEs. The search space for PDCCH reception, which defines those resources

in any given subframe that might include control information for the UEs, is known to the UEs. The UEs thus blindly decode those portions of the received signal to find PDCCHs targeted to them.

More broadly, PDCCHs are used to convey UE-specific scheduling assignments for the downlink and uplink grants, as noted, and are further used for Physical Random Access Channel (PRACH) responses, uplink power control commands, and common scheduling assignments for signaling messages that include, among other things, system information and paging.

Figure 4 illustrates that a "normal" downlink subframe includes a control region at the beginning of the subframe, followed by a data region. The size of the control region in which PDCCHs are transmitted can vary in size from one to four OFDM symbols in dependence on the involved configuration. A Physical Control Format Indicator (PCFICH) is used to indicate the control region length and is transmitted within the control region at locations known by the UEs. A UE thus learns the size of the control region in a given downlink subframe by decoding the PCFICH transmitted in that subframe, and therefore knows in which OFDM symbol the data transmission starts.

PDCCHs are made up of Control Channel Elements (CCEs), where each CCE consists of nine Resource Element Groups (REGs). Each REG in turn consists of four resource elements (REs). LTE defines four PDCCH formats 0-3, which use aggregation levels of 1, 2, 4, and 8 CCEs, respectively. Given the modulation format used for PDCCH transmission, two bits can be transmitted on each individual RE aggregated within a PDCCH; with 1 CCE = 9 REGs = 36 REs and 2 bits/symbol, one can transmit 72 bits via a format 0 PDCCH, 144 bits via a format 1 PDCCH, etc. As noted, PDCCHs are transmitted in the defined control region—the first 1-4 symbols—of any given downlink subframe and extend over substantially the entire system bandwidth. Thus, the size of the control region in the given downlink subframe and the overall system bandwidth define the number of overall CCEs available for PDCCH transmission.

Figure 4 also illustrates the presence of Cell-specific Reference Symbols (CRS) within the downlink subframe. The locations and values of CRS are known by the UEs, which use the received CRS for estimation of the radio channel. The channel estimates are in turn used in the demodulation of data by the UEs. CRS are also used for mobility measurements performed by the UEs.

Because the CRS are common to all UEs in a cell, the transmission of CRS cannot be easily adapted to suit the needs of a particular UE. Therefore, LTE also supports UE-specific reference symbols generally intended only for assisting channel estimation for demodulation purposes. These UE-specific RS are referred to as Demodulation Reference Symbols (DMRS).

DMRS for a particular UE are placed in the data region of the downlink subframe, as part of Physical Downlink Shared Channel (PDSCH) transmissions.

Release 11 of the 3GPP standards introduced the enhanced PDCCH (ePDCCH) as an additional, and more flexible, channel for transmitting control messages to UEs. An ePDCCH
5 uses resources in the data region associated with PDSCH transmissions, rather than resource elements within the defined control region at the beginning of the subframe. See "Universal Mobile Telecommunications System (UMTS); Technical Specifications and Technical Reports for a UTRAN-based 3GPP system", 3GPP TS 21.101, v.1 1.0.0.

Figure 5 provides a basic illustration of PRB pairs allocated from the data region of a
10 downlink subframe, for use in the transmission of given ePDCCHs. The remaining PRB pairs in the data portion of the subframe can be used for PDSCH transmissions; hence the ePDCCH transmissions are frequency multiplexed with PDSCH transmissions. That arrangement differs from PDCCH transmissions, which are time multiplexed with respect to PDSCH
15 transmissions—i.e., PDCCH transmissions occur only in the control portion of the downlink subframe, which occurs in time before the data portion in which PDSCH transmissions are performed.

Resource allocation for PDSCH transmissions can be according to several resource allocation types, depending on the downlink control information (DCI) format. Some resource allocation types have a minimum scheduling granularity of a resource block group (RBG). An
20 RBG is a set of adjacent (in frequency) resource blocks. When scheduling the UE according to these resource allocation types, the UE is allocated resources in terms of RBGs, rather than according to individual resource blocks (RBs) or RB pairs.

When a UE is scheduled in the downlink from an ePDCCH, the UE shall assume that the PRB pairs carrying the downlink assignment are excluded from the resource allocation, i.e., rate
25 matching applies. For example, if a UE is scheduled to receive PDSCH in a certain RBG that consists of three adjacent PRB pairs, and if one of these PRB pairs contains the downlink assignment, then the UE shall assume that the PDSCH is transmitted in only the two remaining PRB pairs in this RBG. Notably, Release 11 does not support multiplexing of PDSCH and ePDCCH transmission within the same PRB pair.

30 ePDCCH messages are made up of enhanced Control Channel Elements (eCCEs), which are analogous to the CCEs used in the PDCCH. For purposes of mapping ePDCCH messages to PRB pairs, each PRB pair is divided into sixteen enhanced resource element groups (eREGs). Each eCCE is made up of four or eight of these eREGs, for normal and extended cyclic prefix, respectively. An ePDCCH is consequently mapped to a multiple of either four or eight eREGs,

depending on the aggregation level. The eREGs belonging to a particular ePDCCH resides in either a single PRB pair (as is typical for localized transmission) or a multiple of PRB pairs (as is typical for distributed transmission).

One example of the possible division of a PRB pair into eREGs is illustrated in Figure 6, which illustrates an unconstrained subframe. Each block or tile in the figure is an individual resource element (RE) and the tile number corresponds to the EREG that the RE is grouped within. For example, tiles having the dotted background all belong to same EREG indexed at 0.

A UE can be configured so that multiple sets of PRB pairs are available for use as ePDCCH resources. Each ePDCCH resource set consists of $N=2, 4$, or 8 PRB pairs. In addition, two modes of ePDCCH transmission are supported, i.e., localized and distributed ePDCCH transmission. Each set of ePDCCH resources is independently configured as being of localized or distributed type. In distributed transmission, an ePDCCH is mapped to resource elements in an ePDCCH set in a distributed manner, i.e., using multiple PRB pairs that are separated from each other in frequency. In this way, frequency diversity can be achieved for the ePDCCH message. As of Release 11, the ePDCCH can be mapped to resource elements in up to D PRB pairs, where $D = 2, 4$, or 8 (the value of $D=16$ is also being considered in 3GPP). Figure 7A illustrates an example of distributed transmission, where $D=4$ is illustrated. As seen in the example, the ePDCCH is divided into four parts, which are mapped to different PRB pairs. These four parts may correspond to eCCEs, for example.

In a localized transmission, on the other hand, an ePDCCH is mapped to one PRB pair only, if the space allows. Mapping to a single PRB pair is always possible for aggregation levels one and two, and is possible also for aggregation level four for the case of a normal, "unconstrained" subframe and a normal CP length. Here, an "unconstrained" or normal subframe is one having a PDSCH region that is not abbreviated. Constrained subframes include "special" subframes in TDD LTE that include uplink and downlink portions, and subframes that are given over to another purpose, such as Multicast-Broadcast Single Frequency Network (MBSFN) transmissions. The number of eCCEs that fit into one PRB pair is given by Table 1, below. Thus, for example, in a normal subframe with a normal CP length, localized transmission using aggregation levels of 1, 2, or 4 uses only a single PRB pair, while localized transmission using an aggregation level of 8 requires the use of two PRB pairs.

Normal cyclic prefix			Extended cyclic prefix	
Normal subframe	Special subframe, configuration 3, 4, 8	Special subframe, configuration 1, 2, 6, 7, 9	Normal subframe	Special subframe, configuration 1, 2, 3, 5, 6
4			2	

Table 1 - Number of eCCEs per PRB pair in localized transmission

In case the aggregation level of the ePDCCH is too large, a second PRB pair is used as well, and so on, using more PRB pairs, until all eCCEs belonging to the ePDCCH have been mapped. Figure 7B illustrates an example of localized transmission. In this example, the same four parts of the ePDCCH are mapped to a single PRB pair.

As described above, certain downlink resources are made available for sending PDCCH and ePDCCH messages to the UE. However, a given UE is not targeted to receive control channel messages in every subframe. Further, the UE does not know in advance precisely where a control channel message will be located among the resources made available for the control channel messages. Thus, the UE must search for a control message that may not exist, in each of several possible locations for the message. The concept of a "search space" is used to define a range of possible locations for control messages, to keep the required amount of searching to a reasonable level.

For the PDCCH, Release 8 of the 3GPP specifications for LTE define a search space $S_*^{(L)}$ for each of the possible aggregation levels $L \in \{1, 2, 4, 8\}$. This search space is defined by a contiguous set of CCEs given by the following:

$$(Z_k^{(L)} + i) \bmod N_{CCEk} \quad (1)$$

where $N_{CCE,k}$ is the total number of CCEs in the control region of subframe k , $Z_k^{(L)}$ defines the start of the search space. i is an index value that ranges according to $i = 0, 1, \dots, M^{(L)} \cdot T - 1$, where $M^{(L)}$ is a pre-determined number of PDCCHs to monitor in the given search space, which depends on the aggregation level. Table 2, which is reproduced from Table 9.1.1-1 of 3GPP TS 36.213, "Physical Layer Procedures (Release 8)," provides the values of $M^{(L)}$ for each of the possible aggregation levels L . Each CCE contains 36 QPSK modulation symbols.

Type	Search space $S_k^{(L)}$		Number of PDCCH candidates $M^{(L)}$
	Aggregation level L	Size [in CCEs]	
UE-specific	1	6	6
	2	12	6
	4	8	2
	8	16	2
Common	4	16	4
	8	16	2

Table 2: $M^{(l)}$ vs. Aggregation Level L for PDCCH

It should be noted that with this definition, search space for different aggregation levels may overlap with each other, regardless of system bandwidth. More specifically, UE-specific search space and common search space might overlap and the search spaces for different aggregation levels might overlap. One example is shown below, in Table 3, where there are nine CCEs in total and very frequent overlap between PDCCH candidates.

Search space $S_k^{(L)}$		PDCCH candidates in terms of CCE index
Type	Aggregation Level L	
UE-Specific	1	{1}, {2}, {3}, {4}, {5}, {6}
	2	{6, 7}, {8, 0}, {1, 2}, {3, 4}, {5, 6}, {7, 8}
	4	{4, 5, 6, 7}, {8, 0, 1, 2}
	8	{0, 1, 2, 3, 4, 5, 6, 7}, {8, 0, 1, 2, 3, 4, 5, 6}
Common	4	{0, 1, 2, 3}, {4, 5, 6, 7}, {8, 0, 1, 2}, {3, 4, 5, 6}
	8	{0, 1, 2, 3, 4, 5, 6, 7}, {8, 0, 1, 2, 3, 4, 5, 6}

Table 3: $N_{CCE,k} = 9$, $Z_k^{(L)} = \{1, 6, 4, 0\}$ for $L = \{1, 2, 4, 8\}$, respectively.

As is also the case for PDCCH, the ePDCCH is transmitted over radio resources shared by multiple UEs. The enhanced CCE (eCCE) is introduced as the equivalent of the CCE for PDCCH. Like a CCE, an eCCE also has a fixed number of resource elements. However, the number of resource elements actually available for ePDCCH mapping is generally fewer than the fixed number, because many resource elements are occupied by other signals such as Cell-specific Reference Signals (CRS) and Channel State Information-Reference Signal (CSI-RS). Code-chain rate matching is applied whenever a resource element belonging to an eCCE

contains other colliding signals such as the CRS, CSI-RS, legacy control region or in case of Time Division Duplexing (TDD), the Guard Period (GP) and Uplink Pilot Time Slot (UpPTS).

Consider the example in Figure 8, where item 40 illustrates the PDCCH mapping. The PDCCH always avoids the CRS, so that a CCE always contains $T_{majl} = 36$ available resource elements. In item 42, on the other hand, it is shown how an eCCE contains 36 resource elements nominally, but the number of available resource elements is reduced in the event that there are colliding signals. Hence, $T_{majl} \leq 36$ resource elements for ePDCCH. Since the colliding signals are subframe dependent, the value of T_{majl} becomes subframe dependent as well, and could even be different for different eCCEs, if the collisions impact on the eCCEs unevenly. It is noted that when the number of eCCEs per PRB pair is two (see Table 1), the nominal number of resource elements per eCCE is not 36, but instead is either 72 (for normal CP length) or 64 (for extended CP length).

As of Release 11 of the 3GPP standards for LTE, the ePDCCH supports only the UE-specific search space, whereas the common search space remains to be monitored in the PDCCH in the same subframe. In future releases, the common search space may be introduced also for ePDCCH transmission. The Release 11 standards specify that the UE monitors eCCE aggregation levels 1, 2, 4, 8, 16 and 32, with restrictions shown in Table 4 below, where n_{EPDCCH} is the number of available resource elements for ePDCCH transmission in a PRB pair. In Table 4, distributed and localized transmission refers to the ePDCCH mapping to resource elements.

ePDCCH format	Aggregation levels			
	Normal subframes and special subframes, configuration 3, 4, 8, with $n_{\text{EPDCCH}} < 104$ and using normal cyclic prefix		All other cases	
	Localized transmission	Distributed transmission	Localized transmission	Distributed transmission
0	2	2	1	1
1	4	4	2	2
2	8	8	4	4
3	16	16	8	8
4	-	32	-	16

Table 4: Aggregation levels for ePDCCH

In distributed transmission, an ePDCCH can be mapped to resource elements in up to D PRB pairs, where $D = 2, 4, \text{ or } 8$ (the value of $D=6$ is also being considered in 3GPP). In this way, frequency diversity can be achieved for the ePDCCH message. See Figure 7A for a schematic example in which a downlink subframe shows four parts belonging to an ePDCCH which is mapped to multiple of the enhanced control regions known as PRB pairs, to achieve distributed transmission and frequency diversity or sub-band precoding.

As of September 2012, the 3GPP has not reached agreement as to how four or eight eREGs respectively should be grouped into the eCCEs. It is also an open question as to how the encoded and modulated symbols of an ePDCCH message are mapped to the resource elements within the resources reserved by its associated eREGs. Further, the number of blind decodes per aggregation level for ePDCCH has not yet been decided in the 3GPP standardization work. Likewise, how randomization of the search space for localized and distributed mappings is generated has not yet been decided, although it is clear that overlap between ePDCCH candidates of different aggregation levels will occur also for the ePDCCH, as is the case for the PDCCH.

Time-Division Duplex (TDD) operation in LTE systems presents additional challenges with respect to PDCCH and ePDCCH to PUCCH mapping. These challenges to PUCCH HARQ-ACK resource determination arise from the asymmetry between uplink and downlink. When there are more downlink subframes than uplink subframes, the one to one mapping used in Frequency-Division Duplex (FDD) mode cannot be reused, since PUCCH resources selected according to this approach will collide with each other across different downlink subframes. On the other hand, overall HARQ-ACK resource utilization should be considered, since the resources for PUSCH transmission will be reduced if excessive uplink resources are reserved for PUCCH HARQ-ACK transmission. The TDD PUCCH resource for HARQ-ACK transmission in response to legacy PDCCH has been specified in the technical standardization document 3GPP TS 36.213, "Physical Layer Procedures," v10.6.0.

Figure 9 provides an illustration of the allocation of PUCCH resources for PDCCH, in TDD mode. The illustrated example is for four downlink subframes (SF0, SF1, SF2, and SF3) and one uplink subframe (SF4). Therein the resource determination for HARQ-ACK multiplexing and HARQ-ACK bundling are similar and can be derived as specified in 3GPP TS 36.213 v10.6.0, "Physical Layer Procedures". It can be seen that the PUCCH HARQ-ACK resources will be stacked firstly for the lowest eCCE index of the DCI that fall within the first one-third CCEs of the control region, across multiple subframes (from SF 0 to SF 3) (marked with diagonal shading). These PUCCH HARQ-ACK resources are followed by the DCIs belonging to the second one-third CCEs of the control region (shaded). Finally are the last one-

third CCEs (marked with cross-hatching). The design philosophy is that when system load is low, the control region could be automatically reduced by the dynamic signaling of PCFICH, hence the PUCCH HARQ-ACK resource could be compressed to a continuous region.

TDD PUCCH resource determination for ePDCCH has not been resolved in 3GPP RAN1 yet, i.e., no concrete solution is provided. However, a separate design different from FDD is needed, just as for PDCCH. Due to the fundamental differences in resource structures, the current design for PDCCH cannot be reused for ePDCCH. For example, PDCCH is a common control region (first one to four OFDM symbols) for all UEs while ePDCCH is multiplexed in frequency with PDSCH in a UE-specific manner. Accordingly, techniques for TDD PUCCH HARQ resource allocation for the Enhanced Physical Downlink Control Channel (ePDCCH) in radio communication systems are needed.

SUMMARY

According to several embodiments of the techniques disclosed herein, solutions are provided for PUCCH resource determination for HARQ-ACK transmission in response to ePDCCH-scheduled PDSCH or ePDCCH-indicated SPS release in a TDD radio communication system. Several different categories of embodiments are detailed below, each of which may have different combinations of PUCCH blocking probability, PUCCH resource utilization efficiency, eNB scheduler complexity and implementation complexity.

One example embodiment of the presently disclosed techniques is a processing method, suitable for implementation by a wireless device, for determining the resources for transmitting hybrid automatic-repeat-request (HARQ) feedback in a wireless communication network configured for time-division duplexing (TDD) operation. The example method begins with receiving downlink control information (DCI) via an Enhanced Physical Downlink Control Channel (ePDCCH) in a downlink subframe. The received ePDCCH schedules a downlink shared channel transmission to the wireless device or indicates a release of semi-persistent scheduling (SPS) to the wireless device. The method continues with determining a resource index for a Physical Uplink Control Channel (PUCCH) resource based on the lowest enhanced Control Channel Element (eCCE) index of the received DCI, a device-specific offset value previously signaled to the wireless device via Radio Resource Control (RRC) signaling, and an index i . The index i identifies the downlink subframe in a pre-determined set of one or more downlink subframes associated with an uplink subframe. The determining of the PUCCH resource is performed according to a formula that results in a sequential allocation of PUCCH resources in the uplink subframe with respect to the downlink subframes associated with the uplink subframe, for each of a plurality of sets of ePDCCH resources. The method continues

with the transmitting of HARQ feedback in the uplink subframe, using a PUCCH resource that corresponds to the resource index.

In some embodiments, determining the resource index for the PUCCH resource comprises determining the resource index based on the sum of (i) the lowest enhanced eCCE of the received DCI, (ii) the device-specific offset value previously signaled to the wireless device via RRC signaling, and (iii) the product of the index i and the number of eCCEs in a set of ePDCCH resources that includes those ePDCCH resources used by the received ePDCCH. In some of these embodiments, the set of ePDCCH resources is set q of a plurality of sets of ePDCCH resources, wherein the uplink subframe is subframe n and the downlink subframe is subframe $n-k_i$, where k_i is the i -th element in the pre-determined set of downlink subframes associated with subframe n , the pre-determined set comprising M elements indexed according to k_0, k_1, \dots, k_{M-1} , and determining the resource index comprises calculating:

$$n_{\text{PUCCH},i}^{(1)} = i \cdot N_q^{\text{eCCE}} + n_{\text{eCCE},i} + N_{\text{UE-PUCCH}}^{(q)},$$

where $n_{\text{eCCE},i}$ is the lowest eCCE index of the received DCI and N_q^{eCCE} is the number of eCCEs in ePDCCH set q . The resource index in these

embodiments is derived from $\llbracket n_{\text{PUCCH},i}^{(1)} \rrbracket$.

Other embodiments include corresponding operations implemented by a network node, e.g., an LTE eNB, in determining the PUCCH resource used by a wireless device and receiving the HARQ feedback in that resource. Still other embodiments include wireless devices and network nodes configured to carry out one or more of the techniques detailed herein. It will be appreciated that other embodiments include variations of and extensions to these enumerated

embodiments, in accordance with the detailed procedures and variants described below.

Of course, the present invention is not limited to the above features and advantages. Indeed, those skilled in the art will recognize additional features and advantages upon reading the following detailed description, and upon viewing the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a diagram illustrating physical resources as defined in LTE.
 Figure 2 is a diagram of the LTE time-domain structure.
 Figure 3 is a diagram of a PRB pair within an LTE time-frequency grid.
 Figure 4 is a diagram of mapping within an LTE downlink subframe for PDCCH, CRS,
 etc.

Figure 5 is a diagram of ePDCCH, as defined in the PDSCH region of a downlink subframe.

Figure 6 is a diagram of RE/EREG mapping within a PRB pair using normal CP.

Figures 7A and 7B illustrate examples of distributed and localized sets of PRBs, respectively, as used for ePDCCH.

Figure 8 illustrates a difference between a control channel element (CCE) and an enhanced CCE (eCCE) with respect to mapping around cell-specific reference symbols (CRS).

5 Figure 9 illustrates the allocation of PUCCH resources for PDCCH, in TDD mode. Figure 10 is a block diagram of an example embodiment of a network node and a wireless device that are configured according to the teachings herein.

Figure 11 is a block diagram of example details for the network node and wireless device of Figure 10.

10 Figure 12 depicts an exemplary ePDCCH resource configuration example having three ePDCCH sets with 4 PRBs per set.

Figure 13 illustrates an example of a PUCCH HARQ-ACK resource structure according to an embodiment.

15 Figure 14 illustrates an example of a PUCCH HARQ-ACK resource structure according to another embodiment.

Figure 15 illustrates an example of a PUCCH HARQ-ACK resource structure according to another embodiment.

Figure 16 illustrates an example of a PUCCH HARQ-ACK resource structure according to another embodiment.

20 Figure 17 illustrates an example of a PUCCH HARQ-ACK resource structure according to another embodiment.

Figure 18 is a logic flow diagram of one embodiment of a method of processing at a wireless device.

25 Figure 19 is a logic flow diagram of one embodiment of a method of processing at a network node.

DETAILED DESCRIPTION

Figure 10 illustrates a network node 10 and a wireless device 12. Wireless device 12 is configured to carry out terminal-side (i.e., UE-side) processing for the PUCCH allocation and hybrid automatic-repeat request (HARQ)-related teachings herein. In particular, the wireless
30 device 12 is configured to determine, using one or more of several techniques detailed below, a particular Physical Uplink Control Channel (PUCCH) for hybrid automatic-repeat-request (HARQ) feedback in response to an ePDCCH-scheduled PDSCH transmission or an ePDCCH-indicated SPS release, in TDD systems. Correspondingly, the network node 10 is configured to

carry out complementary network-side processing for determining the PUCCH resource used by a wireless device 12 for HARQ feedback.

The network node 10 includes one or more processing circuits 14 and associated memory/storage 16. The memory/storage 16 may be one or more types of computer-readable medium, such as a mix of volatile, working memory and non-volatile configuration and program memory or storage. The network node 10 further includes one or more communication interfaces 18. The communication interface(s) 18 depend on the nature of the network node 10. In a base station or other radio node example, the communication interface(s) 18 include a radio transceiver—e.g., pools of radio transmission, reception, and processing circuitry—for communicating with any number of wireless devices 12 in any one or more cells of a wireless communication network. Further, the network node 10 may support Carrier Aggregation (CA) operation, Time Division Duplex (TDD) operation, Multiple-Input-Multiple-Output (MIMO) operation, etc. Additionally, the communication interface(s) 18 may include inter-base-station interfaces and/or backhaul or other CN communication interfaces. In an LTE-based example where the network node 10 comprises an eNodeB, the communication interface(s) 18 include an "X2" interface for inter-eNodeB communications.

Correspondingly, the wireless device 12 may be a cellular radiotelephone—smartphone, feature phone, tablet, etc.—or may be a network adaptor, card, modem or other such interface device, or may be a laptop computer or other such device with integrated wireless communication capabilities. Of course, these examples are non-limiting and the wireless device 12 should be broadly understood as a communications transceiver configured for network operation according to the teachings herein. Further, it should be appreciated that references herein to "user equipment" or "UE" should be understood to refer more generally to a wireless device as pictured in Figure 10.

The wireless device 12 includes a transceiver circuit 20, which includes a receiver 22 and a transmitter 24, which are cellular radio circuits, for example. The illustrated wireless device 12 further includes one or more processing circuits 26, which include or are associated with one or more memory/storage devices or circuits 28. The memory/storage 28 includes, for example, one or more types of computer-readable medium. Example media include a mix of volatile, working memory and non-volatile configuration and program memory or other storage—e.g., Random Access Memory (RAM), Read-Only Memory (ROM), Electrically-Eraseable Programmable Read-Only Memory (EEPROM), Flash memory, and the like.

Those of ordinary skill in the art will appreciate that the transmitter 24 and/or receiver 22 each may comprise a mix of analog and digital circuits. For example, the receiver 22 in one or

more embodiments comprises a receiver front-end circuit, which is not explicitly shown in Figure 10. Such circuitry generates one or more streams of digital signal samples corresponding to antenna-received signal(s) and receiver processing circuits—e.g., baseband digital processing circuitry and associated buffer memory—operate on the digital samples. Example operations
5 include linearization or other channel compensation, possibly with interference suppression, and symbol demodulation and decoding, for recovering transmitted information.

Those of ordinary skill in the art will appreciate that Figure 10 illustrates high-level physical circuit arrangements and that the network node 10 and the wireless device 12 generally will include digital processing circuits and associated memory or other computer-readable
10 medium, for storing configuration data, operational or working data, and for storing computer program instructions. In at least some of the embodiments contemplated herein, the network-side and device-side functionality is realized at least in part through the programmatic configuration of digital processing circuitry, based on the execution by that circuitry of stored computer program instructions. The functional circuits realized in this manner shall be understood as
15 "machines" specially adapted for the purpose(s) described herein. The processing circuit 14 in the network node 10 and the processing circuit 26 in the wireless device 12 may be at least partly configured in this manner.

Figure 11 provides example details for both the network node 10 and the wireless device 12 where the network node 10 is an eNodeB configured for operation in an LTE network, or is
20 another type of base station or radio node. Consequently, the network node 10 in such embodiments includes RF interface circuitry 30, which represents or is included in the communication interface(s) 18 introduced in Figure 10. Further, the processing circuit 14, which may comprise one or more microprocessors, DSPs, or other digital processing circuitry, includes a control circuit 32 that is configured according to the teachings herein. The control circuit 32
25 also may be referred to as a processing circuit, a processing unit, or a control unit. In at least one embodiment, the control circuit 32 is specially adapted according to the network-side teachings herein, based on its execution of stored computer program instructions from a computer program 34 stored in the memory/storage 16.

The network node 10 may comprise a rack or cabinet of processing circuits using a
30 card/backplane arrangement and may include a host of additional processing circuits/functions not shown in the simplified diagram. More generally, the processing circuit 14 may comprise any one or more computer-based circuits that control at least communication-related processing—e.g., transmit and receive operations through the RF interface circuitry 30. Thus, the processing circuit 14 may include a number of other functional circuits not shown, such as user-

scheduling circuits to control uplink and/or downlink transmissions among a plurality of wireless devices 12 being supported by the network node 10, and may include one or more conditions-determination circuits, such as for determining network loading, e.g., for one or more served cells and/or one or more neighboring cells.

5 In a similar fashion, the wireless device 12 may be configured to operate according to any one or more wireless communication standards, such as the WCDMA and/or LTE and LTE-A standards. Broadly, the wireless device 12 may support more than one Radio Access Technology (RAT), such as may be used in heterogeneous network deployments involving macro cells and base stations and micro cells and base stations, where macro and micro base
10 stations may or may not use the same RAT(s). The transceiver circuitry 20 therefore may comprise one or more cellular radios, and is shown overlapping the processing circuit 26 to indicate that the receiver 22 and/or transmitter 24 may be implemented in a mix of analog and digital circuits, including baseband processing circuits comprising or otherwise included in the processing circuit 26. In one such example, the processing circuit 26 implements one or more
15 received signal processing chains that provide, for example, received signal linearization and/or interference compensation, symbol detection and corresponding decoding (Viterbi, joint detection, etc.), for the recovery of transmitted information.

A control circuit 36 is implemented within or as part of the processing circuit 26 of the wireless device and the memory/storage 28 in some embodiments stores one or more computer
20 programs 38 and/or configuration data. The control circuit 36 carries out device-side processing regarding PRB set expansion, as taught herein. In at least one embodiment, the control circuit 36 is implemented based on the execution of computer program instructions by the processing circuit 26, where the program instructions are stored as a computer program 38 in the storage/memory 28, for example.

25 It will be appreciated that references throughout the present disclosure to "one embodiment" or "an embodiment" mean that a particular feature, structure, or characteristic described in connection with an embodiment is included in at least one embodiment or aspect of the presently disclosed inventive techniques. Thus, the appearance of the phrases "in one embodiment" or "in an embodiment" in various places throughout the specification do not
30 necessarily all refer to the same embodiment. Further, the particular features, structures or characteristics may be combined in any suitable manner in one or more embodiments.

According to several embodiments of the presently disclosed techniques, solutions are provided for PUCCH resource determination for HARQ-ACK transmission in response to ePDCCH-scheduled PDSCH or ePDCCH-indicated SPS release in a TDD radio communication

system. Several different categories of embodiments are described below, which have different combinations of PUCCH blocking probability, PUCCH resource utilization efficiency, eNB scheduler complexity and implementation complexity. For convenience, these embodiments are described under headings of "Embodiment 1," "Embodiment 2," etc. However it should be appreciated by those skilled in the art that each of these categories may include several variations, that these embodiments are not necessarily mutually exclusive, and that various aspects of these embodiments can be used together.

The embodiments described below can fit into (be used in conjunction with) different FDD PUCCH HARQ-ACK resource allocation schemes for ePDCCH. To provide context for the described embodiments, the proposal for FDD PUCCH HARQ-ACK resource allocation described in a 3GPP submission numbered R1-123870 and entitled "PUCCH resource allocation for ePDCCH" for distributed ePDCCH is described below. (R1-123870 is available at http://www.3gpp.org/ftp/tsg_ran/wgl_rll/TSGRI_70/Docs/.) However those skilled in the art will appreciate that the presently disclosed embodiments are not limited to usage with this FDD resource allocation scheme and that, in fact, these TDD resource allocation schemes can be used with other FDD resource allocation schemes.

However, for context, the PUCCH resource in FDD mode is determined by $n_{PUCCH}^{(i)} = n_{eCCE} + N_{UE-PUCCH}^{(q)}$, where n_{eCCE} is the lowest eCCE index of the DCI detected on ePDCCH and $N_{UE-PUCCH}^{(q)}$ is a UE-specific offset, signaled to the UE by Radio Resource Control (RRC) signaling. It has been agreed by 3GPP that a UE can be configured with Q sets of N PRB pairs respectively, to be used for ePDCCH. Each set can have one of several different sizes, e.g., 2, 4, 8 PRB pairs. In the following, it is assumed for purposes of illustration that the UE is configured with three ePDCCH sets, and with four PRBs per set as shown in Figure 12. Each set of PRBs is configured with a PUCCH HARQ-ACK resource starting position $N_{UE-PUCCH}^{(q)}$, $q = 1, \dots, Q$, and the PRB pairs of each set are distributed across the frequency band, as shown in Figure 12, where diagonally-marked, shaded, and cross-hatched blocks are used to represent elements of sets 1, 2 and 3, respectively. As mentioned above, the proposed solutions described in detail below could be easily extended to any ePDCCH resource configurations and the example of Figure 12 (which is used as a baseline reference to describe the embodiments below) can be varied, e.g., to include more or fewer ePDCCH sets and/or more or fewer PRBs per set.

Embodiment 1

According to this embodiment and variants thereof, for PDSCH transmission indicated by the detection of corresponding ePDCCH or an ePDCCH indicating downlink SPS release within subframe $n - k_i$, where k_i belongs to a set of M elements $k_i \in \{k_1, k_2, \dots, k_{M-1}\}$ as defined in Table 10.1.3.1-1 of 3GPP TS 36.213, v10.6.0, the UE shall determine the PUCCH resource $n_{\text{PUCCH},i}^{(1)}$ so that the allocated PUCCH resources for a given subframe k follows the following rule:

$$n_{\text{PUCCH},i}^{(1)} = i \cdot N_q^{\text{eCCE}} + n_{\text{eCCE},i} + N_{\text{UE-PUCCH}}^{(q)} \quad (2)$$

where $n_{\text{eCCE},i}$, which is the lowest eCCE index of the DCI detected on ePDCCH, belongs to ePDCCH set q of subframe $n - k_i$, $0 \leq i \leq M - 1$. M is the number of elements in the set defined in Table 10.1.3.1-1, and N_q^{eCCE} is the number of eCCEs in ePDCCH set q . Note that although this and the following embodiments refer to the UE determining the relevant PUCCH HARQ resources, it will be understood by those skilled in the art that both the UE and its serving base station (e.g., eNB, or another network node connected thereto) will need to determine the relevant PUCCH HARQ resources for the connection between the UE and its serving base station so that, e.g., both nodes know which resource the UE/BS is using to be able to decode the ACK/NAK correctly. Accordingly, although other embodiments described below may not explicitly restate this, it shall be understood that each embodiment can be implemented in both the UE and the network side, e.g., base station.

Following equation (2) above, the PUCCH HARQ-ACK resource will be stacked across subframes for each ePDCCH set independently, as shown in Figure 13. Thus, for each ePDCCH set, the PUCCH ACK/NAK resource is stacked across the subframes sequentially, i.e., DCI messages belonging to subframe 0 first, followed by DCIs belonging to subframe 1...etc. Therein, each of the columns are associated with a different ePDCCH set (yellow(Y), blue(B) and red(R)) as indicated. An advantage of this alternative is simplicity and the resource utilization will be effective at low system load if the scheduler could always allocate DCI to the ePDCCH Set 1 with high priority. However, this solution increases the PUCCH HARQ-ACK blocking probability since it introduces additional PUCCH resource blocking among different subframes. This also makes the eNB scheduler more complicated.

Note that equation (2) assumes that there are an equal number of eCCEs per each subframe in the first i subframes of the M downlink subframes that are associated with uplink subframe n . This may not always be the case, in which case equation (2) may not always apply.

However, the sequential stacking of PUCCH HARQ-ACK resources, where resources for each of the Q ePDCCH set are stacked independently, as shown in Figure 13, may still be applied in cases where there is an unequal number of eCCEs across the subframes. The same advantages described above apply.

5 In an extension to the formula in equation (2), the PUCCH resources are compressed between the different sets q together with a varying M for the HARQ-ACK feedback in the uplink. In an embodiment, an HARQ-ACK compression scheme is introduced that compresses the HARQ-ACK PUCCH resources based on M . In a further example the compression scheme works by compressing the HARQ-ACK PUCCH resources between different sets q together. An
10 example of such a compression scheme is shown here by using eq. (2) as a base, resulting in equation (2a) below. However it is also possible to extend the other embodiments described below in a similar manner.

$$n_{\text{PUCCH},i}^{(1)} = i \cdot N_{q}^{\text{eCCE}} + n_{\text{eCCE},i} + N_{\text{SL-PUCCH}} - \sum_{q'=0}^{q-1} (M_{\text{max}} - M) \cdot N_{q'}^{\text{eCCE}} \quad (2a)$$

where the definitions for equation 2a are the same as in equation 2, with the addition that
15 $N_{q'}^{\text{eCCE}} = \max_i M_{\text{max}}$ is the maximum M over all possible HARQ-ACK feedback subframes for a given UL/DL configuration, as set forth according to table 10.1.3.1-1 in 3GPP TS 36.213, v10.6.0. For example, M_{max} can be 3 in the event that UL/DL configuration 3 is used.

Embodiment 2

20 According to this embodiment and variants thereof, for PDSCH transmission indicated by the detection of corresponding ePDCCH or an ePDCCH indicating downlink SPS release within subframe $n - k_i$, where k_i belongs to a set of M elements $k_i \in \{k_1, k_2, \dots, k_{M-1}\}$ as defined in Table 10.1.3.1-1 in 3GPP TS 36.213, v10.6.0, the UE shall determine the PUCCH resource
 $n_{\text{PUCCH},i,k}^{(1)}$ according to this embodiment as follows:

$$25 \quad n_{\text{PUCCH},i,q}^{(1)} = n_{\text{eCCE},i} + N_{\text{UE-PUCCH}}^{(0)} + i \cdot N_{\text{eCCE}}^{(q)} + \sum_{q'=-1}^{q-1} M \cdot N_{\text{eCCE}}^{(q')} \quad (3)$$

where $n_{\text{eCCE},i,k}$ belongs to ePDCCH set q of subframe $n - k_i$, $0 \leq i \leq M - 1$; M is the number of elements in the set defined in Table 10.1.3.1-1 in 3GPP TS 36.213, v10.6.0; $N_{\text{SL-PUCCH}}$ is a UE-specific offset parameter for the set with the lowest PUCCH resource starting position and $N_{\text{eCCE}}^{(q)}$ is the total amount of CCE in an set q' per subframe with $N_{\text{eCCE}}^{(-1)} = 0$. Following equation (3)
30 above, the PUCCH HARQ-ACK resource will be stacked across subframes after each other per

set q as shown in Figure 14. Thus, the PUCCH ACK/NAK resources according to this embodiment are stacked for each ePDCCH set, one by one. Starting from the set with the lowest PUCCH ACK/NAK starting position, the PUCCH ACK/NAK resources are stacked across the subframes sequentially, i.e., DCI messages belonging to subframe 0 first followed by DCIs belonging to subframe 1, etc. The set with second lowest PUCCH ACK/NAK starting position will be stacked beginning at the end of region for the first set, then the set with the third lowest PUCCH ACK/NAK starting position, etc. In Figure 14, each of the different ePDCCH sets is indicated by diagonally-marked, shaded, and cross-hatched blocks. An advantage with this embodiment is that a single parameter $N_{\text{PUCCH}}^{(3/4)}$ is able to provide unique PUCCH resources for all of the different sets at the same time. Thus, there will be no resource collisions among different sets, as well as no resource collisions between subframes.

Embodiment 3

In this third embodiment and variants thereof, the PUCCH resources from the corresponding ePDCCH are stacked first within one subframe for all sets. This is quite distinct from embodiment 2, where the PUCCH resources are stacked per all subframes within a set. Thus, for PDSCH transmission indicated by the detection of corresponding ePDCCH or an ePDCCH indicating downlink SPS release within subframe $n - k_i$, where k_i belongs to a set of M elements $k_i \in \{k_1, k_2, \dots, k_{M-1}\}$ as defined in Table 10.1.3.1-1 in 3GPP TS 36.213, v10.6.0, the UE shall determine the PUCCH resource $n_{\text{PUCCH},i}^{(1)}$ for this third embodiment as follows:

$$n_{\text{PUCCH},i}^{(1)} = i \cdot N_{\text{PUCCH}}^{\text{ePDCCH}} + n_{\text{eCCE},i} + N_{\text{UE-PUCCH}}^{(k)}, \quad (4)$$

where $n_{\text{eCCE},i}$ belongs to ePDCCH set q of subframe $n - k^i$ $0 \leq i \leq M - 1$; M is the number of elements in the set defined in Table 10.1.3.1-1 of 3GPP TS 36.213, v. 10.6.0; and $N_{\text{PUCCH}}^{\text{ePDCCH}}$ is the total number of PUCCH resources in all sets within one subframe. Following equation (4) above, the PUCCH HARQ-ACK resource in different subframes will not be overlapped as shown in the example of Figure 15, again with diagonally-marked blocks indicating subframes belonging to a first set, shaded blocks indicating subframes belonging to a second set and cross-hatched blocks indicating subframes belonging to a third set. Thus, according to this embodiment, the PUCCH ACK/NAK resources are stacked for each subframe sequentially. Starting from subframe 0, the PUCCH ACK/NAK resources are stacked separately for each set. Note that the size of the resource region within one subframe depends on the size of each ePDCCH set and the PUCCH starting position of each set. The PUCCH ACK/NAK resource for

subframe 1 starts from the end of resource region for subframe 0 in the same manner, then subframe 2 is after subframe 1, etc. $N_{\text{PUCCH}}^{\text{can}}$ can, for example, either be calculated by the UE based on all configured sets or signaled from the eNodeB. This solution also has low complexity. Compared to the first embodiment, there will be no resource collisions among different subframes but the resource utilization is relatively low, since the resources are reserved even when there is no user scheduled within a particular subframe.

Embodiment 4

According to this fourth embodiment and variants thereof, for PDSCH transmission indicated by the detection of corresponding ePDCCH or an ePDCCH indicating downlink SPS release within subframe $n - k_i$, where k_i belongs to a set of M elements $k_i \in \{k_1, k_2, \dots, k_{M-1}\}$ as defined in Table 10.1.3.1-1 in 3GPP TS 36.213, v10.6.0, the UE shall determine the PUCCH resource $n_{\text{PUCCH},i}^{(1)}$ according to this embodiment as follows:

$$n_{\text{PUCCH},i}^{(1)} = n_{\text{eCCE},i} + N_{\text{UE-PUCCH}}^{(i,q)}, \quad (5)$$

where $n_{\text{eCCE},i}$ belongs to ePDCCH set k of subframe $n - k^{\wedge}$ $0 \leq i \leq M - 1$. M is the number of elements in the set defined in Table 10.1.3.1-1, and $N_{\text{UE-PUCCH}}^{(i,q)}$ is the UE-specific PUCCH resource start position for ePDCCH set q for index i . This solution provides full flexibility to configure PUCCH HARQ-ACK regions for each subframe. On one hand, this gives the eNB full freedom to manage PUCCH HARQ-ACK resources. This embodiment can provide orthogonal resources for all sets in a cell, even if some UEs are only configured with a subset of them. The drawback of this embodiment is the additional signaling needed.

One example of the PUCCH resource configuration according to this embodiment is illustrated in Figure 16, again with diagonally-marked blocks indicating subframes belonging to a first set, shaded blocks indicating subframes belonging to a second set and cross-hatched blocks indicating subframes belonging to a third set. From Figure 16 it can be seen that, according to this embodiment, the PUCCH ACK/NAK resources for each subframe and each set are stacked completely independently from each other.

As a variant of this fourth embodiment, for PDSCH transmission indicated by the detection of corresponding ePDCCH or an ePDCCH indicating downlink SPS release within subframe $n - k_i$, where k_i belongs to a set of M elements $k_i \in \{k_1, k_2, \dots, k_{M-1}\}$ as defined in Table 10.1.3.1-1 in 3GPP TS 36.213, v10.6.0, the UE shall determine the PUCCH resource $n_{\text{PUCCH},i}^{(1)}$ according to this embodiment as follows:

$$n_{\text{PUCCH},i}^{(1)} = n_{\text{eCCE},i} + i \cdot N_{\text{UE-PUCCH-OFFSET}}^{(q)} + N_{\text{UE-PUCCH}}^{(q)}, \quad (6)$$

where $n_{\text{eCCE},i}$ belongs to ePDCCH set k of subframe $n - k$, $0 \leq i \leq M - 1$; M is the number of elements in the set defined in Table 10.1.3.1-1; $N_{\text{UE-PUCCH}}^{(q)}$ is the UE-specific PUCCH resource start position for ePDCCH set q ; and $N_{\text{UE-PUCCH-OFFSET}}^{(q)}$ is the UE-specific offset value for set q .

- 5 This embodiment has less flexibility than embodiment 3, but with lower signaling overhead. This embodiment can provide orthogonal resources for all sets in a cell even if some UEs are only configured with a subset of them. If $N_{\text{UE-PUCCH-OFFSET}}^{(q)}$ is the same for all sets, then this becomes the same as embodiment 2, with a configured $N_{\text{PUCCH}}^{(q)}$.

10 Fifth Embodiment

According to this fifth embodiment and variants thereof, for PDSCH transmission indicated by the detection of corresponding ePDCCH or an ePDCCH indicating downlink SPS release within subframe $n - k_i$, where k_i belongs to a set of M elements $k_i \in \{k_1, k_2, \dots, k_{M-1}\}$ as defined in Table 10.1.3.1-1 in 3GPP TS 36.213, v10.6.0, the UE shall determine the PUCCH

- 15 resource $n_{\text{PUCCH},i}^{(1)}$ as follows:

$$n_{\text{PUCCH},i}^{(1)} = (M - m - 1) \cdot \sum_{j=0, j \in V_c}^c (N_C^{\text{eCCE}}(j) - N_C^{\text{eCCE}}(j-1)) + m \cdot \sum_{j=0, j \in V_c}^c (N_C^{\text{eCCE}}(j+1) - N_C^{\text{eCCE}}(j)) + n_{\text{eCCE},i} + N_{\text{UE-PUCCH}}^{(q)} \quad (7)$$

where $n_{\text{eCCE},i}$ belongs to ePDCCH set q of subframe $n - k_i$, $0 \leq i \leq M - 1$; and M is the number of elements in the set defined in Table 10.1.3.1-1. In this embodiment, the UE first selects a c out of $\{0, 1, 2, \dots, 2Q\}$, where the selected c makes $N_C^{\text{eCCE}}(c) \leq (n_{\text{eCCE},i} + N_{\text{UE-PUCCH}}^{(q)}) < N_C^{\text{eCCE}}(c+1)$,

- 20 where $N_C^{\text{eCCE}} = \text{sort}(N_{\text{UE-PUCCH}}^{(0)}, N_{\text{UE-PUCCH}}^{(0)} + N_0^{\text{eCCE}}, \dots, N_{\text{UE-PUCCH}}^{(Q)}, N_{\text{UE-PUCCH}}^{(Q)} + N_Q^{\text{eCCE}})$, the function sortQ is with increasing order, $N_C^{\text{eCCE}}(-1) = N_C^{\text{eCCE}}(0)$, V_c is a set of c which satisfies the

following condition $V_c = \left\{ c \left| \left[N_C^{\text{eCCE}}(c), N_C^{\text{eCCE}}(c+1) \right] \in \left[N_{\text{PUCCH}}^{(q)}, N_{\text{PUCCH}}^{(q)} + N_q^{\text{eCCE}} \right] \right\}$. This

- solution has relatively high complexity but has the advantage of high resource utilization efficiency. One example of the PUCCH resource configuration according to this embodiment is illustrated in Figure 17. Thus, according to this embodiment, based on the PUCCH ACK/NAK resources starting position and the size of resource region for each ePDCCH set, the whole PUCCH ACK/NAK region is first divided into multiple non-overlapping subregions in an

increasing order. For example, starting from the first subregion, the PUCCH ACK/NAK resources are stacked across subframes, i.e., DCI messages belonging to (subframe 0, subregion 0) followed by DCIs belonging to (subframe 1, subregion 0), then DCIs belonging to (subframe 2, subregion 0), etc. Then for the second subregion, the PUCCH ACK/NAK resources are stacked in the same manner from the end of first subregion. The same principles are then applied for the rest of the subregions.

Embodiments 6-10

As an additional variation of any of the previously described embodiments 1-5, an additional correction term can be added to the resource calculation. This term relates to the size of the legacy PDCCH region. Such alternative embodiments result in the PUCCH resource that is used being scaled by the size of the PDCCH region in all the subframes that are part of the HARQ-ACK window. It is further possible to foresee that the number of PDCCH resources may be approximately derived and not be exactly the number that is derived.

This modification is exemplified in equation (8) below, using embodiment 1, but the same modification can be applied to any embodiment described herein. With this extension the

UE shall determine the PUCCH resource $n_{\text{PUCCH},i}^m$ as follows:

$$n_{\text{PUCCH},i}^{(1)} = i \cdot N_q^{\text{CCE}} + n_{\text{eCCE},i} + N_{\text{UE-PUCCH}}^{(q)} + (M - 1) * N^{\text{CCE}}, \quad (8)$$

where N^{CCE} is the maximum number of CCEs available on the legacy PDCCH in a subframe. In a more general formulation the UE shall determine the PUCCH resource $n_{\text{PUCCH},i}^{(1)}$ as follows:

$$n_{\text{PUCCH},i}^{(1)} = i \cdot N_k^{\text{CCE}} + n_{\text{eCCE},i} + N_{\text{UE-PUCCH}}^{(k)} + \sum_{j=1}^{M-1} N_j^{\text{CCE}}, \quad (9)$$

where N_j^{CCE} is the largest number of available CCEs on the legacy PDCCH in subframe $n - k_j$.

In other embodiments the sum may instead go from $j = 0$.

Among other things, the foregoing embodiments provide several solutions for PUCCH resource determination for HARQ-ACK transmission in response to ePDCCH-scheduled PDSCH or ePDCCH-indicated SPS release in a TDD system. These embodiments offer different alternatives with tradeoffs among, for example, PUCCH blocking probability, PUCCH resource utilization efficiency, eNB scheduler complexity and implementation complexity.

From the foregoing discussion of various exemplary embodiments, it will be appreciated that these and other embodiments will, when implemented, have impacts on various nodes in a radio communication system. For example, the various PUCCH resource determination schemes for HARQ-ACK transmission in response to ePDCCH-scheduled PDSCH or ePDCCH-indicated

SPS release in a TDD system described above may need to be implemented at both a network side node (e.g., eNB) and at the user equipment.

Figure 18 illustrates a non-limiting example embodiment of a processing method 1800, which corresponds to the above-described processing for the wireless device 12, for at least
 5 embodiment 1. The method 1800 is directed to a technique for determining the resources for transmitting hybrid automatic-repeat-request (HARQ) feedback in a wireless communication network configured for time-division duplexing (TDD) operation. The method begins, as shown at block 1810, with receiving downlink control information (DCI) via an Enhanced Physical Downlink Control Channel (ePDCCH) in a downlink subframe. The received ePDCCH
 10 schedules a downlink shared channel transmission to the wireless device or indicates a release of semi-persistent scheduling (SPS) to the wireless device.

As shown at block 1820, the method continues with determining a resource index for a Physical Uplink Control Channel (PUCCH) resource based on the lowest enhanced Control Channel Element (eCCE) index of the received DCI, a device-specific offset value previously
 15 signaled to the wireless device via Radio Resource Control (RRC) signaling, and an index i . The index i identifies the downlink subframe in a pre-determined set of one or more downlink subframes associated with an uplink subframe. The determining of the PUCCH resource is performed according to a formula that results in a sequential allocation of PUCCH resources in the uplink subframe with respect to the downlink subframes associated with the uplink subframe,
 20 for each of a plurality of sets of ePDCCH resources. As shown at block 1830, the method continues with the transmitting of HARQ feedback in the uplink subframe, using a PUCCH resource that corresponds to the resource index.

In some embodiments, such as those described above under the heading "Embodiment 1," determining the resource index for the PUCCH resource comprises determining the resource
 25 index based on the sum of (i) the lowest enhanced eCCE of the received DCI, (ii) the device-specific offset value previously signaled to the wireless device via RRC signaling, and (iii) the product of the index i and the number of eCCEs in a set of ePDCCH resources that includes those ePDCCH resources used by the received ePDCCH. In some of these embodiments, determining the resource index comprises calculating the resource index according to equation
 30 (2), as set forth above.

As noted earlier, the operations carried out by a wireless device 12 in determining the PUCCH resource and transmitting HARQ feedback in that resource are complemented by corresponding operations in a network node 10, e.g., an LTE eNB, in determining the PUCCH resource used by the wireless device 12 and receiving the HARQ feedback in that resource.

Figure 19 thus illustrates a non-limiting example embodiment of a processing method 1900, which corresponds to this processing for a network node 10, for at least embodiment 1. Method 1900 is thus generally directed to a technique for determining the resources for receiving hybrid automatic-repeat-request (HARQ) feedback in a wireless communication network configured for time-division duplexing (TDD) operation. The method begins, as shown at block 1910, with transmitting downlink control information (DCI) to a wireless device, via an Enhanced Physical Downlink Control Channel (ePDCCH) in a downlink subframe. The transmitted ePDCCH schedules a downlink shared channel transmission to the wireless device or indicates a release of semi-persistent scheduling (SPS) to the wireless device.

As shown at block 1920, the method continues with determining a resource index for a Physical Uplink Control Channel (PUCCH) resource based on the lowest enhanced Control Channel Element (eCCE) index of the transmitted DCI, a device-specific offset value previously signaled to the wireless device via Radio Resource Control (RRC) signaling, and an index i . The index i identifies the downlink subframe in a pre-determined set of one or more downlink subframes associated with an uplink subframe. The determining of the PUCCH resource is performed according to a formula that results in a sequential allocation of PUCCH resources in the uplink subframe with respect to the downlink subframes associated with the uplink subframe, for each of a plurality of sets of ePDCCH resources. As shown at block 1910, the method continues with the receiving of HARQ feedback in the uplink subframe, using a PUCCH resource that corresponds to the resource index.

In some embodiments, such as those described above under the heading "Embodiment 1," determining the resource index for the PUCCH resource comprises determining the resource index based on the sum of (i) the lowest enhanced eCCE of the transmitted DCI, (ii) the device-specific offset value previously signaled to the wireless device via RRC signaling, and (iii) the product of the index i and the number of eCCEs in a set of ePDCCH resources that includes those ePDCCH resources used by the transmitted ePDCCH. In some of these embodiments, determining the resource index comprises calculating the resource index according to equation (2), as set forth above.

With the above examples in mind, it should be clear that the teachings herein provide several solutions for PUCCH resource determination for HARQ-ACK transmission in response to ePDCCH-scheduled PDSCH or ePDCCH-indicated SPS release in a TDD system. The different alternatives provide different tradeoffs among PUCCH blocking probability, PUCCH resource utilization efficiency, eNB scheduler complexity and implementation complexity.

It will be appreciated by the person of skill in the art that various modifications may be made to the above described embodiments without departing from the scope of the present invention. The specific embodiments described above should therefore be considered exemplary rather than limiting the scope of the invention. Because it is not possible, of course, to describe every conceivable combination of components or techniques, those skilled in the art will appreciate that the present invention can be implemented in other ways than those specifically set forth herein, without departing from essential characteristics of the invention. The present embodiments are thus to be considered in all respects as illustrative and not restrictive.

It will be understood that although the terms first, second, third, etc. may be used herein to describe various elements/operations, these elements/operations should not be limited by these terms. These terms are only used to distinguish one element/operation from another element/operation. Thus a first element/operation in some embodiments could be termed a second element/operation in other embodiments without departing from the teachings of present inventive concepts. The same reference numerals or the same reference designators denote the same or similar elements throughout the specification.

As used herein, the terms "comprise", "comprising", "comprises", "include", "including", "includes", "have", "has", "having", or variants thereof are open-ended, and include one or more stated features, integers, elements, steps, components or functions but does not preclude the presence or addition of one or more other features, integers, elements, steps, components, functions or groups thereof.

Example embodiments are described herein with reference to block diagrams and/or flowchart illustrations of computer-implemented methods, apparatus (systems and/or devices) and/or computer program products. It is understood that a block of the block diagrams and/or flowchart illustrations, and combinations of blocks in the block diagrams and/or flowchart illustrations, can be implemented by computer program instructions that are performed by one or more computer circuits. These computer program instructions may be provided to a processor circuit of a general purpose computer circuit, special purpose computer circuit, and/or other programmable data processing circuit to produce a machine, such that the instructions, which execute via the processor of the computer and/or other programmable data processing apparatus, transform and control transistors, values stored in memory locations, and other hardware components within such circuitry to implement the functions/acts specified in the block diagrams and/or flowchart block or blocks, and thereby create means (functionality) and/or structure for implementing the functions/acts specified in the block diagrams and/or flowchart block(s).

These computer program instructions may also be stored in a tangible computer-readable medium that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable medium produce an article of manufacture including instructions which implement the functions/acts specified in the block diagrams and/or flowchart block or blocks. Accordingly, embodiments of present inventive concepts may be embodied in hardware and/or in software (including firmware, resident software, micro-code, etc.) running on a processor such as a digital signal processor, which may collectively be referred to as "circuitry," "a module" or variants thereof.

It should also be noted that in some alternate implementations, the functions/acts noted in the blocks may occur out of the order noted in the flowcharts. For example, two blocks shown in succession may in fact be executed substantially concurrently or the blocks may sometimes be executed in the reverse order, depending upon the functionality/acts involved. Moreover, the functionality of a given block of the flowcharts and/or block diagrams may be separated into multiple blocks and/or the functionality of two or more blocks of the flowcharts and/or block diagrams may be at least partially integrated. Finally, other blocks may be added/inserted between the blocks that are illustrated, and/or blocks/operations may be omitted without departing from the scope of inventive concepts. Moreover, although some of the diagrams include arrows on communication paths to show a primary direction of communication, it is to be understood that communication may occur in the opposite direction to the depicted arrows.

Many variations and modifications can be made to the embodiments without substantially departing from the principles of the present inventive concepts. All such variations and modifications are intended to be included herein within the scope of present inventive concepts. Thus, to the maximum extent allowed by law, the scope of present inventive concepts are to be determined by the broadest permissible interpretation of the present disclosure, and shall not be restricted or limited by the foregoing detailed description.

CLAIMS

What is claimed is:

1. A method (1800) in a wireless device (12) operating in a wireless communication network (50) configured for time-division duplexing, TDD, operation, said method including receiving (1810) downlink control information, DCI, via an Enhanced Physical Downlink Control Channel, ePDCCH, in a downlink subframe, the received ePDCCH scheduling a downlink shared channel transmission to the wireless device (12) or indicating a release of semi-persistent scheduling, SPS, to the wireless device, characterized in that the method further comprises:
 - determining (1820) a resource index for a Physical Uplink Control Channel, PUCCH, resource based on the lowest enhanced Control Channel Element, eCCE, index of the received DCI, a device-specific offset value previously signaled to the wireless device via Radio Resource Control, RRC, signaling, and an index i , wherein the index i identifies the downlink subframe in a pre-determined set of one or more downlink subframes associated with an uplink subframe, wherein said determining is according to a formula that results in a sequential allocation of PUCCH resources in the uplink subframe with respect to the downlink subframes associated with the uplink subframe, for each of a plurality of sets of ePDCCH resources; and
 - transmitting (1830) hybrid automatic-repeat-request, HARQ, feedback in the uplink subframe, using a PUCCH resource corresponding to the resource index.
2. The method of claim 1, wherein determining (1820) the resource index for the PUCCH resource comprises determining the resource index based on the sum of (i) the lowest enhanced eCCE of the received DCI, (ii) the device-specific offset value previously signaled to the wireless device via RRC signaling, and (iii) the product of the index i and the number of eCCEs in a set of ePDCCH resources that includes those ePDCCH resources used by the received ePDCCH.
3. The method of claim 2, wherein the set of ePDCCH resources is set q of a plurality of sets of ePDCCH resources, wherein the uplink subframe is subframe n and the downlink subframe is subframe $n-k_i$, where k_i is the i -th element in the pre-determined set of downlink subframes associated with subframe n , the pre-determined set comprising M elements indexed according to k_0, k_1, \dots, k_{M-1} , and wherein determining the resource index comprises calculating:

$$n_{\text{PUCCH},i}^m = i \cdot N_q^{\text{eCCE}} + n_{\text{eCCE},i}^{\text{offset}} + n_{\text{UE-PUCCH}}^{(q)},$$

where $n_{eCCE,i}$ is the lowest eCCE index of the received DCI and N_q^{eCCE} is the number of eCCEs in ePDCCH set q , wherein the resource index is derived from $n_{PUCCH}^{(1)}$.

4. A wireless device (12) configured for operation in a wireless communication network (50) and comprising

a communication interface (20) configured for communicating with one or more network nodes (10) in the wireless communication network (50) and adapted to receive downlink control information, DCI, via an Enhanced Physical Downlink Control Channel, ePDCCH, in a downlink subframe, the received ePDCCH scheduling a downlink shared channel transmission to the wireless device (12) or indicating a release of semi-persistent scheduling, SPS, to the wireless device, and one or more processing circuits (26) configured to control the communication interface (20),

characterized in that the processing circuits (26) are adapted to:

determine a resource index for a Physical Uplink Control Channel, PUCCH, resource based on the lowest enhanced Control Channel Element, eCCE, index of the received DCI, a device-specific offset value previously signaled to the wireless device via Radio Resource Control, RRC, signaling, and an index i , wherein the index i identifies the downlink subframe in a pre-determined set of one or more downlink subframes associated with an uplink subframe, wherein said determining is according to a formula that results in a sequential allocation of PUCCH resources in the uplink subframe with respect to the downlink subframes associated with the uplink subframe, for each of a plurality of sets of ePDCCH resources; and

control the communication interface (20) to transmit hybrid automatic-repeat-request, HARQ, feedback in the uplink subframe, using a PUCCH resource corresponding to the resource index.

5. The wireless device (12) of claim 4, wherein the processing circuit is configured to determine the resource index for the PUCCH resource based on the sum of (i) the lowest enhanced eCCE of the received DCI, (ii) the device-specific offset value previously signaled to the wireless device via RRC signaling, and (iii) the product of the index i and the number of eCCEs in a set of ePDCCH resources that includes those ePDCCH resources used by the received ePDCCH.

6. The wireless device (12) of claim 5, wherein the set of ePDCCH resources is set q of a plurality of sets of ePDCCH resources, wherein the uplink subframe is subframe n and the downlink subframe is subframe $n-k_i$, where k_i is the i -th element in the pre-determined set of downlink subframes associated with subframe n , the pre-determined set comprising M elements indexed according to k_0, k_1, \dots, k_{M-1} , and wherein determining the resource index comprises calculating:

$$n_{\text{PUCCH},i}^m = i \cdot N_q^{\text{eCCE}} + n_{\text{eCCE},i} + \Delta_{\text{UE-PUCCH}}^{(q)},$$

where $n_{\text{eCCE},i}$ is the lowest eCCE index of the received DCI and N_q^{eCCE} is the number of eCCEs in ePDCCH set q , wherein the resource index is derived from $n_{\text{PUCCH},i}^{(1)}$.

7. A method (1900) in a network node (10) operating in a wireless communication network (50) configured for time-division duplexing, TDD, operation, said method including transmitting (1910) downlink control information, DCI, to a wireless device (12) via an Enhanced Physical Downlink Control Channel, ePDCCH, in a downlink subframe, the transmitted ePDCCH scheduling a downlink shared channel transmission to the wireless device (12) or indicating a release of semi-persistent scheduling, SPS, to the wireless device, characterized in that the method further comprises:

determining (1920) a resource index for a Physical Uplink Control Channel, PUCCH, resource based on the lowest enhanced Control Channel Element, eCCE, index of the received DCI, a device-specific offset value previously signaled to the wireless device via Radio Resource Control, RRC, signaling, and an index i , wherein the index i identifies the downlink subframe in a pre-determined set of one or more downlink subframes associated with an uplink subframe, wherein said determining is according to a formula that results in a sequential allocation of PUCCH resources in the uplink subframe with respect to the downlink subframes associated with the uplink subframe, for each of a plurality of sets of ePDCCH resources; and

receiving (1930) hybrid automatic-repeat-request, HARQ, feedback from the wireless device (12) in the uplink subframe, using a PUCCH resource corresponding to the resource index.

8. The method of claim 7, wherein determining (1920) the resource index for the PUCCH resource comprises determining the resource index based on the sum of (i) the lowest enhanced

eCCE of the transmitted DCI, (ii) the device-specific offset value previously signaled to the wireless device via RRC signaling, and (iii) the product of the index i and the number of eCCEs in a set of ePDCCH resources that includes those ePDCCH resources used by the transmitted ePDCCH.

9. The method of claim 8, wherein the set of ePDCCH resources is set q of a plurality of sets of ePDCCH resources, wherein the uplink subframe is subframe n and the downlink subframe is subframe $n-k_i$, where k_i is the i -th element in the pre-determined set of downlink subframes associated with subframe n , the pre-determined set comprising M elements indexed according to k_0, k_1, \dots, k_{M-1} , and wherein determining the resource index comprises calculating:

$$n_{\text{PUCCH},i}^m = i \cdot N_q^{\text{eCCE}} + n_{\text{eCCE},i} + \hat{v}_{\text{UE-PUCCH}}^{(q)},$$

where $n_{\text{eCCE},i}$ is the lowest eCCE index of the received DCI and N_q^{eCCE} is the number of eCCEs in ePDCCH set q , wherein the resource index is derived from $n_{\text{PUCCH},i}^{(1)}$.

10. A network node (10) configured for operation in a wireless communication network (50) and comprising

a communication interface (18) configured for communicating with one or more wireless devices (12) in the wireless communication network (50) and adapted to transmit downlink control information, DCI, to a wireless device (12) via an Enhanced Physical Downlink Control Channel, ePDCCH, in a downlink subframe, the transmitted ePDCCH scheduling a downlink shared channel transmission to the wireless device (12) or indicating a release of semi-persistent scheduling, SPS, to the wireless device (12), and

one or more processing circuits (14) configured to control the communication interface (18),

characterized in that the processing circuits (14) are adapted to:

determine a resource index for a Physical Uplink Control Channel, PUCCH, resource based on the lowest enhanced Control Channel Element, eCCE, index of the transmitted DCI, a device-specific offset value previously signaled to the wireless device via Radio Resource Control, RRC, signaling, and an index i , wherein the index i identifies the downlink subframe in a pre-determined set of one or more downlink subframes associated with an uplink subframe, wherein said determining is according to a formula that results in a sequential allocation of

PUCCH resources in the uplink subframe with respect to the downlink subframes associated with the uplink subframe, for each of a plurality of sets of ePDCCH resources; and,

using the communication interface (18), receive hybrid automatic-repeat-request, HARQ, feedback in the uplink subframe, using a PUCCH resource corresponding to the resource index.

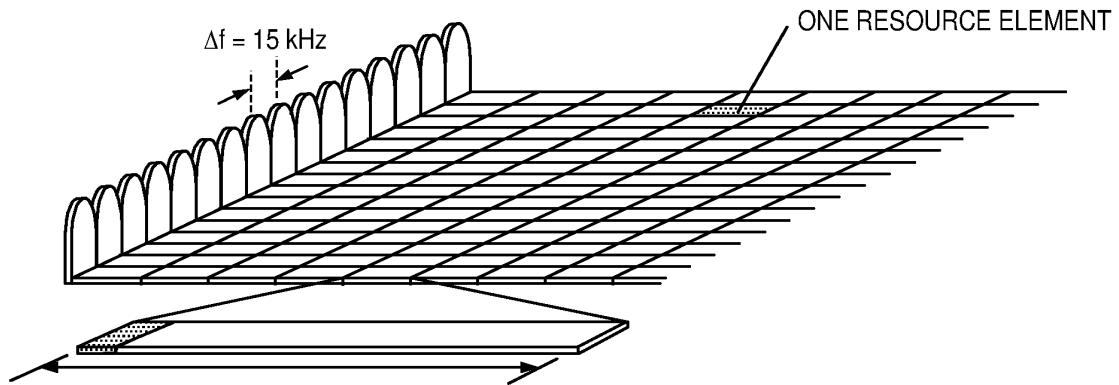
11. The network node (10) of claim 10, wherein the processing circuit is configured to determine the resource index for the PUCCH resource based on the sum of (i) the lowest enhanced eCCE of the received DCI, (ii) the device-specific offset value previously signaled to the wireless device via RRC signaling, and (iii) the product of the index i and the number of eCCEs in a set of ePDCCH resources that includes those ePDCCH resources used by the transmitted ePDCCH.

12. The network node (10) of claim 11, wherein the set of ePDCCH resources is set q of a plurality of sets of ePDCCH resources, wherein the uplink subframe is subframe n and the downlink subframe is subframe $n-k_i$, where k_i is the i -th element in the pre-determined set of downlink subframes associated with subframe n , the pre-determined set comprising M elements indexed according to k_0, k_1, \dots, k_{M-1} , and wherein determining the resource index comprises calculating:

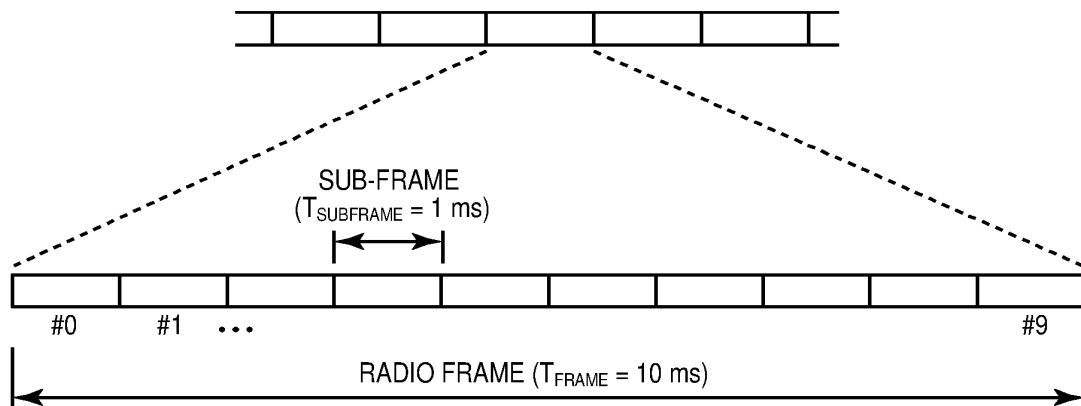
$$n_{\text{PUCCH},i}^m = i \cdot N_q^{\text{eCCE}} + n_{\text{eCCE},i} + \hat{n}_{\text{UE-PUCCH}}^{(q)},$$

where $n_{\text{eCCE},i}$ is the lowest eCCE index of the received DCI and N_q^{eCCE} is the number of eCCEs in ePDCCH set q , wherein the resource index is derived from $n_{\text{PUCCH},i}^{(1)}$.

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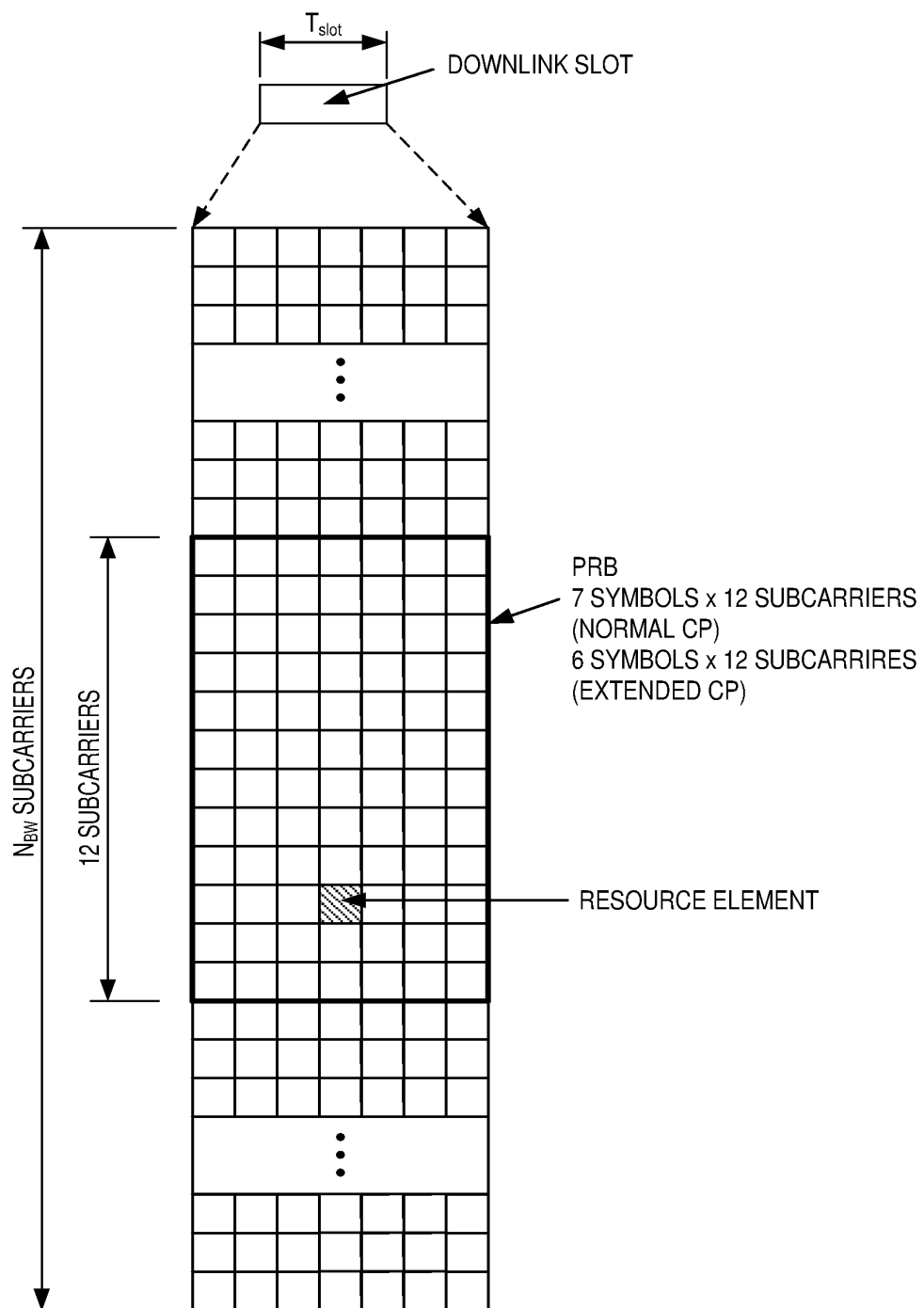


PRIOR ART
FIG. 1

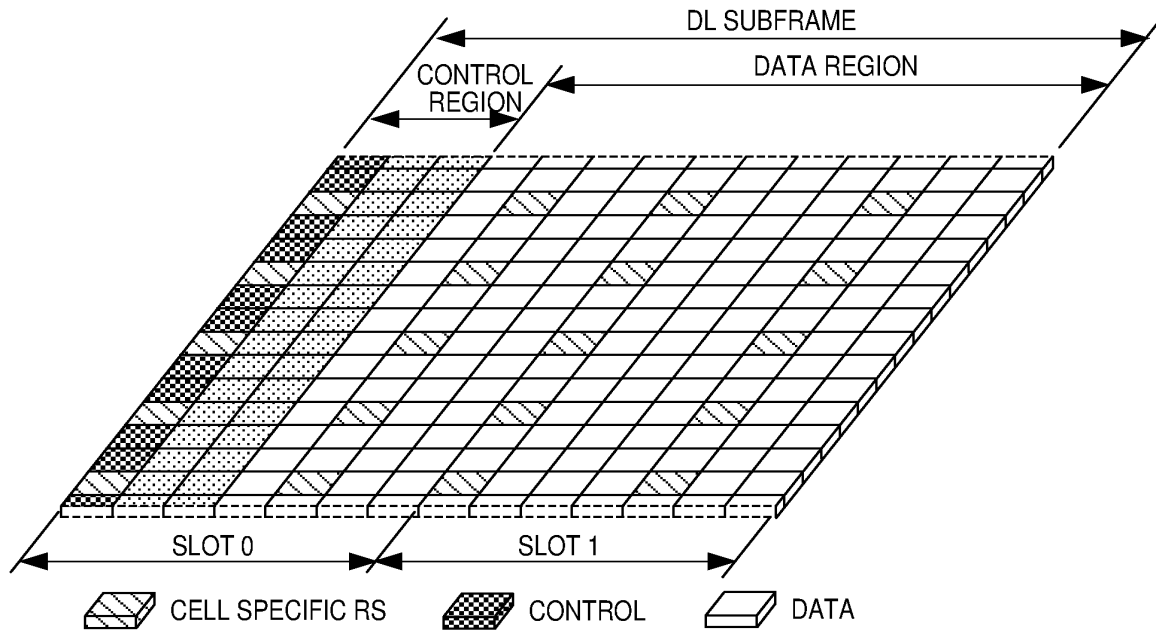


PRIOR ART
FIG. 2

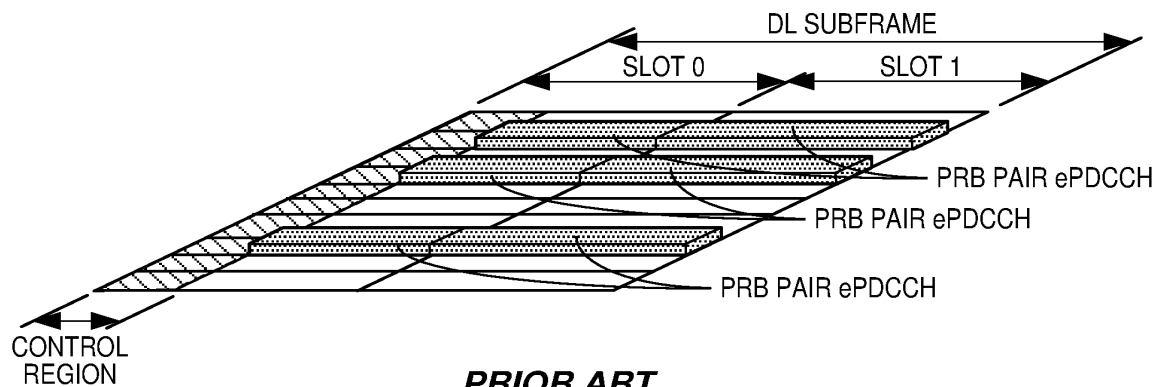
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**FIG. 3**

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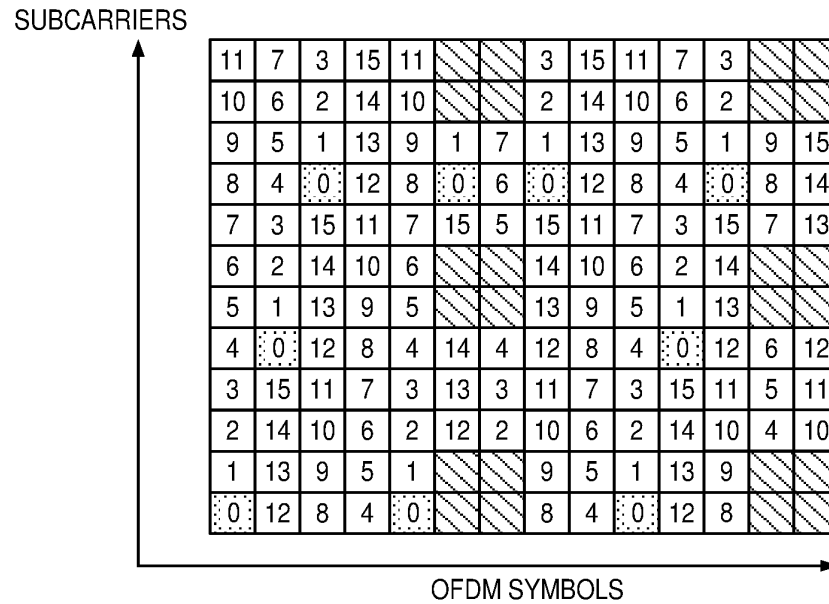


PRIOR ART
FIG. 4

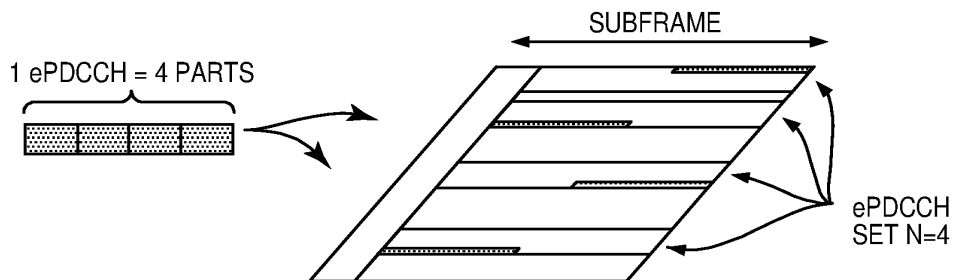


PRIOR ART
FIG. 5

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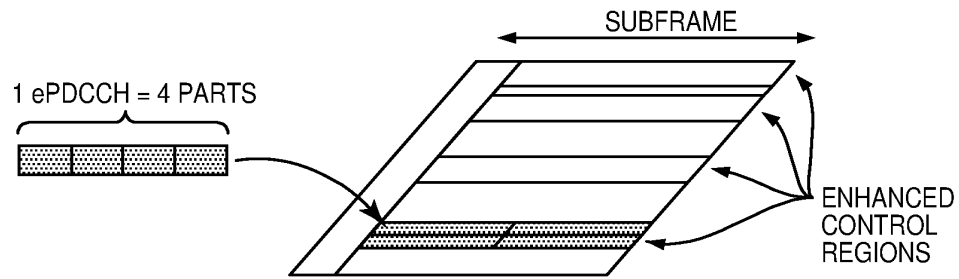


PRIOR ART
FIG. 6



PRIOR ART
FIG. 7A

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PRIOR ART
FIG. 7B

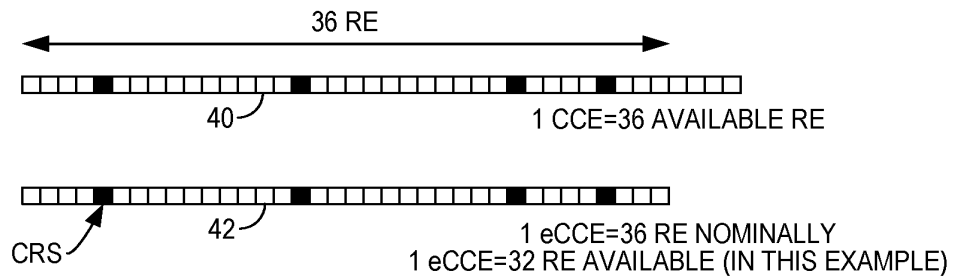


FIG. 8

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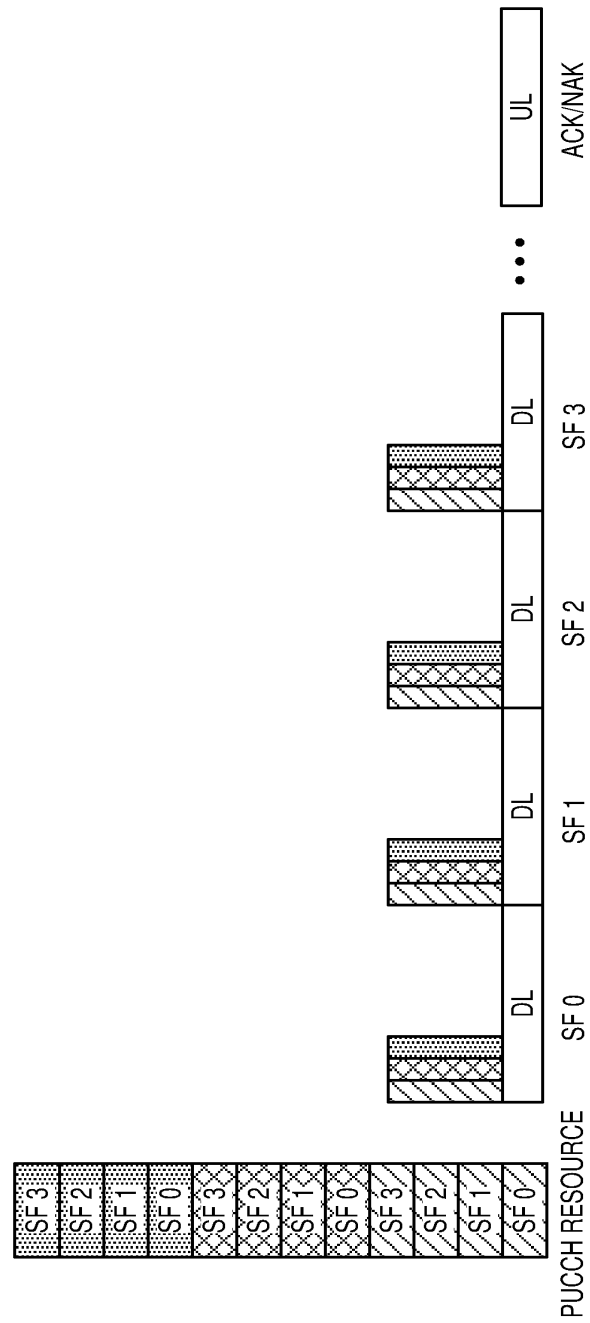


FIG. 9

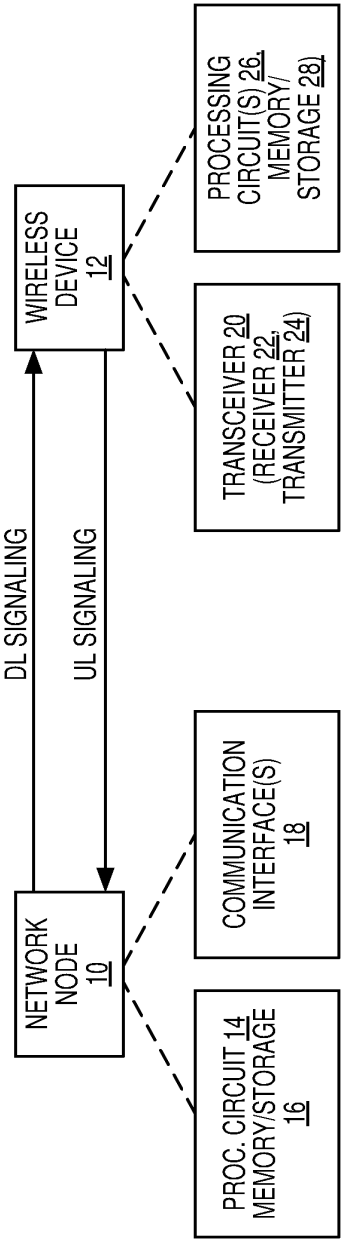
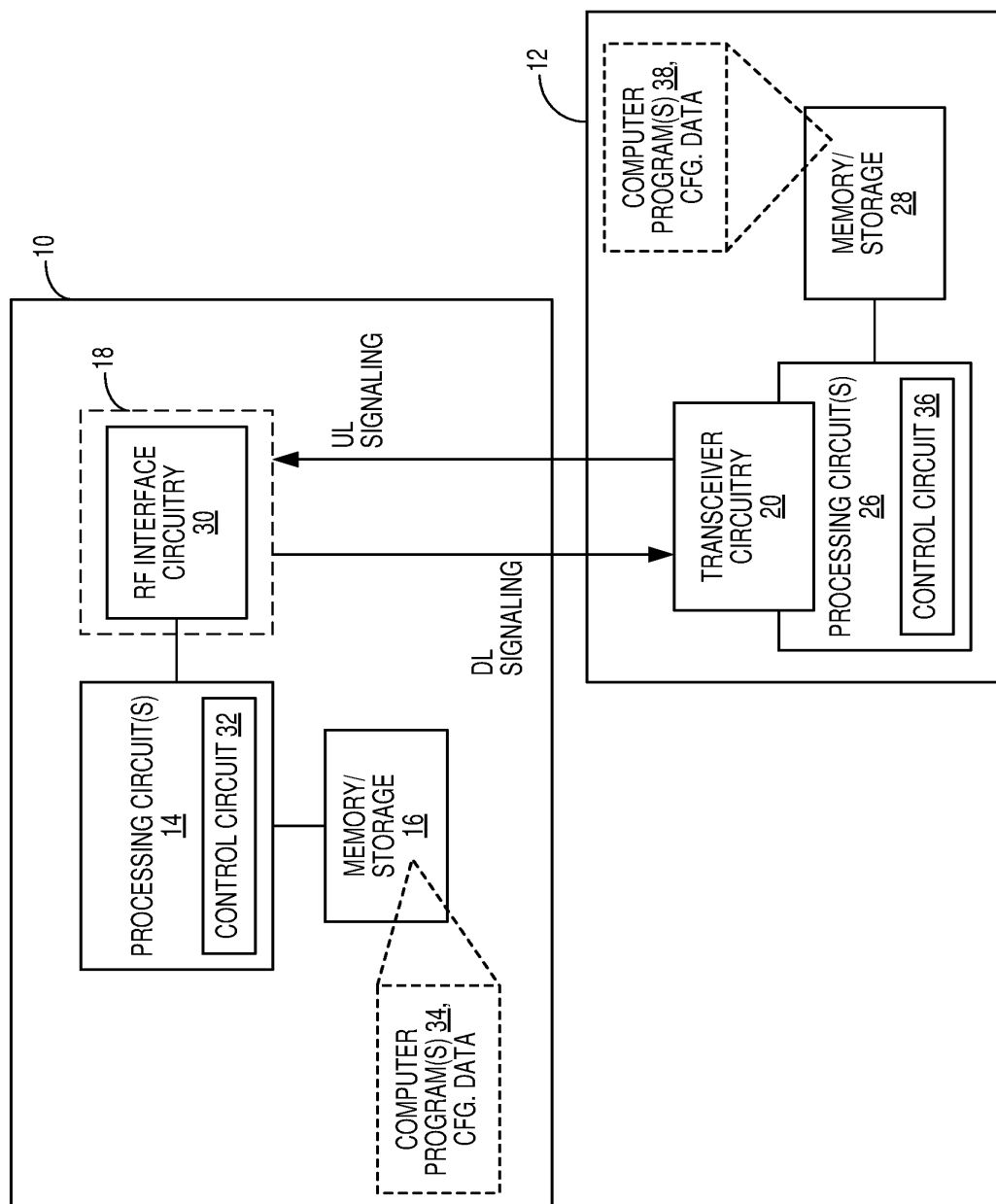


FIG. 10

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**FIG. 11**

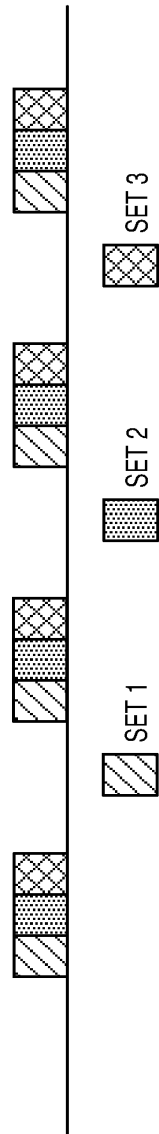
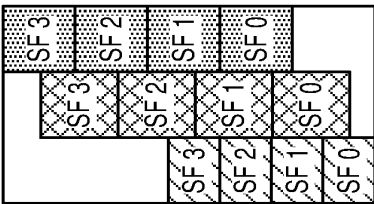


FIG. 12



PUCCH RESOURCE

FIG. 13

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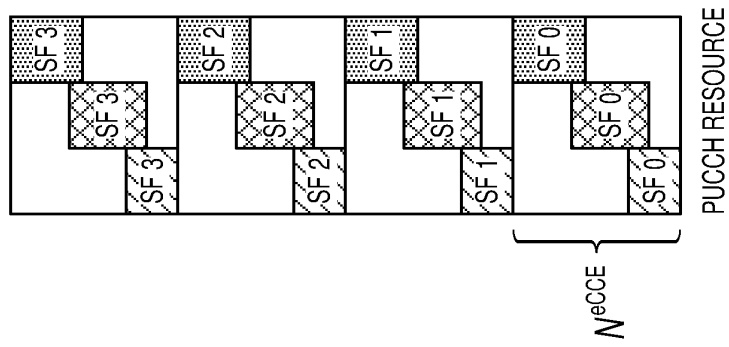


FIG. 15

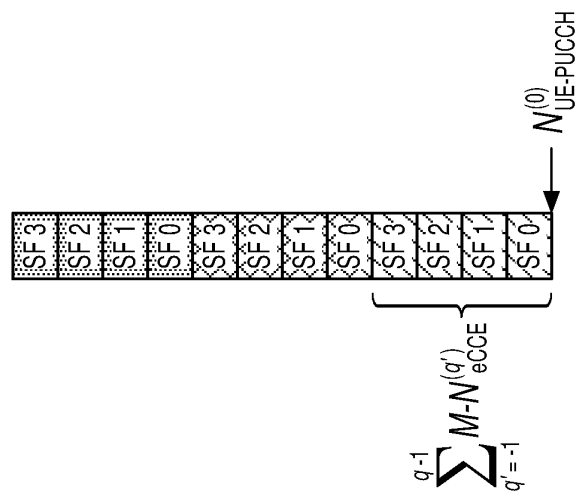


FIG. 14

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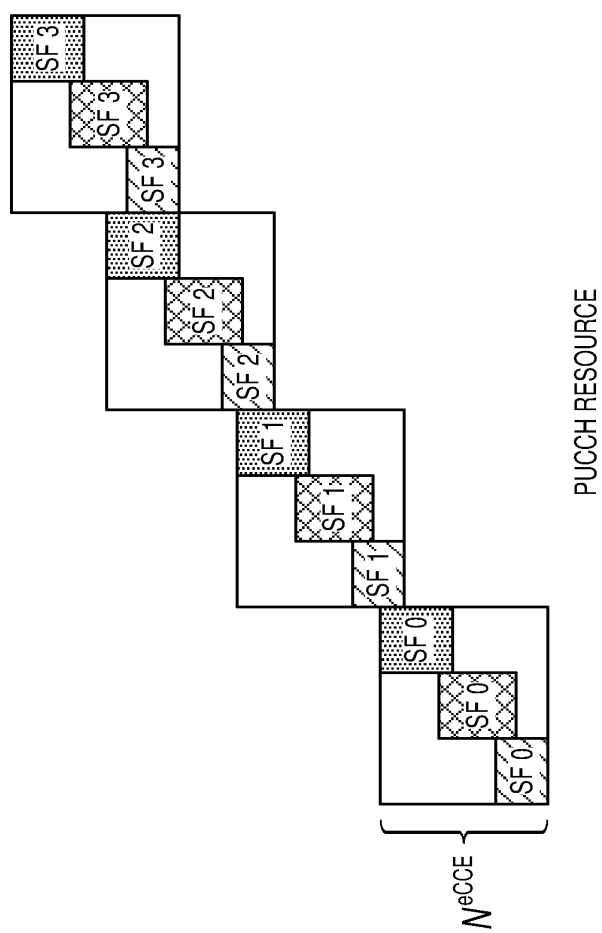
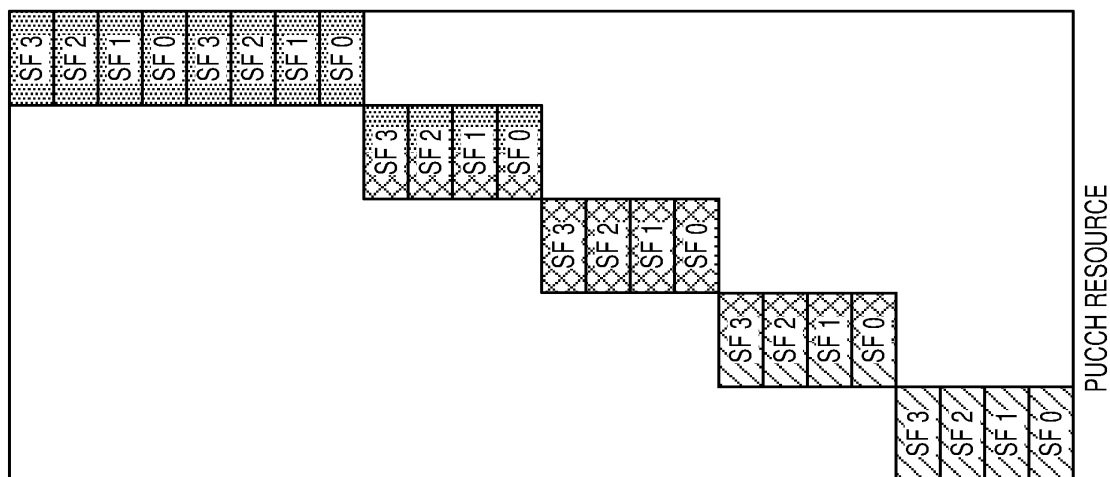


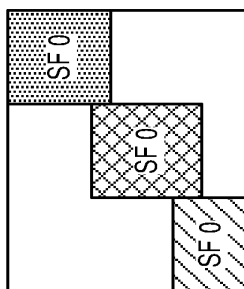
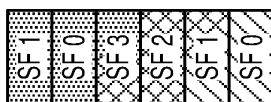
FIG. 16

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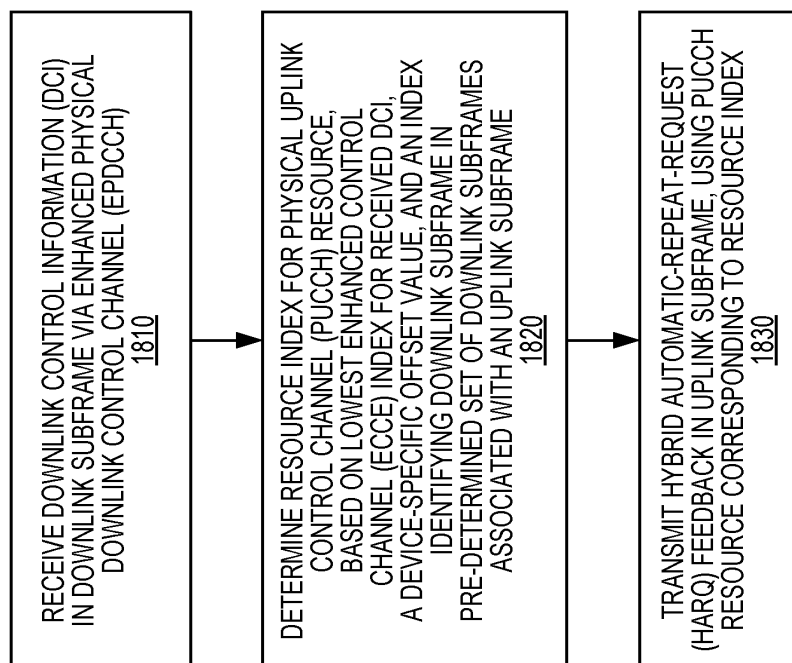


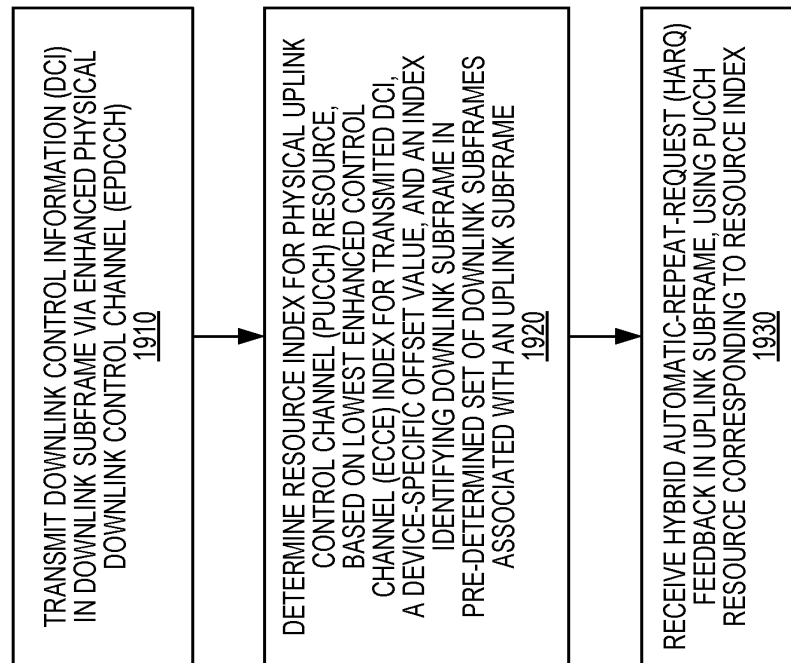
PUCCH RESOURCE

FIG. 17



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**FIG. 18**

**FIG. 19**

INTERNATIONAL SEARCH REPORT

International application No

PCT/SE2013/051116

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W72/12 H04L5/00 H04L1/16 H04L1/18
ADD.

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)

H04W 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 practicable, search terms used)

EPO-Internal , WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2011/243039 AI (PAPASAKELLARIOU ARIS [US] ET AL) 6 October 2011 (2011-10-06)	1,2,4,5 , 7,8, 10, 11
A	paragraphs [0022] , [0023] , [0027] , [0097] , [0098] , [0103] - [0106] -----	3,6,9 , 12
X	CATT: "RI-123227 PUCCH resource for E-PDCCH" 3GPP TSG RAN WGI Meeting #70 5 August 2012 (2012-08-05) , XP002719254, Retrieved from the Internet: URL: www.3gpp.org/ftp/TSG_RAN/WGI_RLI/TSGRI 70/Docs/RI-123227 .zip [retrieved on 2014-01-24]	1,4,7 , 10
A	* Section 3.2 - Resource allocation method for TDD * ; figure 4 -----	2,3,5,6, 8,9 , 11 , 12



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 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

27 January 2014

Date of mailing of the international search report

06/02/2014

Name and mailing address of the ISA/

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Fax: (+31-70) 340-3016

Authorized officer

Marjanovic, Djordje

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/SE2013/051116

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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		EP 2553857 A2	06-02-2013
		JP 2013526121 A	20-06-2013
		KR 20130081650 A	17-07-2013
		US 2011243039 AI	06-10-2011
		WO 2011122874 A2	06-10-2011

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Date Lodged: 15.03.2013

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(31) 61383307 (32) 15.09.2010 (33) US

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(51) INT CL:

H04L 1/18 (2006.01) H04B 7/26 (2006.01)
H04L 27/26 (2006.01)

(56) Documents Cited:

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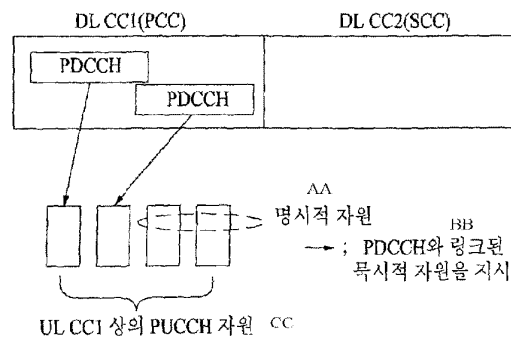
(58) Field of Search:

INT CL H04L
Other: eKOMPASS (KIPO Internal), Korean +
Japanese Utility Models (Including Applications)

(54) Title of the Invention: **Method and device for transmitting control information**
Abstract Title: **Method and device for transmitting control information**

(57) The present invention relates to a wireless communication system. Specifically, the present invention relates to a method for transmitting uplink control information and to an apparatus for same. The present invention relates to a method and to a device for said method which comprises the steps of selecting one uplink control channel resource corresponding to a plurality of HARQ-ACKs from among a plurality of uplink control channel resources, and transmitting a bit value corresponding to the plurality of HARQ-ACKs by using the selected uplink control channel resource.

[도 14]



AA ... Explicit resource
BB ... Indicate implicit resource linked with PDCCH
CC ... PUCCH resource on UL CC1

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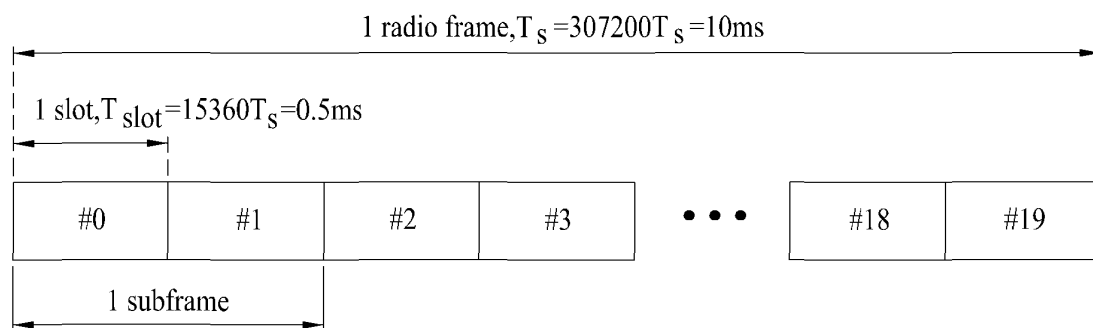
FIG. 1

FIG. 2

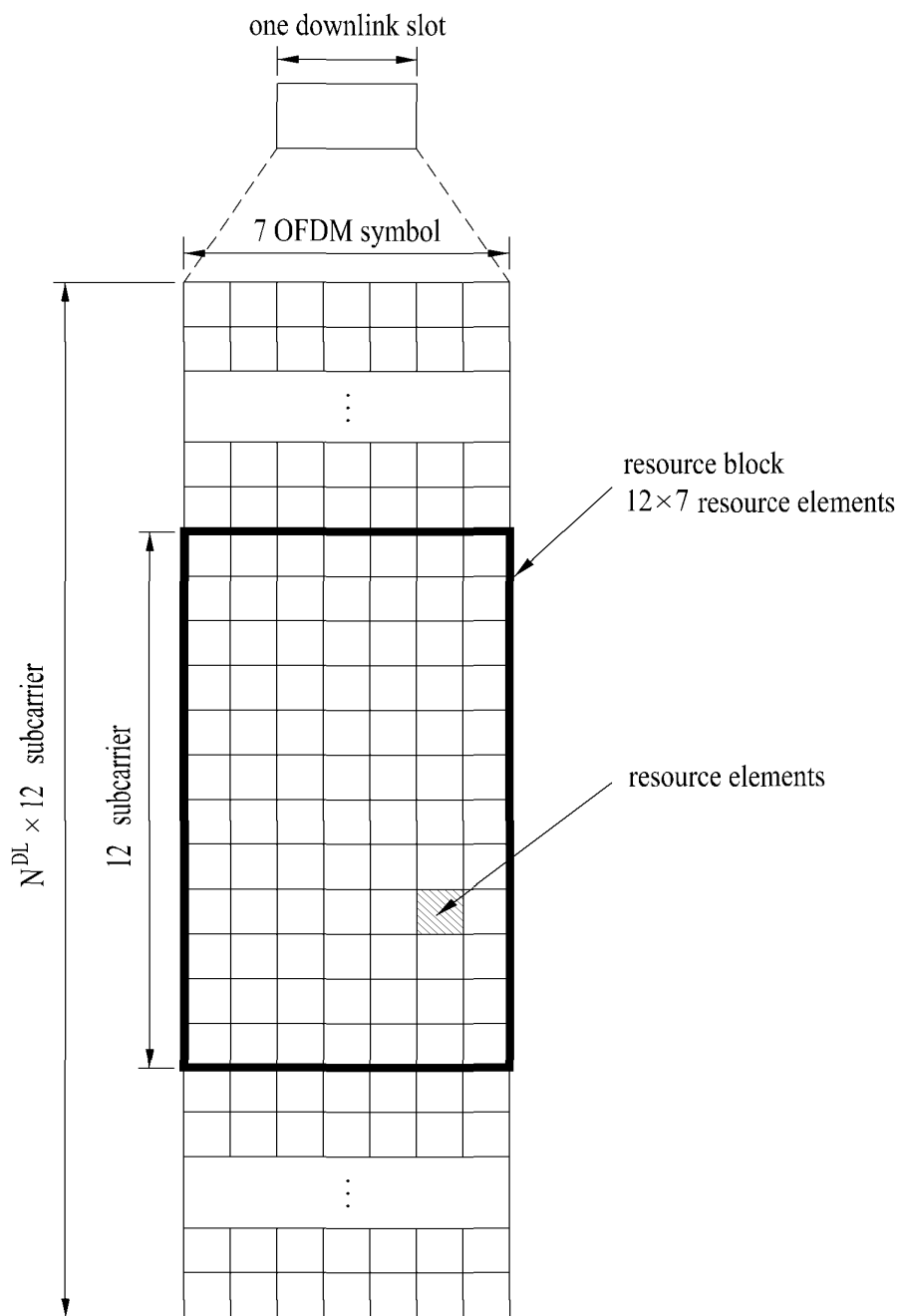


FIG. 3

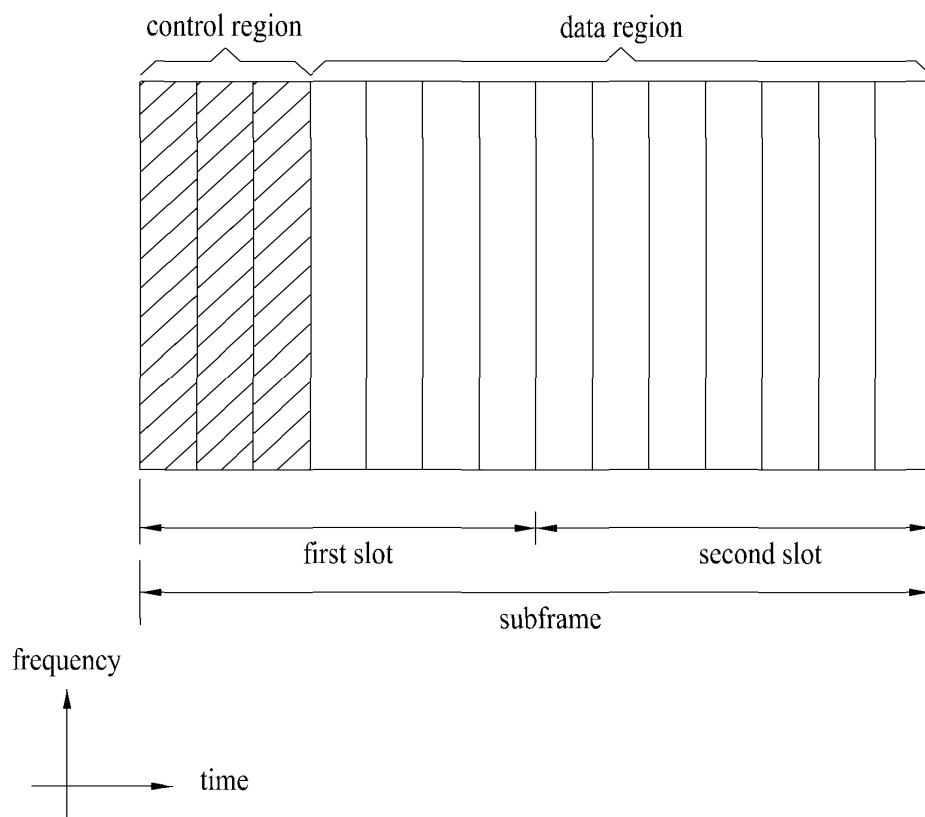


FIG. 4

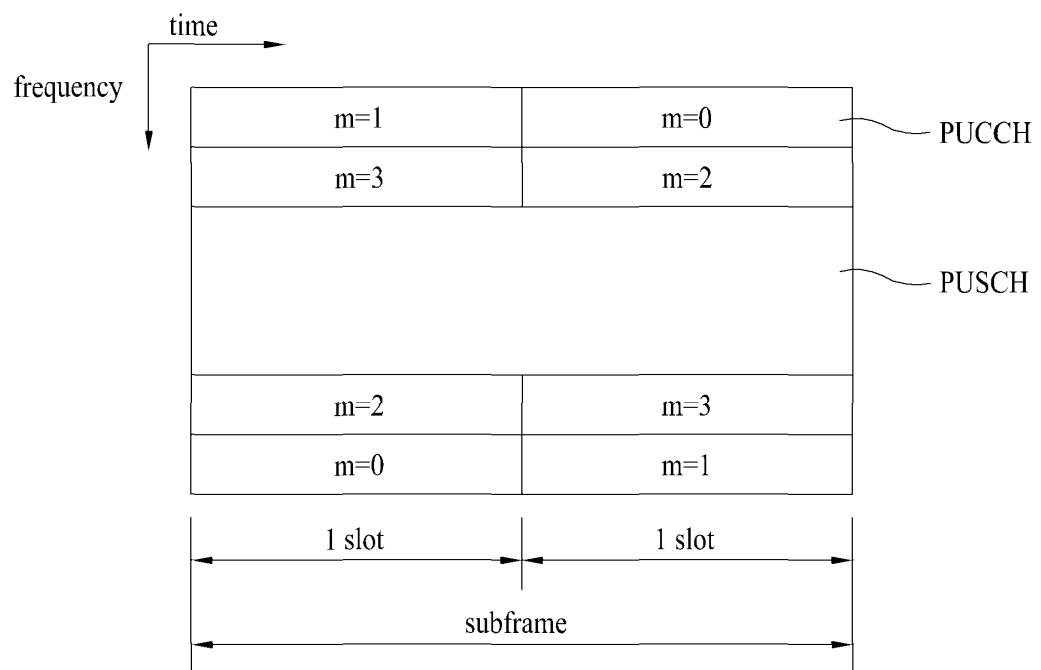


FIG. 5

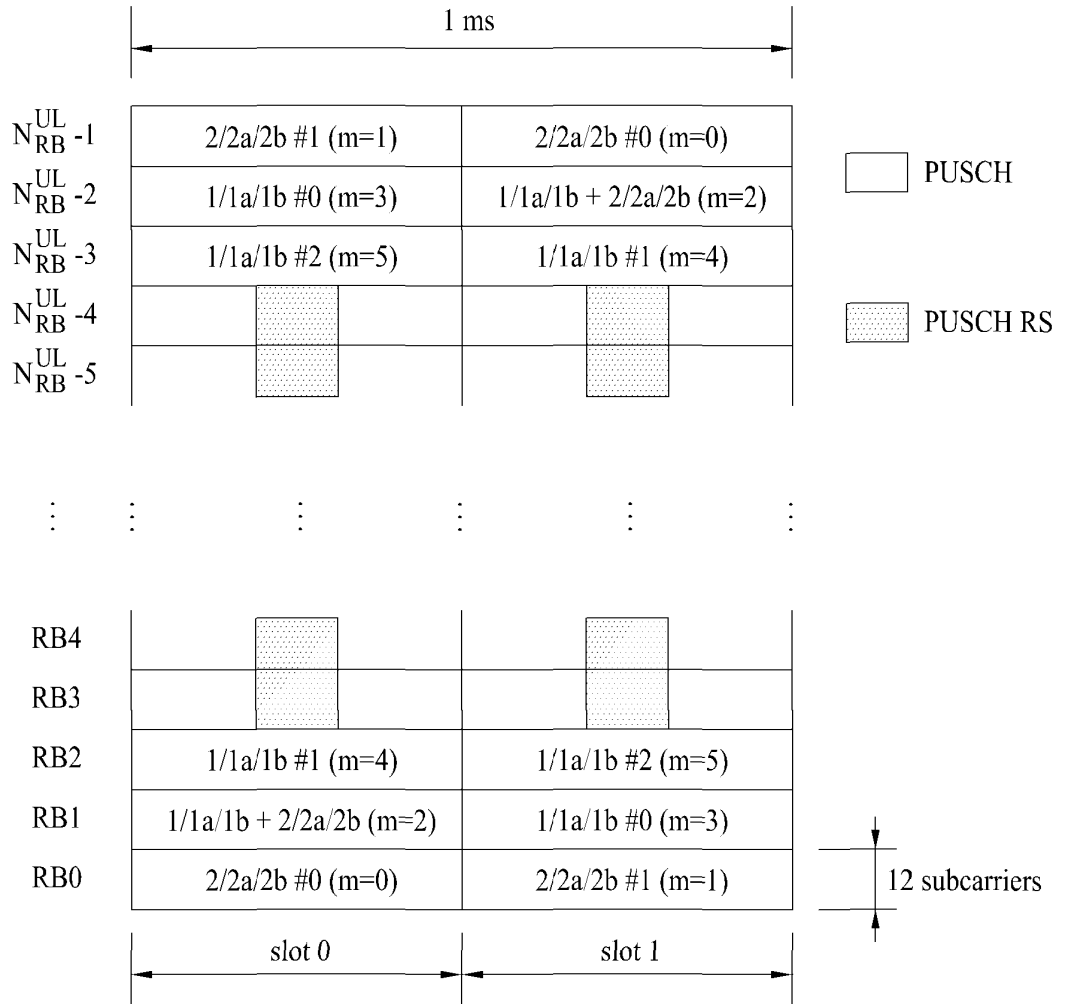


FIG. 6

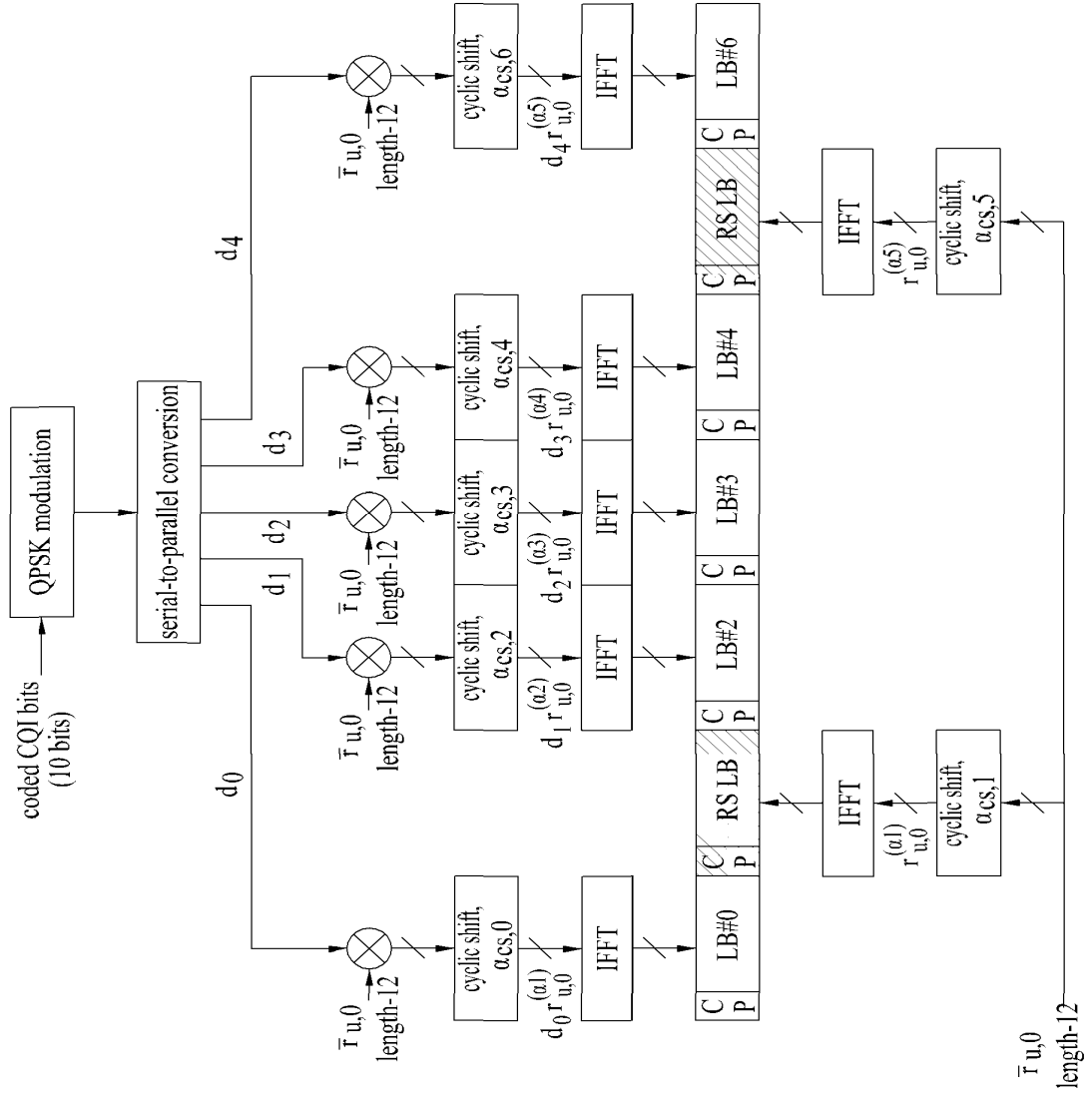


FIG. 7

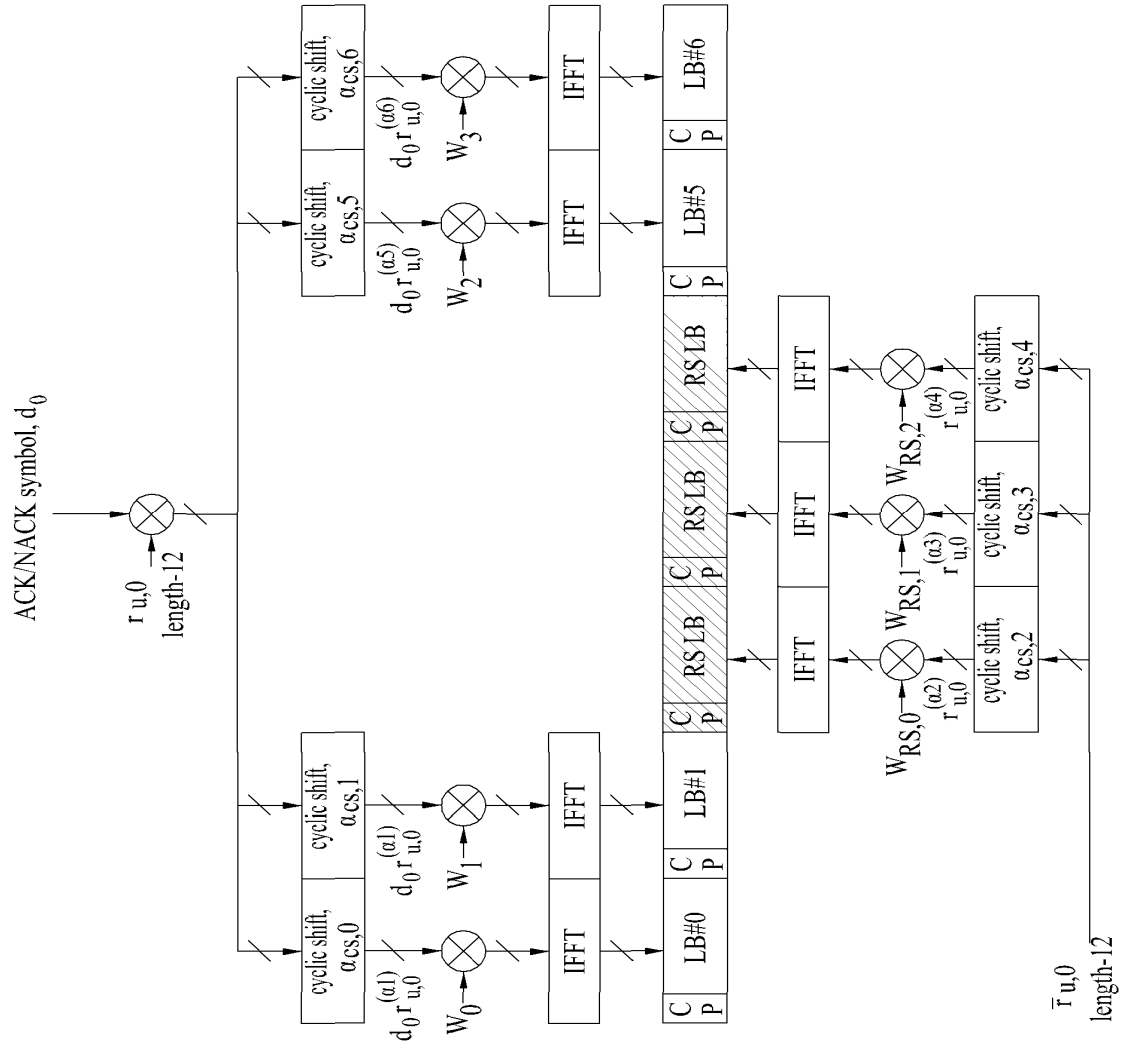


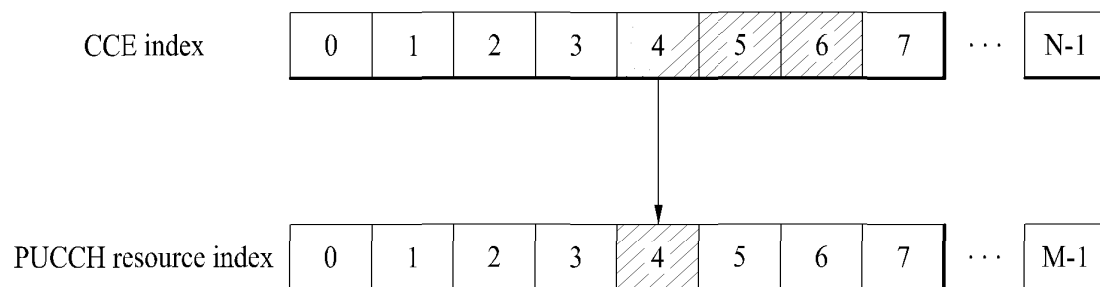
FIG. 8

FIG. 9

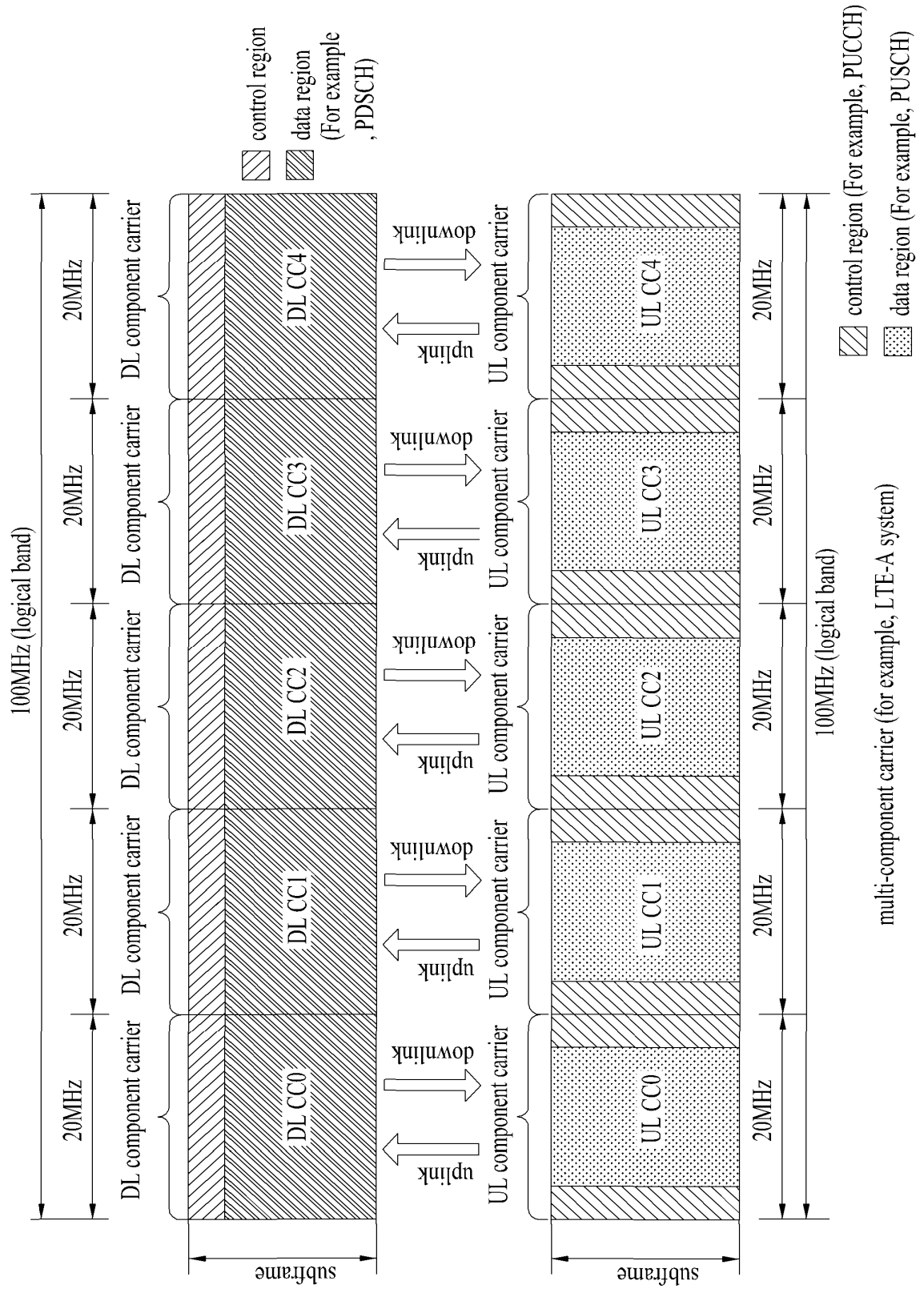


FIG. 10

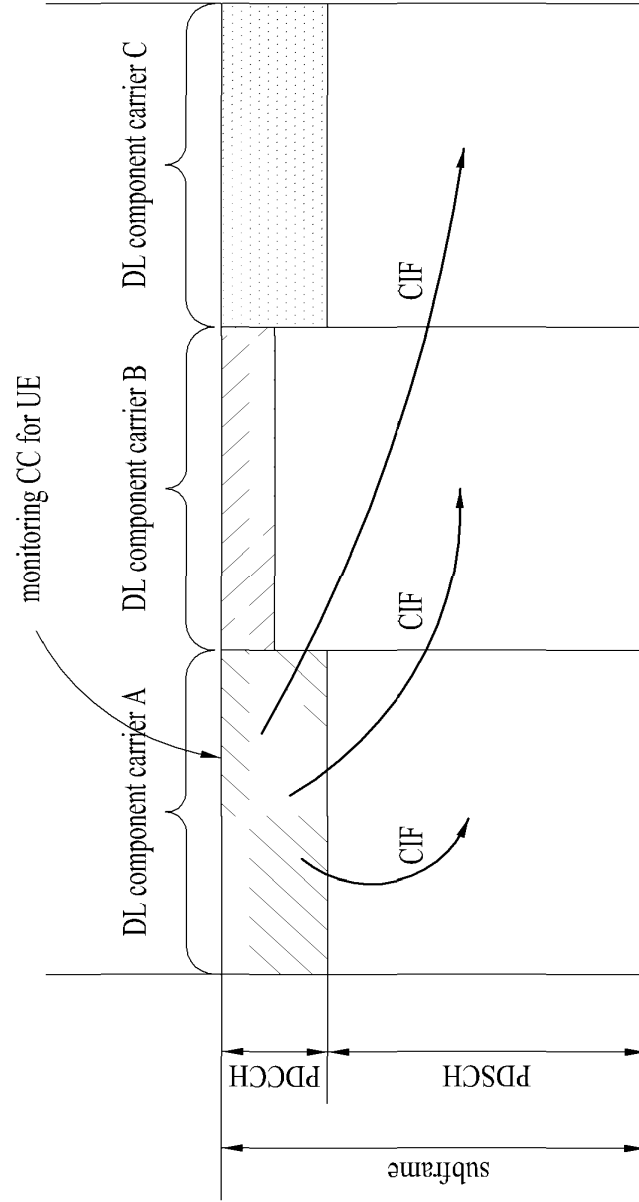


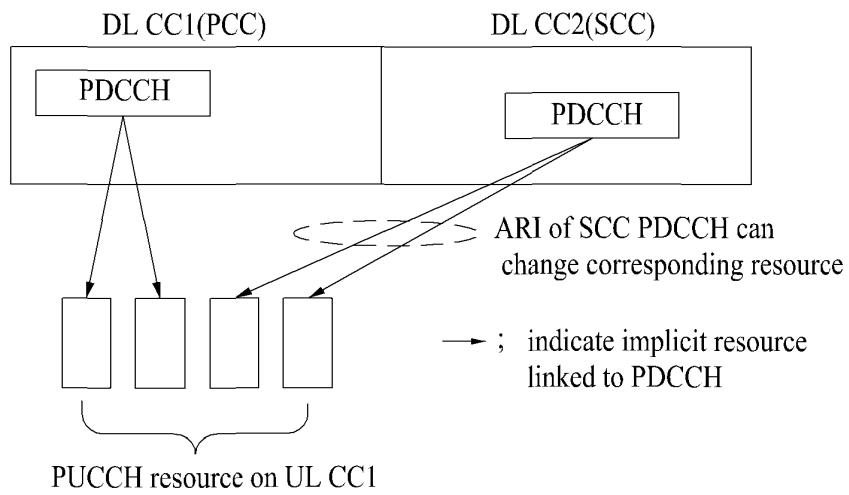
FIG. 11

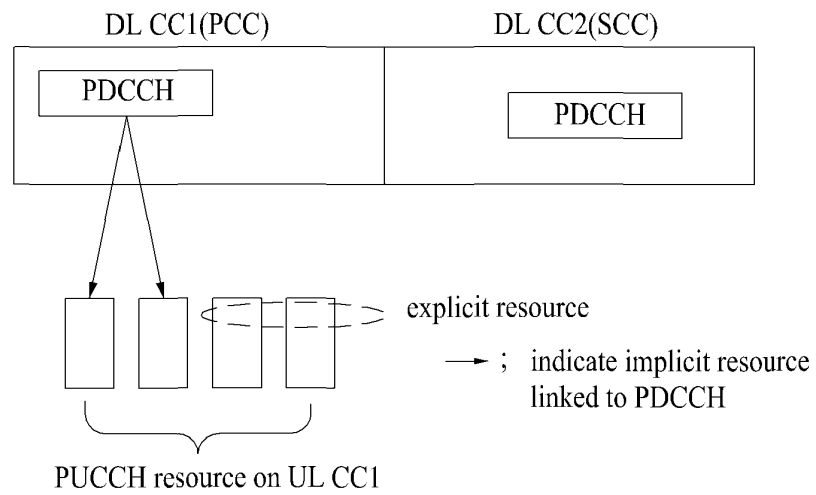
FIG. 12

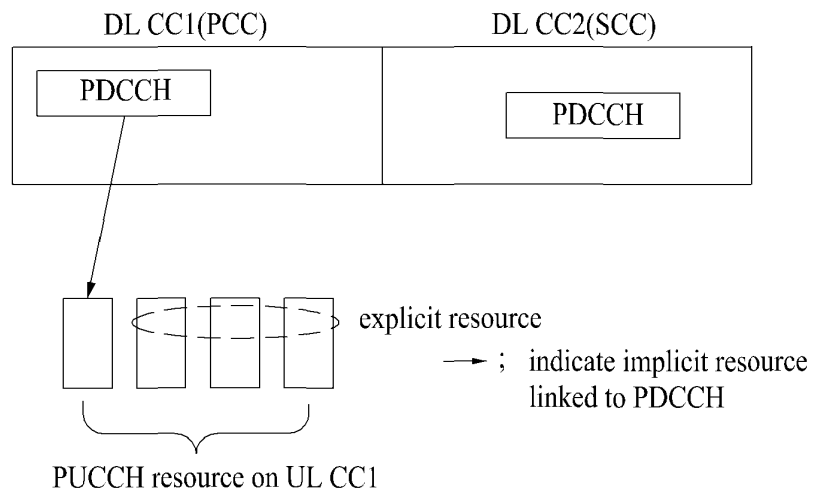
FIG. 13

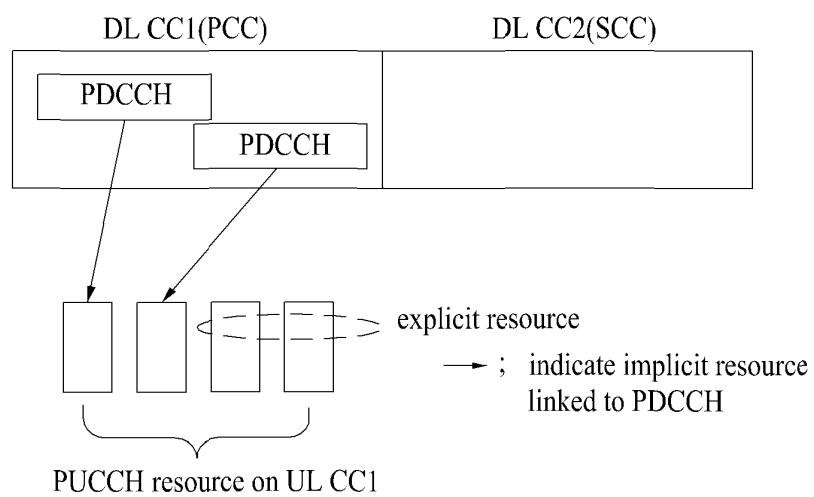
FIG. 14

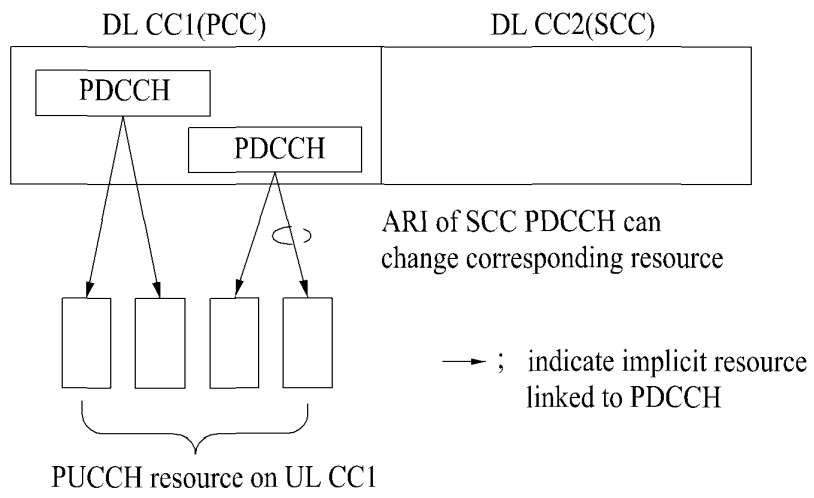
FIG. 15

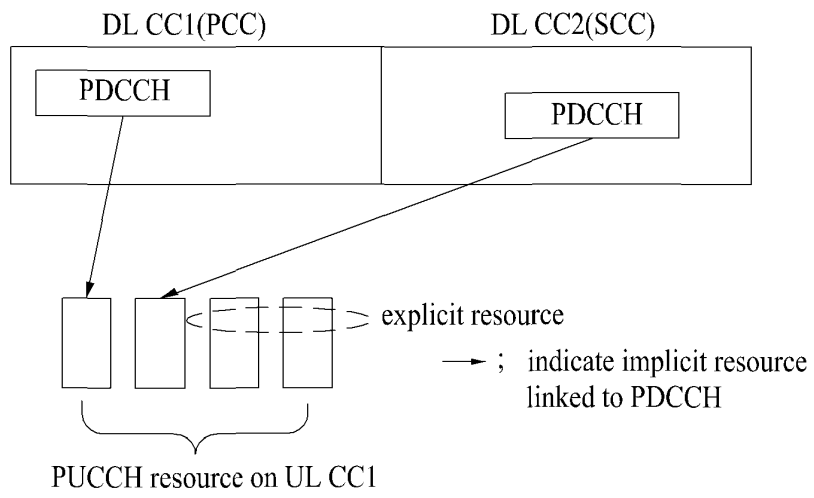
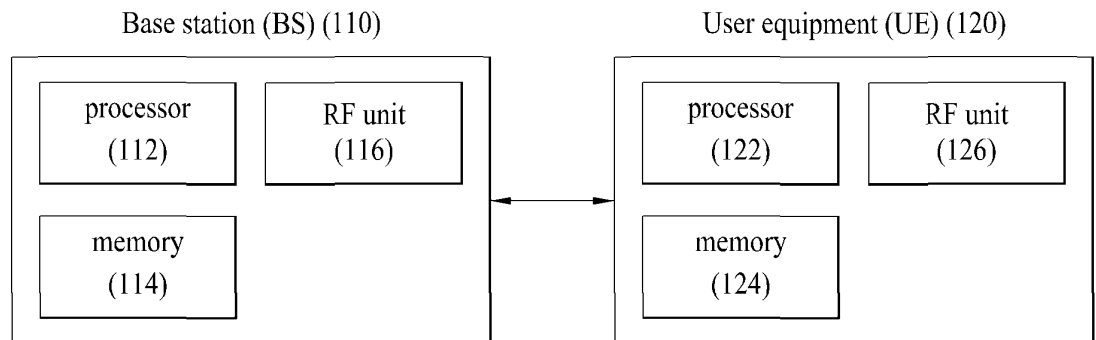
FIG. 16

FIG. 17

【DESCRIPTION】

【Invention Title】

METHOD AND DEVICE FOR TRANSMITTING CONTROL INFORMATION

【Technical Field】

The present invention relates to a wireless communication system, and more particularly, to a method and apparatus for transmitting control information.

【Background Art】

Wireless communication systems have been widely deployed to provide various types of communication services including voice and data services. In general, a wireless communication system is a multiple access system that supports communication among multiple users by sharing available system resources (e.g. bandwidth, transmit power, etc.) among the multiple users. The multiple access system may adopt a multiple access scheme such as Code Division Multiple Access (CDMA), Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Orthogonal Frequency Division Multiple Access (OFDMA), or Single Carrier Frequency Division Multiple Access (SC-FDMA).

【Disclosure】

【Technical Problem】

An object of the present invention devised to solve the problem lies in a method of efficiently transmitting uplink control information and an apparatus therefor in a wireless communication system. Another object of the present invention is to provide a method of efficiently transmitting control information, preferably, ACK/NACK information in a multicarrier situation and an apparatus therefor.

It will be appreciated by persons skilled in the art that the objects that could be achieved with the present invention are not limited to what has been particularly described hereinabove and the above and other objects that the present invention can achieve will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings.

【Technical Solution】

The object of the present invention can be achieved by providing a method for transmitting uplink control information by a communication apparatus configured with a plurality of cells in a wireless communication system, the method including: receiving a plurality of PDCCH (Physical Downlink Control Channel) signals on one cell; receiving a

plurality of PDSCH (Physical Downlink Shared Channel) signals indicated by the plurality of PDCCH signals; generating a plurality of HARQ ACKs (Hybrid Automatic Repeat request – Acknowledgements) corresponding to the plurality of PDSCH signals; and transmitting bit values corresponding to the plurality of HARQ ACKs using one of a plurality of PUCCH (Physical Uplink Control Channel) resources, wherein the plurality of PUCCH resources includes a plurality of first PUCCH resources linked to a resource index for transmission of each PDCCH signal and at least one second PUCCH resource configured by a higher layer.

In another aspect of the present invention, provided herein is a communication apparatus configured to transmit uplink control information when a plurality of cells is configured in a wireless communication system, the communication apparatus including a radio frequency (RF) unit, and a processor, wherein the processor is configured to receive a plurality of PDCCH (Physical Downlink Control Channel) signals on one cell, to receive a plurality of PDSCH (Physical Downlink Shared Channel) signals indicated by the plurality of PDCCH signals, to generate a plurality of HARQ ACKs (Hybrid Automatic Repeat request – Acknowledgements) corresponding to the plurality of PDSCH signals, and to transmit bit values corresponding to the plurality of HARQ ACKs using one of a plurality of PUCCH (Physical Uplink Control Channel) resources, wherein the plurality of PUCCH resources includes a plurality of first PUCCH resources linked to a resource index for transmission of each PDCCH signal and at least one second PUCCH resource configured by a higher layer.

At least one of the plurality of PDCCH signals may include resource indication information for HARQ-ACK and the resource indication information for HARQ-ACK may be used to change the at least one second PUCCH resource.

The resource indication information for HARQ-ACK may include an offset value.

The resource indication information for HARQ-ACK may be included in a TPC (Transmit Power Control) field of a PDCCH signal corresponding to a PDSCH signal transmitted on a secondary cell.

At least one of the plurality of PDCCH signals may include resource indication information for HARQ-ACK, and the resource indication information may include information indicating the at least one second PUCCH resource from a second PUCCH resource candidate set configured by the higher layer.

The first PUCCH resources may be indicated using a lowest CCE (Control Channel Element) index for transmission of a corresponding PDCCH signal.

The plurality of PDCCH signals may be received on a primary cell.

【Advantageous Effects】

According to the present invention, uplink control information can be efficiently transmitted in a wireless communication system. Furthermore, control information, preferably, ACK/NACK information can be efficiently transmitted in a multicarrier situation.

It will be appreciated by persons skilled in the art that the effects that could be achieved with the present invention are not limited to what has been particularly described hereinabove and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings.

【Description of Drawings】

The accompanying drawings, which are included to provide a further understanding of the invention, illustrate embodiments of the invention and together with the description serve to explain the principle of the invention.

In the drawings:

FIG. 1 illustrates a radio frame structure;

FIG. 2 illustrates a resource grid of a downlink slot;

FIG. 3 illustrates a downlink subframe structure;

FIG. 4 illustrates an uplink subframe structure;

FIG. 5 illustrates an example of physically mapping a PUCCH format to a PUCCH region;

FIG. 6 illustrates a slot level structure of PUCCH format 2/2a/2b;

FIG. 7 illustrates a slot level structure of PUCCH format 1a/1b;

FIG. 8 illustrates an example of determining a PUCCH resource for ACK/NACK;

FIG. 9 illustrates a carrier aggregation (CA) communication system;

FIG. 10 illustrates scheduling in case of aggregation of a plurality of carriers;

FIGS. 11 to 16 illustrate ACK/NACK resource allocation methods according to embodiments of the present invention; and

FIG. 17 illustrates a base station (BS) and a user equipment (UE) applicable to an embodiment of the present invention.

【Best Mode】

Embodiments of the present invention are applicable to a variety of wireless access technologies such as Code Division Multiple Access (CDMA), Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Orthogonal Frequency Division Multiple Access (OFDMA), and Single Carrier Frequency Division Multiple Access (SC-FDMA). CDMA can be implemented as a radio technology such as Universal Terrestrial Radio Access (UTRA) or CDMA2000. TDMA can be implemented as a radio technology such as Global System for Mobile communications (GSM)/General Packet Radio Service (GPRS)/Enhanced Data Rates for GSM Evolution (EDGE). OFDMA can be implemented as a radio technology such as Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wireless Fidelity (Wi-Fi)), IEEE 802.16 (Worldwide interoperability for Microwave Access (WiMAX)), IEEE 802.20, Evolved UTRA (E-UTRA). UTRA is a part of Universal Mobile Telecommunications System (UMTS). 3rd Generation Partnership Project (3GPP) Long Term Evolution (LTE) is a part of Evolved UMTS (E-UMTS) using E-UTRA, employing OFDMA for downlink and SC-FDMA for uplink. LTE-Advanced (LTE-A) is an evolution of 3GPP LTE.

While the following description is given, centering on 3GPP LTE/LTE-A to clarify the description, this is purely exemplary and thus should not be construed as limiting the present invention.

FIG. 1 illustrates a radio frame structure.

Referring to FIG. 1, a radio frame includes 10 subframes. A subframe includes two slots in time domain. A time for transmitting one subframe is defined as a transmission time interval (TTI). For example, one subframe may have a length of 1 millisecond (ms), and one slot may have a length of 0.5 ms. One slot includes a plurality of orthogonal frequency division multiplexing (OFDM) or single carrier frequency division multiple access (SC-FDMA) symbols in time domain. Since LTE uses the OFDMA in the downlink and uses SC-FDMA in the uplink, an OFDM or SC-FDMA symbol represents one symbol period. A resource block (RB) is a resource allocation unit, and includes a plurality of contiguous subcarriers in one slot. The structure of the radio frame is shown for exemplary purposes only. 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 may be modified in various manners.

FIG. 2 illustrates a resource grid of a downlink slot.

Referring to FIG. 2, a downlink slot includes a plurality of OFDM symbols in the time domain. One downlink slot may include 7(6) OFDM symbols, and one resource block

(RB) may include 12 subcarriers in the frequency domain. Each element on the resource grid is referred to as a resource element (RE). One RB includes $12 \times 7(6)$ REs. The number N_{RB} of RBs included in the downlink slot depends on a downlink transmit bandwidth. The structure of an uplink slot may be same as that of the downlink slot except that OFDM symbols by replaced by SC-FDMA symbols.

FIG. 3 illustrates a downlink subframe structure.

Referring to FIG. 3, a maximum of three (four) OFDM symbols located in a front portion of a first slot within a subframe correspond to a control region to which a control channel is allocated. The remaining OFDM symbols correspond to a data region to which a physical downlink shared channel (PDSCH) is allocated. A PDSCH is used to carry a transport block (TB) or a codeword (CW) corresponding to the TB. The TB means a data block transmitted from a MAC layer to a PHY layer through a transport channel. The codeword corresponds to a coded version of a TB. The corresponding relationship between the TB and the CW depends on swiping. In the specifically, the PDSCH, TB and CW are interchangeably used. Examples of downlink control channels used in LTE include a physical control format indicator channel (PCFICH), a physical downlink control channel (PDCCH), a physical hybrid ARQ indicator channel (PHICH), etc. The PCFICH is transmitted at a first OFDM symbol of a subframe and carries information regarding the number of OFDM symbols used for transmission of control channels within the subframe. The PHICH is a response of uplink transmission and carries an HARQ acknowledgment (ACK)/not-acknowledgment (NACK) signal.

Control information transmitted through the PDCCH is referred to as downlink control information (DCI). The DCI includes resource allocation information for a UE or a UE group and other control information. For example, the DCI includes uplink/downlink scheduling information, an uplink transmit (Tx) power control command, etc. Transmission modes and information content of DCI formats for configuring a multi-antenna technology are as follows.

Transmission mode

- Transmission mode 1: Transmission from a single base station antenna port
- Transmission mode 2: Transmit diversity
- Transmission mode 3: Open-loop spatial multiplexing
- Transmission mode 4: Closed-loop spatial multiplexing
- Transmission mode 5: Multi-user MIMO

- Transmission mode 6: Closed-loop rank-1 precoding
- Transmission mode 7: Transmission using UE-specific reference signals

DCI format

- Format 0: Resource grants for the PUSCH transmissions (uplink)
- Format 1: Resource assignments for single codeword PDSCH transmissions (transmission modes 1, 2 and 7)
 - Format 1A: Compact signaling of resource assignments for single codeword PDSCH (all modes)
 - Format 1B: Compact resource assignments for PDSCH using rank-1 closed loop precoding (mod 6)
 - Format 1C: Very compact resource assignments for PDSCH (e.g. paging/broadcast system information)
 - Format 1D: Compact resource assignments for PDSCH using multi-user MIMO (mode 5)
 - Format 2: Resource assignments for PDSCH for closed-loop MIMO operation (mode 4)
 - Format 2A: Resource assignments for PDSCH for open-loop MIMO operation (mode 3)
 - Format 3/3A: Power control commands for PUCCH and PUSCH with 2-bit/1-bit power adjustments

As described above, the PDCCH may carry a transport format and a resource allocation of a downlink shared channel (DL-SCH), resource allocation information of an uplink shared channel (UL-SCH), paging information on a paging channel (PCH), system information on the DL-SCH, information on resource allocation of an upper-layer control message such as a random access response transmitted on the PDSCH, a set of Tx power control commands on individual UEs within an arbitrary UE group, a Tx power control command, information on activation of a voice over IP (VoIP), etc. A plurality of PDCCHs can be transmitted within a control region. The UE can monitor the plurality of PDCCHs. The PDCCH is transmitted on an aggregation of one or several consecutive control channel elements (CCEs). The CCE is a logical allocation unit used to provide the PDCCH with a coding rate based on a state of a radio channel. The CCE corresponds to a plurality of resource element groups (REGs). A format of the PDCCH and the number of

bits of the available PDCCH are determined by the number of CCEs. The BS determines a PDCCH format according to DCI to be transmitted to the UE, and attaches a cyclic redundancy check (CRC) to control information. The CRC is masked with a unique identifier (referred to as a radio network temporary identifier (RNTI)) according to an owner or usage of the PDCCH. If the PDCCH is for a specific UE, a unique identifier (e.g., cell-RNTI (C-RNTI)) of the UE may be masked to the CRC. Alternatively, if the PDCCH is for a paging message, a paging identifier (e.g., paging-RNTI (P-RNTI)) may be masked to the CRC. If the PDCCH is for system information (more specifically, a system information block (SIB)), a system information RNTI (SI-RNTI) may be masked to the CRC. When the PDCCH is for a random access response, a random access-RNTI (RA-RNTI) may be masked to the CRC.

FIG. 4 illustrates an uplink subframe structure. Referring to FIG. 4, an uplink subframe includes a plurality of (e.g. 2) slots. A slot may include different numbers of SC-FDMA symbols according to CP lengths. The uplink subframe is divided into a control region and a data region in the frequency domain. The data region is allocated with a PUSCH and used to carry a data signal such as audio data. The control region is allocated a PUCCH and used to carry uplink control information (UCI). The PUCCH includes an RB pair located at both ends of the data region in the frequency domain and hopped in a slot boundary.

The PUCCH can be used to transmit the following control information.

- Scheduling Request (SR): This is information used to request a UL-SCH resource and is transmitted using On-Off Keying (OOK) scheme.
- HARQ ACK/NACK: This is a response signal to a downlink data packet on a PDSCH and indicates whether the downlink data packet has been successfully received. A 1-bit ACK/NACK signal is transmitted as a response to a single downlink codeword and a 2-bit ACK/NACK signal is transmitted as a response to two downlink codewords.
- Channel Quality Indicator (CQI): This is feedback information about a downlink channel. Feedback information regarding Multiple Input Multiple Output (MIMO) includes Rank Indicator (RI) and Precoding Matrix Indicator (PMI). 20 bits are used for each subframe.

The quantity of control information (UCI) that a UE can transmit through a subframe depends on the number of SC-FDMA symbols available for control information transmission. The SC-FDMA symbols available for control information transmission correspond to SC-FDMA symbols other than SC-FDMA symbols of the subframe, which

are used for reference signal transmission. In the case of a subframe in which a Sounding Reference Signal (SRS) is configured, the last SC-FDMA symbol of the subframe is excluded from the SC-FDMA symbols available for control information transmission. A reference signal is used to detect coherence of the PUCCH. The PUCCH supports 7 formats according to information transmitted thereon.

Table 1 shows the mapping relationship between PUCCH formats and UCI in LTE.

[Table 1]

PUCCH format	UCI (Uplink Control Information)
Format 1	SR (Scheduling Request) (non-modulated waveform)
Format 1a	1-bit HARQ ACK/NACK (SR exist/non-exist)
Format 1b	2-bit HARQ ACK/NACK (SR exist/non-exist)
Format 2	CQI (20 coded bits)
Format 2	CQI and 1- or 2-bit HARQ ACK/NACK (20 bits) (corresponding to only extended CP)
Format 2a	CQI and 1-bit HARQ ACK/NACK (20+1 coded bits)
Format 2b	CQI and 2-bit HARQ ACK/NACK (20+2 coded bits)

FIG. 5 illustrates an example of physically mapping a PUCCH format to a PUCCH region.

Referring to FIG. 5, PUCCH formats are mapped onto RBs in the order of PUCCH formats 2/2a/2b (CQI) (e.g. PUCCH regions $m=0, 1$), PUCCH formats 2/2a/2b (CQI) or PUCCH formats 1/1a/1b (SR/HARQ ACK/NACK) (e.g. PUCCH region $m=2$ if present), and PUCCH formats 1/1a/1b (SR/HARQ ACK/NACK) (e.g. PUCCH regions $m=3, 4, 5$), starting from the band-edge, and transmitted. The number of PUCCH RBs, $N_{RB}^{(2)}$, which can be used for PUCCH formats 2/2a/2b (CQI) is signaled to a UE in a cell through broadcast signaling.

The periodicity and frequency resolution to be used by a UE to report CQI are both controlled by the BS. In the time domain, both periodic and aperiodic CQI reporting are supported. The PUCCH format 2 is used for periodic CQI reporting. In periodic CQI reporting, CQI is piggybacked on data and then transmitted through a PUSCH if the PUSCH is scheduled for a subframe reserved for CQI transmission. A PUSCH is used for

aperiodic CQI reporting, whereby the BS specifically instructs the UE to send an individual CQI report embedded into a resource which is scheduled for uplink data transmission.

FIG. 6 illustrates a slot level structure of PUCCH formats 2/2a/2b. The PUCCH formats 2/2a/2b are used for CQI transmission. In the case of normal CP, SC-FDMA symbols #1 and #5 in a slot are used for transmission of a Demodulation Reference Signal (DM RS). In the case of extended CP, only SC-FDMA #3 in the slot is used for DM RS transmission.

Referring to FIG. 6, at a subframe level, 10-bit CSI is channel-coded into 20 coded bits using (20, k) Reed-Muller code punctured at a rate of 1/2 (not shown). The coded bits are scrambled (not shown) and then mapped to Quadrature Phase Shift Keying (QPSK) constellation (QPSK modulation). Scrambling can be performed using length-31 gold sequence in a similar manner that PUSCH data is scrambled. 10 QPSK modulation symbols are generated according to the QPSK modulation, and 5 QPSK modulation symbols d_0, d_1, d_2, d_3 and d_4 are transmitted through SC-FDMA symbols corresponding thereto in each slot. Each of the QPSK modulation symbols is used to modulate a length-12 base RS sequence $r_{u,0}$ prior to being subjected to Inverse Fast Fourier Transform (IFFT). Consequently, the RS sequence is cyclic-shifted in the time domain according to the QPSK modulation symbol value ($d_x * r_{u,0}^{(ax)}$, $x=0$ to 4). The RS sequence multiplied by the QPSK modulation symbol is cyclic-shifted ($\alpha_{cs,x}$, $x=1,5$). When the number of cyclic shifts is N, N UEs can be multiplexed on the same CSI PUCCH RB. While a DM RS sequence is similar to a CSI sequence in the frequency domain, the DM RS sequence is not modulated by a CQI modulation symbol.

Parameters/resources for periodic CQI reports are configured semi-statically according to higher layer (e.g. Radio Resource Control (RRC)) signaling. If PUCCH resource index $n_{PUCCH}^{(2)}$ is set for CQI transmission, for example, CQI is periodically transmitted on a CQI PUCCH linked to PUCCH resource index $n_{PUCCH}^{(2)}$. PUCCH resource index $n_{PUCCH}^{(2)}$ indicates a PUCCH RB and cyclic shift α_{cs} .

FIG. 7 illustrates a slot level structure of PUCCH formats 1a/1b. The PUCCH formats 1a/1b are used for ACK/NACK transmission. In the case of normal CP, SC-FDMA symbols #2, #3 and #4 are used for DM RS transmission. In the case of extended CP, SC-FDMA symbols #2 and #3 are used for DM RS transmission. Accordingly, 4 SC-FDMA symbols in a slot are used for ACK/NACK transmission. PUCCH format 1a/1b is called PUCCH format 1 for convenience.

Referring to FIG. 7, 1-bit [b(0)] and 2-bit [b(0)b(1)] ACK/NACK information are modulated according to BPSK and QPSK modulation schemes respectively, to generate one ACK/NACK modulation symbol d_0 . Each bit [b(i), i=0, 1] of the ACK/NACK information indicates a HARQ response to a corresponding DL transport block, corresponds to 1 in the case of positive ACK and corresponds to 0 in case of negative ACK (NACK). Table 2 shows a modulation table defined for PUCCH formats 1a and 1b in LTE.

[Table 2]

PUCCH format	b(0),...,b(M _{bit} -1)	d(0)
1a	0	1
	1	-1
1b	00	1
	01	-j
	10	j
	11	-1

PUCCH formats 1a/1b perform time domain spreading using an orthogonal spreading code W_0, W_1, W_2, W_3 , (e.g. Walsh-Hadamard or DFT code) in addition to cyclic shift $\alpha_{cs,x}$ in the frequency domain. In the case of PUCCH formats 1a/1b, a larger number of UEs can be multiplexed on the same PUCCH RB because code multiplexing is used in both frequency and time domains.

RSs transmitted from different UEs are multiplexed using the same method as is used to multiplex UCI. The number of cyclic shifts supported by SC-FDMA symbols for PUCCH ACK/NACK RB can be configured by cell-specific higher layer signaling parameter Δ_{shift}^{PUCCH} . $\Delta_{shift}^{PUCCH} \in \{1, 2, 3\}$ represents that shift values are 12, 6 and 4, respectively. In time-domain CDM, the number of spreading codes actually used for ACK/NACK can be limited by the number of RS symbols because multiplexing capacity of RS symbols is less than that of UCI symbols due to a smaller number of RS symbols.

FIG. 8 illustrates an example of determining PUCCH resources for ACK/NACK. In LTE, a plurality of PUCCH resources for ACK/NACK are shared by a plurality of UEs in a cell every time the UEs need the PUCCH resources rather than allocated to UEs in advance. Specifically, a PUCCH resource used by a UE to transmit an ACK/NACK signal

corresponds to a PDCCH on which scheduling information on DL data involving the ACK/NACK signal is delivered. The region in which the PDCCH is transmitted in a DL subframe is configured with a plurality of Control Channel Elements (CCEs), and the PDCCH transmitted to the UE is composed of one or more CCEs. The UE transmits the ACK/NACK signal through a PUCCH resource corresponding to a specific one (e.g. first CCE) of the CCEs constituting the received PDCCH.

Referring to FIG. 8, each block in a Downlink Component Carrier (DL CC) represents a CCE and each block in an Uplink Component Carrier (UL CC) indicates a PUCCH resource. Each PUCCH index corresponds to a PUCCH resource for an ACK/NACK signal. If information on a PDSCH is delivered on a PDCCH composed of CCEs #4, #5 and #6, as shown in FIG. 8, a UE transmits an ACK/NACK signal on PUCCH #4 corresponding to CCE #4, the first CCE of the PDCCH. FIG. 8 illustrates a case in which maximum M PUCCHs are present in the UL CC when maximum N CCEs exist in the DL CC. Though N can equal M, N may differ from M and CCEs are mapped to PUCCHs in an overlapped manner.

Specifically, a PUCCH resource index in LTE is determined as follows.

[Equation 1]

$$n^{(1)}_{\text{PUCCH}} = n_{\text{CCE}} + N^{(1)}_{\text{PUCCH}}$$

Here, $n^{(1)}_{\text{PUCCH}}$ represents a resource index of PUCCH format 1 for ACK/NACK/DTX transmission, $N^{(1)}_{\text{PUCCH}}$ denotes a signaling value received from a higher layer, and n_{CCE} denotes the smallest value of CCE indexes used for PDCCH transmission. A cyclic shift, an orthogonal spreading code and a Physical Resource Block (PRB) for PUCCH formats 1a/1b are obtained from $n^{(1)}_{\text{PUCCH}}$.

When an LTE system operates in TDD, a UE transmits one multiplexed ACK/NACK signal for a plurality of PDSCHs received through subframes at different timings. Specifically, the UE transmits one multiplexed ACK/NACK signal for a plurality of PDSCHs using an ACK/NACK channel selection scheme (PUCCH selection scheme). The ACK/NACK channel selection scheme is also referred to as a PUCCH selection scheme. When the UE receives a plurality of DL data in the ACK/NACK channel selection scheme, the UE occupies a plurality of UL physical channels in order to transmit a multiplexed ACK/NACK signal. For example, when the UE receives a plurality of PDSCHs, the UE can occupy the same number of PUCCHs as the PDSCHs using a specific CCE of a PDCCH which indicates each PDSCH. In this case, the UE can transmit a

multiplexed ACK/NACK signal using combination of which one of the occupied PUCCHs is selected and modulated/coded results applied to the selected PUCCH.

Table 3 shows an ACK/NACK channel selection scheme defined in LTE.

[Table 3]

HARQ-ACK(0), HARQ-ACK(1), HARQ-ACK(2), HARQ-ACK(3)	Subframe	
	$n_{\text{PUCCH},X}^{(1)}$	b(0),b(1)
ACK, ACK, ACK, ACK	$n_{\text{PUCCH},1}^{(1)}$	1,1
ACK, ACK, ACK, NACK/DTX	$n_{\text{PUCCH},1}^{(1)}$	1,0
NACK/DTX,NACK/DTX,NACK,DTX	$n_{\text{PUCCH},2}^{(1)}$	1,1
ACK, ACK, NACK/DTX, ACK	$n_{\text{PUCCH},1}^{(1)}$	1,0
NACK, DTX, DTX, DTX	$n_{\text{PUCCH},0}^{(1)}$	1,0
ACK, ACK, NACK/DTX, NACK/DTX	$n_{\text{PUCCH},1}^{(1)}$	1,0
ACK, NACK/DTX, ACK, ACK	$n_{\text{PUCCH},3}^{(1)}$	0,1
NACK/DTX, NACK/DTX, NACK/DTX, NACK	$n_{\text{PUCCH},3}^{(1)}$	1,1
ACK, NACK/DTX, ACK, NACK/DTX	$n_{\text{PUCCH},2}^{(1)}$	0,1
ACK, NACK/DTX, NACK/DTX, ACK	$n_{\text{PUCCH},0}^{(1)}$	0,1
ACK, NACK/DTX, NACK/DTX, NACK/DTX	$n_{\text{PUCCH},0}^{(1)}$	1,1
NACK/DTX, ACK, ACK, ACK	$n_{\text{PUCCH},3}^{(1)}$	0,1
NACK/DTX, NACK, DTX, DTX	$n_{\text{PUCCH},1}^{(1)}$	0,0
NACK/DTX, ACK, ACK, NACK/DTX	$n_{\text{PUCCH},2}^{(1)}$	1,0
NACK/DTX, ACK, NACK/DTX, ACK	$n_{\text{PUCCH},3}^{(1)}$	1,0
NACK/DTX, ACK, NACK/DTX, NACK/DTX	$n_{\text{PUCCH},1}^{(1)}$	0,1
NACK/DTX, NACK/DTX, ACK, ACK	$n_{\text{PUCCH},3}^{(1)}$	0,1
NACK/DTX, NACK/DTX, ACK, NACK/DTX	$n_{\text{PUCCH},2}^{(1)}$	0,0
NACK/DTX, NACK/DTX, NACK/DTX, ACK	$n_{\text{PUCCH},3}^{(1)}$	0,0
DTX, DTX, DTX, DTX	N/A	N/A

In Table 3, HARQ-ACK(i) indicates the HARQ ACK/NACK/DTX result of an i-th data unit ($0 \leq i \leq 3$). DTX (Discontinuous Transmission) represents that there is no transmission of a data unit corresponding to HARQ-ACK(i) or the UE does not detect the data unit corresponding to HARQ-ACK(i). In the specification, HARQ-ACK and ACK/NACK are interchangeably used. Maximum 4 PUCCH resources (i.e., $n_{\text{PUCCH},0}^{(1)}$ to $n_{\text{PUCCH},3}^{(1)}$) can be occupied for each data unit. The multiplexed ACK/NACK signal is transmitted through one PUCCH resource selected from the occupied PUCCH resources. In

Table 3, $n_{\text{PUCCH},X}^{(1)}$ represents a PUCCH resource actually used for ACK/NACK transmission, and $b(0)b(1)$ indicates two bits transmitted through the selected PUCCH resource, which are modulated using QPSK. For example, when the UE has decoded 4 data units successfully, the UE transmits bits (1, 1) to a BS through a PUCCH resource linked with $n_{\text{PUCCH},1}^{(1)}$. Since combinations of PUCCH resources and QPSK symbols cannot represent all available ACK/NACK suppositions, NACK and DTX are coupled except in some cases (NACK/DTX, N/D).

In LTE-A, a plurality of PUCCH resources may be considered for ACK/NACK transmission for a single PDCCH. For example, when a transmit diversity scheme using multiple antennas on uplink is applied, the same ACK/NACK signal needs to be transmitted on different PUCCH resources for different antennas. In this case, the first PUCCH index can be determined by the first CCE index used for transmission of a corresponding PDCCH, similarly to LTE. However, LTE does not define a method of allocating PUCCH indexes other than the first PUCCH index.

FIG. 9 illustrates a carrier aggregation (CA) communication system. To use a wider frequency band, an LTE-A system employs CA (or bandwidth aggregation) technology which aggregates a plurality of UL/DL frequency blocks to obtain a wider UL/DL bandwidth. Each frequency block is transmitted using a component carrier (CC). The CC can be regarded as a carrier frequency (or center carrier, center frequency) for the frequency block.

Referring to FIG. 9, a plurality of UL/DL CCs can be aggregated to support a wider UL/DL bandwidth. The CCs may be contiguous or non-contiguous in the frequency domain. Bandwidths of the CCs can be independently determined. Asymmetrical CA in which the number of UL CCs is different from the number of DL CCs can be implemented. For example, when there are two DL CCs and one UL CC, the DL CCs can correspond to the UL CC in the ratio of 2:1. A DL CC/UL CC link can be fixed or semi-statically configured in the system. Even if the system bandwidth is configured with N CCs, a frequency band that a specific UE can monitor/receive can be limited to M ($<N$) CCs. Various parameters with respect to CA can be set cell-specifically, UE-group-specifically, or UE-specifically. Control information may be transmitted/received only through a specific CC. This specific CC can be referred to as a Primary CC (PCC) (or anchor CC) and other CCs can be referred to as Secondary CCs (SCCs).

In LTE-A, the concept of a cell is used to manage radio resources. A cell is defined as a combination of downlink resources and uplink resources. Yet, the uplink resources are

not mandatory. Therefore, a cell may be composed of downlink resources only or both downlink resources and uplink resources. The linkage between the carrier frequencies (or DL CCs) of downlink resources and the carrier frequencies (or UL CCs) of uplink resources may be indicated by system information. A cell operating in primary frequency resources (or a PCC) may be referred to as a primary cell (PCell) and a cell operating in secondary frequency resources (or an SCC) may be referred to as a secondary cell (SCell). The PCell is used for a UE to establish an initial connection or re-establish a connection. The PCell may refer to a cell indicated during handover. The SCell may be configured after an RRC connection is established and may be used to provide additional radio resources. The PCell and the SCell may collectively be referred to as a serving cell. Accordingly, a single serving cell composed of a PCell only exists for a UE in an RRC_Connected state, for which CA is not set or which does not support CA. On the other hand, one or more serving cells exist, including a PCell and entire SCells, for a UE in an RRC_CONNECTED state, for which CA is set. For CA, a network may configure one or more SCells in addition to an initially configured PCell, for a UE supporting CA during connection setup after an initial security activation operation is initiated.

FIG. 10 illustrates scheduling when a plurality of carriers is aggregated. It is assumed that 3 DL CCs are aggregated and DL CC A is set to a PDCCH CC. DL CC A, DL CC B and DL CC C can be called serving CCs, serving carriers, serving cells, etc. In case of CIF disabled, a DL CC can transmit only a PDCCH that schedules a PDSCH corresponding to the DL CC without a CIF. When the CIF is enabled according to UE-specific (or UE-group-specific or cell-specific) higher layer signaling, DL CC A (monitoring DL CC) can transmit not only a PDCCH that schedules the PDSCH corresponding to the DL CC A but also PDCCHs that schedule PDSCHs of other DL CCs. In this case, DL CC B and DL CC C that are not set to PDCCH CCs do not deliver PDCCHs. Accordingly, the DL CC A (PDCCH CC) needs to include all of a PDCCH search space relating to the DL CC A, a PDCCH search space relating to the DL CC B and a PDCCH search space relating to the DL CC C.

LTE-A considers transmission of a plurality of ACK/NACK information/signals with respect to a plurality of PDSCHs, which are transmitted through a plurality of DL CCs, through a specific UL CC (e.g. UL PCC or UL PCell). For description, it is assumed that a UE operates in a SU-MIMO (Single User-Multiple Input Multiple Output) mode in a certain DL CC to receive 2 codewords (or transport blocks). In this case, the UE needs to be able to transmit 4 feedback states, ACK/ACK, ACK/NACK, NACK/ACK and NACK/NACK,

or up to 5 feedback states including even DTX for the DL CC. If the DL CC is set to support a single codeword (or transport block), up to 3 states of ACK, NACK and DTX are present for the DL CC. Accordingly, if NACK and DTX are processed as the same state, a total of 2 feedback states of ACK and NACK/DTX are present for the DL CC. Accordingly, if the UE aggregates a maximum of 5 DL CCs and operates in the SU-MIMO mode in all CCs, the UE can have up to 55 transmittable feedback states and an ACK/NACK payload size for representing the feedback states corresponds to 12 bits. If DTX and NACK are processed as the same state, the number of feedback states is 45 and an ACK/NACK payload size for representing the same is 10 bits.

To achieve this, LTE-A discusses transmission of a plurality of ACK/NACK information/signals using PUCCH format 1a/1b and ACK/NACK multiplexing (i.e. ACK/NACK selection) in a multi-carrier situation. Here, schemes by which each UE secures a plurality of PUCCH resources for ACK/NACK transmission can be classified into an implicit scheme and an explicit scheme. The implicit scheme allocates a PUCCH resource linked to a PDCCH that schedules a PDSCH to a UE as in LTE (refer to Equation 1). The explicit scheme pre-allocates a PUCCH resource to be used by the UE through RRC signaling. Accordingly, a scheme of using an implicit resource, an explicit resource or a combination of an implicit resource and an explicit resource may be considered for ACK/NACK channel selection.

The present invention proposes a method of changing a PUCCH resource allocated to a UE for ACK/NACK transmission by transmitting an ARI (ACK/NACK Resource Index) through a PDSCH-scheduling PDCCH to avoid collision between PUCCH resources for ACK/NACK transmission of UEs. Furthermore, the present invention proposes a scheme of applying an ARI according to a combination of implicit/explicit PUCCH resources allocated to a UE.

It is assumed that 2 DL CCs are configured for a UE and the UE receives up to 2 MIMO codewords (e.g. TBs) through a PDSCH of each DL CC in the following description. In addition, it is assumed that a plurality of ACK/NACKs is transmitted using ACK/NACK channel selection. For this, it is assumed that the UE occupies 4 PUCCH resources such that the UE can transmit up to 4-bit ACK/NACK information corresponding to up to 4 codewords (or TBs). In addition, it is assumed that the UE is allocated a PUCCH resource for ACK/NACK transmission only in a specific UL CC (e.g. UL PCC) (e.g. UL CC linked to a DL PCC) although it receives a PDSCH-scheduling PDCCH through a plurality of DL CCs. The above assumption is for aiding in description of the present invention and the

present invention is not limited thereto. The present invention is applicable to a case in which an arbitrary number of DL CCs are configured for a UE and the UE receives an arbitrary number of MIMO codewords through each DL CC and uses a number of PUCCH resources necessary to receive the MIMO codewords.

The following description illustrates a case in which 2 PUCCH resources are secured for one PDCCH on the assumption that up to 2 MIMO codewords (e.g. TBs) are received through a PDSCH using each DL CC. This is also applicable to a case in which a maximum of one codeword (e.g. TB) is received through a PDSCH using each DL CC and an ACK/NACK signal is transmitted using a multi-antenna transmission scheme (e.g. transmit diversity). For example, 2 PUCCH resources can be secured for one PDCCH for 2Tx transmission.

In the following description, a PCC PDCCH means a PDCCH received on a PCC or a PDCCH corresponding to a PDSCH received on an SCC. Similarly, an SCC PDCCH means a PDCCH received on an SCC or a PDCCH corresponding to a PDSCH received on the SCC. A CC is interchangeably used with a cell, the PCC is interchangeably used with PCell and the SCC is interchangeably used with SCell.

Embodiment 1: Case in which PDCCHs are transmitted through a plurality of PDCCH monitoring CCs and implicit resources are used for all PDCCHs

FIG. 11 illustrates a method of allocating PUCCH resources for ACK/NACK transmission. The present embodiment exemplifies a case in which implicit resources are used for all PDCCHs.

Referring to FIG. 11, the UE can receive PDSCH-scheduling PDCCHs through a plurality of DL CCs. The figure shows a case in which one PDCCH is received on each of a PCC and an SCC. The UE receives a PDSCH signal corresponding to each PDCCH. In a MIMO mode, up to 2 codewords can be transmitted through each PDSCH. In the present embodiment, the UE can be allocated 2 PUCCH resources linked to each PDCCH such that the UE can transmit ACK/NACK(s) for up to 4 codewords. The UE feeds back a plurality of ACK/NACKs using ACK/NACK channel selection. That is, the UE transmits bit values corresponding to a plurality of ACK/NACKs using one of the plural PUCCH resources.

The 2 PUCCH resources linked to a PDCCH may be a PUCCH resource linked to a first CCE (i.e. CCE index = n_{CCE}) constituting the PDCCH and a PUCCH resource linked to a CCE (i.e. CCE index = $n_{CCE} + 1$) contiguous to the first CCE. Here, if PUCCH resources for ACK/NACK transmission for two DL CCs are shared for the corresponding UL CC,

instead of being separately secured for the respective DL CCs, PUCCH resources linked to a PCC PDCCH may collide with PUCCH resources linked to an SCC PDCCH.

Accordingly, the present embodiment proposes a scheme of changing a PUCCH resource linked to a PDCCH through ARI information signaled through the PDCCH when implicit PUCCH resources linked to PDCCHs transmitted through different PDCCH monitoring CCs are used for ACK/NACK transmission. For example, the PUCCH resource linked to the PDCCH can be changed by a specific offset through the ARI information. The ARI information may be used for a case in which the PUCCH resource is not changed and a case in which the PUCCH resource is changed by one of one or more offset values. The ARI information may be included only in an SCC PDCCH to change only the position of a PUCCH resource linked to the SCC PDCCH. Otherwise, the ARI information may be included only in a PCC PDCCH to change only the position of a PUCCH resource linked to the PCC PDCCH. Alternatively, the ARI information may be included in both the PCC PDCCH and SCC PDCCH.

When a plurality of PDCCHs includes ARI information, ARI information included in each PDCCH may be applied only to PUCCH resources linked to the corresponding PDCCH. For example, when SCC PDCCHs are transmitted through a plurality of SCCs, ARI information included in each SCC PDCCH can be applied to PUCCH resources linked to the corresponding PDCCH. That is, ARI information of the SCC PDCCHs can be independently set.

An ARI (e.g. an offset value) can be used to change a PUCCH index. A changed cyclic shift, a changed orthogonal cover and/or a changed PRB can be obtained from the changed PUCCH index. In addition the ARI (e.g. offset value) can be used to directly change at least one of a cyclic shift, an orthogonal cover and a PRB.

Equation 2 represents an example of changing implicit PUCCH resource(s) using ARI information. This example can be applied to changing implicit PUCCH resource(s) in the following embodiments in a similar way.

[Equation 2]

PCC PDCCH

$$n_{PUCCH,1}^{(1)} = n_{CCE,PCC} + N_{PUCCH}^{(1)}$$

$$n_{PUCCH,2}^{(1)} = n_{CCE,PCC} + 1 + N_{PUCCH}^{(1)}$$

SCC PDCCH

$$n_{PUCCH,3}^{(1)} = n_{CCE,SCC} + a + N_{PUCCH}^{(1)}$$

$$n_{PUCCH,4}^{(1)} = n_{CCE,SCC} + a + 1 + N_{PUCCH}^{(1)}$$

Here, $n_{\text{PUCCH},x}^{(1)}$ ($x=1,2,3,4$) denotes a PUCCH resource index, $n_{\text{CCE},\text{PCC}}$ denotes a lowest CCE index corresponding to a CCE constituting a PCC PDCCH, and $n_{\text{CCE},\text{SCC}}$ represents a lowest CCE index corresponding to a CCE constituting an SCC PDCCH. $N_{\text{PUCCH}}^{(1)}$ is a signaling value transmitted from a higher layer (e.g. RRC) and α is an offset value according to an ARI.

Offsets for PUCCH index #3 ($n_{\text{PUCCH},3}^{(1)}$) and PUCCH index #4 ($n_{\text{PUCCH},4}^{(1)}$) may be independently provided.

Embodiment 2: Case in which an implicit resource is used for a specific DL CC from among a plurality of PDCCH monitoring CCs and explicit resources are used for the remaining DL CCs

FIG. 12 illustrates a method of allocating PUCCH resources for ACK/NACK transmission. The present embodiment exemplifies a case in which an implicit PUCCH resource is used for a PDCCH transmitted through a specific DL CC (e.g. PCC) and explicit PUCCH resources are used for PDCCHs transmitted through the remaining DL CC(s).

Referring to FIG. 12, the UE can receive PDSCH-scheduling PDCCHs through a plurality of DL CCs. The figure shows a case in which one PDCCH is received on each of a PCC and an SCC. The UE receives a PDSCH signal corresponding to each PDCCH. In a MIMO mode, up to 2 codewords can be transmitted through each PDSCH. In the present embodiment, 2 PUCCH resources linked to a PCC PDCCH can be allocated to the UE for ACK/NACK transmission for 2 codewords (or TBs) transmitted through a PDSCH scheduled by the PCC PDCCH. For 2 codewords (or TBs) transmitted through a PDSCH scheduled by an SCC PDCCH, 2 explicit PUCCH resources can be pre-allocated to the UE for ACK/NACK transmission. The UE feeds back a plurality of ACK/NACKs using ACK/NACK channel selection. That is, the UE transmits bit values corresponding to a plurality of ACK/NACKs using one of the plural PUCCH resources.

To reduce the quantity of PUCCH resources necessary for the system, the same explicit PUCCH resource can be allocated to a plurality of UEs. In this case, the explicit PUCCH resource can be changed/indicated using ARI information included in a PDCCH. The ARI information may be included in a PCC PDCCH and/or an SCC PDCCH. The ARI information is preferably included in a PDCCH (e.g. a PDCCH transmitted through an SCC) which is not used to designate an implicit PUCCH resource.

The ARI information can include an offset value used to change an explicit PUCCH resource, for example. In this case, the ARI information can be used to change a PUCCH

index. A changed cyclic shift, a changed orthogonal cover and/or a changed PRB can be obtained from the changed PUCCH index. In addition the ARI (e.g. offset value) can be used to directly change at least one of a cyclic shift, an orthogonal cover and a PRB.

Table 4 shows explicit PUCCH resources according to the present embodiment. In the table, the higher layer includes the RRC (Radio Resource Control) layer. The present embodiment can be applied to a case in which an explicit PUCCH resource is changed in the following embodiments.

[Table 4]

ARI (2 bits)	PUCCH index #1	PUCCH index #2
00	The 1-1st PUCCH resource value configured by the higher layers	The 1-2st PUCCH resource value configured by the higher layers
01	The 1-1st PUCCH resource value + $\alpha_{1,1}$	The 1-2st PUCCH resource value + $\alpha_{2,1}$
10	The 1-1st PUCCH resource value + $\alpha_{1,2}$	The 1-2st PUCCH resource value + $\alpha_{2,2}$
11	The 1-1st PUCCH resource value + $\alpha_{1,3}$	The 1-2st PUCCH resource value + $\alpha_{2,3}$

In the table, $\alpha_{1,1} \sim \alpha_{2,3}$ denote offsets according to ARI values.

The ARI information can indicate different explicit PUCCH resource sets. An explicit resource set corresponds to a plurality of explicit resources allocated per PDCCH. For example, the explicit resource set includes a PUCCH resource pair.

Table 5 shows explicit PUCCH resources according to the present embodiment. The present embodiment can be applied to a case in which an explicit PUCCH resource is indicated in the following embodiments in a similar way.

[Table 5]

ARI (2 bits)	PUCCH index #1	PUCCH index #2
00	The 1-1st PUCCH resource value configured by the higher layers	The 1-2st PUCCH resource value configured by the higher layers
01	The 2-1nd PUCCH resource value configured by the higher layers	The 2-2nd PUCCH resource value configured by the higher layers
10	The 3-1rd PUCCH resource value configured by the higher layers	The 3-2rd PUCCH resource value configured by the higher layers
11	The 4-1th PUCCH resource value	The 4-2th PUCCH resource value

	configured by the higher layers	configured by the higher layers
--	---------------------------------	---------------------------------

When a plurality of SCC PDCCHs is transmitted and explicit PUCCH resources are used for the same, each SCC PDCCH can include ARI information. Here, the SCC PDCCHs may have the same ARI information (e.g. PUCCH resource offset value or PUCCH resource set). Alternatively, the SCC PDCCHs may include independent ARIs.

The above-described embodiments describe the method of changing/designating only implicit information (embodiment 1) or only explicit information (embodiment 2) through the ARI information. However, the ARI information can also be used to selectively designate/change an implicit resource or an explicit resource. For example, the ARI information can indicate whether an implicit resource linked to a corresponding PDCCH is used (embodiment 1) or an explicit resource is used (embodiment 2). Alternatively, for 2 implicit PUCCH resources linked to a PDCCH, the ARI information can indicate whether the corresponding PUCCH resources are used or explicit resources are used. Alternatively, the ARI information can designate one of an implicit resource derived from the corresponding PDCCH, one or more resource set(s) represented as offsets with respect to the implicit resource, and one explicit resource set. Furthermore, the ARI information can designate one of an implicit resource and a plurality of explicit resource sets (or an explicit resource set and resources determined by offsets with respect to the explicit resource set) derived from the PDCCH. In addition, the ARI information can indicate one of an implicit resource derived from the PDCCH, one or more resource set(s) represented as offsets with respect to the implicit resource, and a plurality of explicit resource sets (or an explicit resource set and resources determined by offsets with respect to the explicit resource set).

Embodiment 3: Case in which a combination of an implicit resource and an explicit resource is used for a specific DL CC from among a plurality of PDCCH monitoring CCs and explicit resources are used for the remaining DL CCs

FIG. 13 illustrates a method of allocating PUCCH resources for ACK/NACK transmission. The present embodiment exemplifies a case in which an implicit PUCCH resource is allocated for a PDCCH that schedules MIMO transmission of 2 codewords transmitted through a specific DL CC (e.g. PCC) and remaining PUCCH resources are allocated in an explicit manner.

Referring to FIG. 13, the UE can receive PDSCH-scheduling PDCCHs through a plurality of DL CCs. The figure shows a case in which one PDCCH is received on each of a PCC and an SCC. The UE receives a PDSCH signal corresponding to each PDCCH. In a MIMO mode, up to 2 codewords can be transmitted through each PDSCH. In the present

embodiment, one PUCCH resource linked to a PCC PDCCH can be allocated to the UE for ACK/NACK transmission for 2 codewords (or TBs) transmitted through a PDSCH scheduled by the PCC PDCCH. The remaining 3 PUCCH resources can be pre-allocated to the UE in an explicit manner. The UE feeds back a plurality of ACK/NACKs using ACK/NACK channel selection. That is, the UE transmits bit values corresponding to a plurality of ACK/NACKs using one of the plural PUCCH resources.

To reduce the quantity of PUCCH resources necessary for the system, the same explicit PUCCH resource can be allocated to a plurality of UEs. In this case, the explicit PUCCH resource can be changed/indicated using ARI information included in a PDCCH. The ARI information may be included in a PCC PDCCH and/or an SCC PDCCH. The ARI information is preferably included in a PDCCH (e.g. a PDCCH transmitted through an SCC) which is not used to designate an implicit PUCCH resource.

The ARI information can include an offset value used to change an explicit PUCCH resource, for example (refer to Table 4). In this case, the ARI information can be used to change a PUCCH index. A changed cyclic shift, a changed orthogonal cover and/or a changed PRB can be obtained from the changed PUCCH index. In addition the ARI (e.g. offset value) can be used to directly change at least one of a cyclic shift, an orthogonal cover and a PRB. Furthermore, the ARI information can designate different explicit PUCCH resource sets (refer to Table 5). An explicit resource set corresponds to a plurality of explicit resources allocated per PDCCH. For example, the explicit resource set includes a PUCCH resource pair.

A PUCCH resource changed by an ARI may correspond to some of all explicit PUCCH resources. For example, one of 3 explicit PUCCH resources shown in FIG. 13 can be used only for mapping of ACK/NACK information with respect to a PDSCH scheduled on the PCC. In this case, ARI information of the SCC PDCCH may not be applied to the corresponding PUCCH resource. This can avoid generation of an error in an ACK/NACK response to the PDSCH transmitted on the PCC when the UE misses the SCC PDCCH.

When a plurality of SCC PDCCHs is transmitted and explicit PUCCH resources are used for the same, each SCC PDCCH can include ARI information. Here, the SCC PDCCHs may have the same ARI information (e.g. PUCCH resource offset value or PUCCH resource set). Otherwise, the SCC PDCCHs may include independent ARIs.

The above-described embodiments describe a method of changing/designating only implicit information (embodiment 1) or only explicit information (embodiment 3) through the ARI information. However, the ARI information can also be used to selectively

designate/change an implicit resource or an explicit resource. For example, the ARI information can indicate whether an implicit resource linked to the corresponding PDCCH is used (embodiment 1) or an explicit resource is used (embodiment 3). Preferably, for 2 implicit PUCCH resources linked to a PDCCH, the ARI information can indicate whether the corresponding PUCCH resources are used or explicit resources are used. More preferably, the ARI information can designate one of an implicit resource derived from the PDCCH, one or more resource set(s) represented as offsets with respect to the implicit resource, and one explicit resource set. Otherwise, the ARI information can designate one of an implicit resource and a plurality of explicit resource sets (or an explicit resource set and resources determined by offsets with respect to the explicit resource set) derived from the PDCCH. Alternatively, the ARI information can indicate one of an implicit resource derived from the PDCCH, one or more resource set(s) represented as offsets with respect to the implicit resource, and a plurality of explicit resource sets (or an explicit resource set and resources determined by offsets with respect to the explicit resource set).

Embodiment 4: Case in which a plurality of PDCCHs is transmitted through a PDCCH monitoring CC and a combination of an implicit resource and an explicit resource is used for each PDCCH

FIG. 14 illustrates a method of allocating PUCCH resources for ACK/NACK transmission. The present embodiment exemplifies a case in which an implicit PUCCH resource is allocated for a PDCCH that schedules MIMO transmission of 2 codewords transmitted through a PDCCH monitoring CC (e.g. PCC) and an additional explicit PUCCH resource is pre-allocated per PDCCH.

Referring to FIG. 14, the UE can receive a plurality of PDSCH-scheduling PDCCHs through one PDCCH monitoring CC. The figure shows a case in which a plurality of PDCCHs is received on the PCC. The UE receives a PDSCH signal corresponding to each PDCCH. In a MIMO mode, up to 2 codewords can be transmitted through each PDSCH. In the present embodiment, one PUCCH resource linked to each PDCCH can be allocated to the UE for ACK/NACK transmission and 2 PUCCH resources can be pre-allocated in an explicit manner. The UE feeds back a plurality of ACK/NACKs using ACK/NACK channel selection. That is, the UE transmits bit values corresponding to a plurality of ACK/NACKs using one of the plural PUCCH resources.

To reduce the quantity of PUCCH resources necessary for the system, the same explicit PUCCH resource can be allocated to a plurality of UEs. In this case, the explicit PUCCH resource can be changed/indicated using ARI information included in a PDCCH.

The ARI information may be included in a PCC PDCCH and/or an SCC PDCCH. The ARI information is preferably included in a PDCCH (e.g. a PDCCH transmitted through an SCC) which is not used to designate an implicit PUCCH resource.

The ARI information can include an offset value used to change an explicit PUCCH resource, for example. In this case, the ARI information can be used to change a PUCCH index (refer to Table 4). A changed cyclic shift, a changed orthogonal cover and/or a changed PRB can be obtained from the changed PUCCH index. In addition the ARI (e.g. offset value) can be used to directly change at least one of a cyclic shift, an orthogonal cover and a PRB. Furthermore, the ARI information can designate different explicit PUCCH resource sets (refer to Table 5). An explicit resource set corresponds to a plurality of explicit resources allocated per PDCCH. For example, the explicit resource set includes a PUCCH resource pair.

A PUCCH resource changed by an ARI may correspond to some of all explicit PUCCH resources. For example, one of 2 explicit PUCCH resources shown in FIG. 13 can be used only for mapping of ACK/NACK information with respect to a PDSCH scheduled on the PCC. In this case, ARI information of the SCC PDCCH may not be applied to the corresponding PUCCH resource. This can avoid generation of an error in an ACK/NACK response to the PDSCH transmitted on the PCC when the UE misses the SCC PDCCH.

When a plurality of SCC PDCCHs is transmitted and explicit PUCCH resources are used for the same, each SCC PDCCH can include ARI information. Here, the SCC PDCCHs may have the same ARI information (e.g. PUCCH resource offset value or PUCCH resource set). Otherwise, the SCC PDCCHs may include independent ARIs.

Alternatively, an implicit resource and an explicit resource may be selectively used using the ARI information for the second PUCCH resource allocated for each PDCCH. For example, the ARI information can indicate whether an implicit resource linked to a corresponding PDCCH is used (embodiment 1) or an explicit resource is used (embodiment 4). Furthermore, the ARI information can designate one of an implicit resource derived from the corresponding PDCCH, one or more resource(s) represented as offsets for the implicit resource and an explicit resource. In addition, the ARI information can designate one of an implicit resource and a plurality of explicit resources (or an explicit resource and resources determined by offsets with respect to the explicit resource) derived from the PDCCH. Otherwise, the ARI information can indicate one of an implicit resource derived from the PDCCH, one or more resource(s) represented as offsets with respect to the implicit

resource, and a plurality of explicit resources (or an explicit resource and resources determined by offsets with respect to the explicit resource).

Embodiment 5: Case in which a plurality of PDCCHs is transmitted through a PDCCH monitoring CC and implicit resources are used for all PDCCHs

FIG. 15 illustrates a method of allocating PUCCH resources for ACK/NACK transmission. The present embodiment exemplifies a case in which implicit PUCCH resources are used for all PDCCHs.

Referring to FIG. 15, the UE can receive a plurality of PDSCH-scheduling PDCCHs through one PDCCH monitoring CC. The figure shows a case in which a plurality of PDCCHs is received on the PCC. The UE receives a PDSCH signal corresponding to each PDCCH. In a MIMO mode, up to 2 codewords can be transmitted through each PDSCH. In the present embodiment, 2 PUCCH resources linked to each PDCCH can be allocated to the UE such that the UE can transmit ACK/NACKs for 2 codewords transmitted over each PDSCH. The UE feeds back a plurality of ACK/NACKs using ACK/NACK channel selection. That is, the UE transmits bit values corresponding to a plurality of ACK/NACKs using one of the plural PUCCH resources.

For 2 codewords corresponding to one PDCCH, 2 PUCCH resources linked to 2 CCEs (e.g. first and second CCEs) constituting the corresponding PDCCH can be allocated. For example, the 2 PUCCH resources linked to the PDCCH may be a PUCCH resource linked to the first CCE (i.e. CCE index = n_{CCE}) constituting the PDCCH and a PUCCH resource linked to a CCE (i.e. CCE index = $n_{\text{CCE}} + 1$) contiguous to the first CCE. Here, if the PDCCH is configured of only one CCE, an allocated PUCCH resource may collide with a PUCCH resource used by another UE.

Accordingly, the present embodiment proposes a scheme of changing all PUCCH resources or some of the PUCCH resources (e.g. a PUCCH resource linked to the second CCE) linked to a PDCCH through ARI information signaled through the PDCCH when a plurality of PUCCH resources are allocated by using linkage with one PDCCH resource. For example, it is possible to change all the PUCCH resources or some of the PUCCH resources (e.g. a PUCCH resource linked to the second CCE) linked to the PDCCH by a specific offset using the ARI information. That is, the ARI information can be used for a case in which a PUCCH resource is not changed and a case in which the PUCCH resource is changed by one of one or more offsets values. The figure shows a scheme of changing only one of 2 PUCCH resources linked to an SCC PDCCH using ARI information.

The ARI information may be included only in the PCC PDCCH to change only a PUCCH resource linked to the PCC PDCCH. Otherwise, the ARI information may be included only in the SCC PDCCH to change only a PUCCH resource linked to the SCC PDCCH. When a plurality of SCC PDCCHs is present, ARI information included in each SCC PDCCH can be applied only to PUCCH resources linked to the corresponding SCC PDCCH. That is, ARI information included in the SCC PDCCHs can be independently set.

An ARI (e.g. offset value) can be used to change PUCCH index linked to a PDCCH. Accordingly, a changed cyclic shift, a changed orthogonal cover and/or a changed PRB can be obtained from the changed PUCCH index. In addition the ARI (e.g. offset value) can be used to directly change at least one of a cyclic shift, an orthogonal cover and a PRB.

Alternatively, it is possible to selectively use an implicit resource or an explicit resource using ARI information for all/some PUCCH resources allocated per PDCCH. For example, ARI information can designate one of an implicit resource derived from the corresponding PDCCH, one or more resources represented as offsets with respect to the implicit resource, and one explicit resource. Otherwise, the ARI information can indicate one of an implicit resource and a plurality of explicit resources (or an explicit resource and resources determined by offsets with respect to the explicit resource) which are derived from the PDCCH. Furthermore, the ARI information can designate one of an implicit resource derived from the PDCCH, one or more resources represented as offsets with respect to the implicit resource, and a plurality of explicit resources (or an explicit resource and resources determined by offsets with respect to the explicit resource).

Embodiment 6: Case in which PDCCHs are transmitted through a plurality of PDCCH monitoring CCs and a combination of an implicit resource and an explicit resource is used for each PDCCH

FIG. 16 illustrates a method of allocating PUCCH resources for ACK/NACK transmission. The present embodiment exemplifies a case in which an implicit PUCCH resource is allocated for each PDCCH that schedules MIMO transmission of 2 codewords transmitted through each DL CC and an explicit PUCCH resource is additionally pre-allocated for each DL CC available for MIMO transmission.

Referring to FIG. 16, the UE can receive PDSCH-scheduling PDCCHs through a plurality of DL CCs. The figure shows a case in which one PDCCH is received on each of a PCC and an SCC. The UE receives a PDSCH signal corresponding to each PDCCH. In a MIMO mode, up to 2 codewords can be transmitted through each PDSCH. In the present embodiment, one PUCCH resource linked to each PDCCH can be allocated to the UE for

ACK/NACK transmission and the remaining PUCCH resources can be pre-allocated to the UE in an explicit manner. Then, the UE feeds back a plurality of ACK/NACKs using ACK/NACK channel selection. That is, the UE transmits bit values corresponding to a plurality of ACK/NACKs using one of the plural PUCCH resources.

To reduce the quantity of PUCCH resources necessary for the system, the same explicit PUCCH resource can be allocated to a plurality of UEs. In this case, the explicit PUCCH resource can be changed/indicated using ARI information included in a PDCCH. The ARI information may be included in a PCC PDCCH and/or an SCC PDCCH. The ARI information is preferably included in a PDCCH (e.g. a PDCCH transmitted through an SCC) which is not used to designate an implicit PUCCH resource.

The ARI information can include an offset value used to change an explicit PUCCH resource, for example. In this case, the ARI information can be used to change a PUCCH index (refer to Table 4). A changed cyclic shift, a changed orthogonal cover and/or a changed PRB can be obtained from the changed PUCCH index. In addition the ARI (e.g. offset value) can be used to directly change at least one of a cyclic shift, an orthogonal cover and a PRB. Furthermore, the ARI information can designate different explicit PUCCH resource sets (refer to Table 5). An explicit resource set corresponds to a plurality of explicit resources allocated per PDCCH. For example, the explicit resource set includes a PUCCH resource pair.

A PUCCH resource changed by an ARI may correspond to some of all explicit PUCCH resources. For example, one of 2 explicit PUCCH resources shown in FIG. 13 can be used only for mapping of ACK/NACK information with respect to a PDSCH scheduled on the PCC. In this case, ARI information of the SCC PDCCH may not be applied to the corresponding PUCCH resource. This can avoid generation of an error in an ACK/NACK response to the PDSCH transmitted on the PCC when the UE misses the SCC PDCCH.

When a plurality of SCC PDCCHs is transmitted and explicit PUCCH resources are used for the same, each SCC PDCCH can include ARI information. Here, the SCC PDCCHs may have the same ARI information (e.g. PUCCH resource offset value or PUCCH resource set). Alternatively, the SCC PDCCHs may include independent ARIs.

An ARI transmitted through a PDCCH can change an implicit PUCCH resource linked to the PDCCH. That is, when implicit PUCCH resources linked to PDCCHs transmitted through different DL CCs are not separately secured for the same UL CC, the implicit PUCCH resources may collide. In this case, collision can be prevented using the

ARI. Here, ARI information can be included only in a PDCCH transmitted through a DL CC other than the PCC.

Alternatively, an implicit resource or an explicit resource may be selectively used using the ARI information for the second PUCCH resource allocated for each PDCCH. For example, the ARI information can indicate whether an implicit resource linked to a corresponding PDCCH is used (embodiment 1) or an explicit resource is used (embodiment 4). Furthermore, the ARI information can designate one of an implicit resource derived from the corresponding PDCCH, one or more resource(s) represented as offsets for the implicit resource and an explicit resource. In addition, the ARI information can designate one of an implicit resource and a plurality of explicit resources (or an explicit resource and resources determined by offsets with respect to the explicit resource) derived from the PDCCH. Alternatively, the ARI information can indicate one of an implicit resource derived from the PDCCH, one or more resource(s) represented as offsets with respect to the implicit resource, and a plurality of explicit resources (or an explicit resource and resources determined by offsets with respect to the explicit resource).

FIG. 17 illustrates a BS and a UE applicable to an embodiment of the present invention. When a wireless communication system includes a relay, communication is performed between a BS and the relay on a backhaul link and between the relay and a UE on an access link. The BS or UE shown in FIG. 16 can be replaced by a relay as necessary.

Referring to FIG. 17, an RF communication system includes a BS 110 and a UE 120. The BS 110 includes a processor 112, a memory 114 and an RF unit 116. The processor 112 may be configured to implement the procedures and/or methods proposed by the present invention. The memory 114 is connected to the processor 112 and stores various types of information relating to operations of the processor 112. The RF unit 116 is connected to the processor 112 and transmits and/or receives RF signals. The UE 120 includes a processor 122, a memory 124 and an RF unit 126. The processor 122 may be configured to implement the procedures and/or methods proposed by the present invention. The memory 124 is connected to the processor 122 and stores various types of information relating to operations of the processor 122. The RF unit 126 is connected to the processor 122 and transmits and/or receives RF signals. The BS 110 and the UE 120 may have a single antenna or multiple antennas.

The embodiments of the present invention described hereinbelow are combinations of elements and features of the present invention. The elements or features may be considered selective unless otherwise mentioned. Each element or feature may be practiced

without being combined with other elements or features. Further, an embodiment of the present invention may be constructed by combining parts of the elements and/or features. Operation orders described in embodiments of the present invention may be rearranged. Some constructions of any one embodiment may be included in another embodiment and may be replaced with corresponding constructions of another embodiment. It is obvious to those skilled in the art that claims that are not explicitly cited in each other in the appended claims may be presented in combination as an embodiment of the present invention or included as a new claim by a subsequent amendment after the application is filed.

In the embodiments of the present invention, a description is made, centering on a data transmission and reception relationship between a BS and a UE. In some cases, a specific operation described as performed by the BS may be performed by an upper node of the BS. Namely, it is apparent that, in a network comprised of a plurality of network nodes including a BS, various operations performed for communication with an MS may be performed by the BS, or network nodes other than the BS. The term 'eNB' may be replaced with the term 'fixed station', 'Node B', 'Base Station (BS)', 'access point', etc. The term 'UE' may be replaced with the term 'Mobile Station (MS)', 'Mobile Subscriber Station (MSS)', 'mobile terminal', etc.

The embodiments of the present invention may be achieved by various means, for example, hardware, firmware, software, or a combination thereof. In a hardware configuration, the methods according to the embodiments of the present invention may be achieved by one or more Application Specific Integrated Circuits (ASICs), Digital Signal Processors (DSPs), Digital Signal Processing Devices (DSPDs), Programmable Logic Devices (PLDs), Field Programmable Gate Arrays (FPGAs), processors, controllers, microcontrollers, microprocessors, etc.

In a firmware or software configuration, the embodiments of the present invention may be implemented in the form of a module, a procedure, a function, etc. For example, software code may be stored in a memory unit and executed by a processor. The memory unit is located at the interior or exterior of the processor and may transmit and receive data to and from the processor via various known means.

Those skilled in the art will appreciate that the present invention may be carried out in other specific ways than those set forth herein without departing from the spirit and essential characteristics of the present invention. The above embodiments are therefore to be construed in all aspects as illustrative and not restrictive. The scope of the invention should be determined by the appended claims and their legal equivalents, not by the above

description, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

【Industrial Applicability】

The present invention is applicable to wireless communication apparatuses such as a UE, a relay, a BS, etc.

【CLAIMS】

【Claim 1】

A method for transmitting uplink control information by a communication apparatus configured with a plurality of cells in a wireless communication system, the method comprising:

receiving a plurality of PDCCH (Physical Downlink Control Channel) signals on one cell;

receiving a plurality of PDSCH (Physical Downlink Shared Channel) signals indicated by the plurality of PDCCH signals;

generating a plurality of HARQ ACKs (Hybrid Automatic Repeat request – Acknowledgements) corresponding to the plurality of PDSCH signals; and

transmitting bit values corresponding to the plurality of HARQ ACKs using one of a plurality of PUCCH (Physical Uplink Control Channel) resources,

wherein the plurality of PUCCH resources includes a plurality of first PUCCH resources linked to a resource index for transmission of each PDCCH signal and at least one second PUCCH resource configured by a higher layer.

【Claim 2】

The method according to claim 1, wherein at least one of the plurality of PDCCH signals includes resource indication information for HARQ-ACK and the resource indication information for HARQ-ACK is used to change the at least one second PUCCH resource.

【Claim 3】

The method according to claim 2, wherein the resource indication information for HARQ-ACK includes an offset value.

【Claim 4】

The method according to claim 2, wherein the resource indication information for HARQ-ACK is included in a TPC (Transmit Power Control) field of a PDCCH signal corresponding to a PDSCH signal transmitted on a secondary cell.

【Claim 5】

The method according to claim 1, wherein at least one of the plurality of PDCCH signals includes resource indication information for HARQ-ACK, and the resource indication information includes information indicating the at least one second PUCCH resource from a second PUCCH resource candidate set configured by the higher layer.

【Claim 6】

The method according to claim 1, wherein the first PUCCH resources are indicated using a lowest CCE (Control Channel Element) index for transmission of a corresponding PDCCH signal.

【Claim 7】

The method according to claim 1, wherein the plurality of PDCCH signals is received on a primary cell.

【Claim 8】

A communication apparatus configured to transmit uplink control information when a plurality of cells is configured in a wireless communication system, the communication apparatus comprising:

- a radio frequency (RF) unit; and
- a processor,

wherein the processor is configured to receive a plurality of PDCCH (Physical Downlink Control Channel) signals on one cell, to receive a plurality of PDSCH signals indicated by the plurality of PDCCH (Physical Downlink Shared Channel) signals, to generate a plurality of HARQ ACKs (Hybrid Automatic Repeat request – Acknowledgements) corresponding to the plurality of PDSCH signals, and to transmit bit values corresponding to the plurality of HARQ ACKs using one of a plurality of PUCCH (Physical Uplink Control Channel) resources,

wherein the plurality of PUCCH resources includes a plurality of first PUCCH resources linked to a resource index for transmission of each PDCCH signal and at least one second PUCCH resource configured by a higher layer.

【Claim 9】

The communication apparatus according to claim 8, wherein at least one of the plurality of PDCCH signals includes resource indication information for HARQ-ACK and the resource indication information for HARQ-ACK is used to change the at least one second PUCCH resource.

【Claim 10】

The communication apparatus according to claim 9, wherein the resource indication information for HARQ-ACK includes an offset value.

【Claim 11】

The communication apparatus according to claim 9, wherein the resource indication information for HARQ-ACK is included in a TPC (Transmit Power Control) field of a PDCCH signal corresponding to a PDSCH signal transmitted on a secondary cell.

【Claim 12】

The communication apparatus according to claim 8, wherein at least one of the plurality of PDCCH signals includes resource indication information for HARQ-ACK, and the resource indication information includes information indicating the at least one second PUCCH resource from a second PUCCH resource candidate set configured by the higher layer.

【Claim 13】

The communication apparatus according to claim 8, wherein the first PUCCH resources are indicated using a lowest CCE (Control Channel Element) index for transmission of a corresponding PDCCH signal.

【Claim 14】

The communication apparatus according to claim 8, wherein the plurality of PDCCH signals is received on a primary cell.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2011/006611**A. CLASSIFICATION OF SUBJECT MATTER****H04L 1/18(2006.01)i, H04L 27/26(2006.01)i, H04B 7/26(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)

H04L 1/18

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: IPC as above

Japanese Utility models and applications for Utility models: IPC as above

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

eKOMPASS (KIPO internal) & Keywords: PDCCH, PDSCH, PUCCH, ACK/NACK, resource mapping, TPC(Transmit Power Field), CCE index, primary cell, secondary cell;

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	Samsung, "PUCCH HARQ-ACK Resource Mapping for DL CA" 3GPP TSG RAN WG1 #61bis, R1-103637, 28 June - 2 July, 2010 See section 2 and figure 1.	1-14
Y	Huawei, "Resource allocation for uplink ACK/NACK multiplexing", 3GPP TSG RAN WG1 #62, R1-104282, 23-27 August, 2010. See section 2 and tables 1-3.	1-14
A	Texas Instruments, "Resource Allocation for A/N Transmission on PUCCH", 3GPP TSG RAN WG1 #62, R1-104466, 23-27 August, 2010. See section 2.1 and section 2.2	1-14
A	Pantech, "UL PUCCH A/N resource allocation for CA" 3GPP TSG RAN WG1 #62, R1-104632, 23-27 August, 2010. See section 2.	1-14

☐ 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 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

24 FEBRUARY 2012 (24.02.2012)

Date of mailing of the international search report

24 FEBRUARY 2012 (24.02.2012)

Name and mailing address of the ISA/KR



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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2011/006611

Patent document cited in search report	Publication date	Patent family member	Publication date
NONE			

A. 발명이 속하는 기술분류(국제특허분류(IPC))		
H04L 1/18(2006.01)i, H04L 27/26(2006.01)i, H04B 7/26(2006.01)i		
B. 조사된 분야		
조사된 최소문헌(국제특허분류를 기재) H04L 1/18		
조사된 기술분야에 속하는 최소문헌 이외의 문헌 한국등록실용신안공보 및 한국공개실용신안공보: 조사된 최소문헌란에 기재된 IPC 일본등록실용신안공보 및 일본공개실용신안공보: 조사된 최소문헌란에 기재된 IPC		
국제조사에 이용된 전산 데이터베이스(데이터베이스의 명칭 및 검색어(해당하는 경우)) eKOMPASS(특허청 내부 검색시스템) & 키워드: PDCCH, PDSCH, PUCCH, ACK/NACK, resource mapping, TPC(Transmit Power Field), CCE index, primary cell, secondary cell;		
C. 관련 문헌		
카테고리*	인용문헌명 및 관련 구절(해당하는 경우)의 기재	관련 청구항
Y	Samsung, "PUCCH HARQ-ACK Resource Mapping for DL CA", 3GPP TSG RAN WG1 #61bis, R1-103637, 28 June - 2 July, 2010. 2절 및 Figure 1 참조.	1-14
Y	Huawei, "Resource allocation for uplink ACK/NACK multiplexing", 3GPP TSG RAN WG1 #62, R1-104282, 23-27 August, 2010. 2절 및 Table 1-3 참조.	1-14
A	Texas Instruments, "Resource Allocation for A/N Transmission on PUCCH", 3GPP TSG RAN WG1 #62, R1-104466, 23-27 August, 2010. 2.1절 및 2.2절 참조.	1-14
A	Pantech, "UL PUCCH A/N resource allocation for CA", 3GPP TSG RAN WG1 #62, R1-104632, 23-27 August, 2010. 2절 참조.	1-14

☐ 추가 문헌이 C(계속)에 기재되어 있습니다.

☒ 대응특허에 관한 별지를 참조하십시오.

* 인용된 문헌의 특별 카테고리:

"A" 특별히 관련이 없는 것으로 보이는 일반적인 기술수준을 정의한 문헌

"E" 국제출원일보다 빠른 출원일 또는 우선일을 가지나 국제출원일 이후에 공개된 선출원 또는 특허 문헌

"L" 우선권 주장에 의문을 제기하는 문헌 또는 다른 인용문헌의 공개일 또는 다른 특별한 이유(이유를 명시)를 밝히기 위하여 인용된 문헌

"O" 구두 개시, 사용, 전시 또는 기타 수단을 언급하고 있는 문헌

"P" 우선일 이후에 공개되었으나 국제출원일 이전에 공개된 문헌

"T" 국제출원일 또는 우선일 후에 공개된 문헌으로, 출원과 상충하지 않으며 발명의 기초가 되는 원리나 이론을 이해하기 위해 인용된 문헌

"X" 특별한 관련이 있는 문헌. 해당 문헌 하나만으로 청구된 발명의 신규성 또는 진보성이 없는 것으로 본다.

"Y" 특별한 관련이 있는 문헌. 해당 문헌이 하나 이상의 다른 문헌과 조합하는 경우로 그 조합이 당업자에게 자명한 경우 청구된 발명은 진보성이 없는 것으로 본다.

"&" 동일한 대응특허문헌에 속하는 문헌

국제조사의 실제 완료일 2012년 02월 24일 (24.02.2012)	국제조사보고서 발송일 2012년 02월 24일 (24.02.2012)
ISA/KR의 명칭 및 우편주소 대한민국 특허청 (302-701) 대전광역시 서구 청사로 189. 정부대전청사 팩스 번호 82-42-472-7140	심사관 성정아 전화번호 82-42-481-8171



국제조사보고서에서 인용된 특허문헌	공개일	대응특허문헌	공개일
없음			

Electronic Patent Application Fee Transmittal				
Application Number:		16203391		
Filing Date:		28-Nov-2018		
Title of Invention:		PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION		
First Named Inventor/Applicant Name:		Havish Koorapaty		
Filer:		Taylor Merritt Meacham/Akiko Cline		
Attorney Docket Number:		P73334-US2		
Filed as Large Entity				
Filing Fees for Utility under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	1806	1	240	240
Total in USD (\$)				240

Electronic Acknowledgement Receipt	
EFS ID:	35491223
Application Number:	16203391
International Application Number:	
Confirmation Number:	3937
Title of Invention:	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION
First Named Inventor/Applicant Name:	Havish Koorapaty
Customer Number:	27045
Filer:	Taylor Merritt Meacham/Akiko Cline
Filer Authorized By:	Taylor Merritt Meacham
Attorney Docket Number:	P73334-US2
Receipt Date:	21-MAR-2019
Filing Date:	28-NOV-2018
Time Stamp:	14:09:15
Application Type:	Utility under 35 USC 111(a)

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Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$240
RAM confirmation Number	032219INTEFSW00000368501379
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The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:					
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1	Information Disclosure Statement (IDS) Form (SB08)	P73334-US2_2019-03-21_195336_IDS.pdf	612178	no	4
			57d8f70752b5e3978d5c449ccdb13feba918d35d		
Warnings:					
Information:					
2	Foreign Reference	WO2012050389A1.pdf	461555	no	39
			62da7d262da89c05912053b403c00cb21b078f00		
Warnings:					
Information:					
3	Foreign Reference	WO2014051508A1.pdf	557573	no	48
			c7511ed9fc97ab5a1d54b4279656fe1cd48368ad		
Warnings:					
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			ea76706c9b59cbe78e5372a6804bb37e753201		
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5	Fee Worksheet (SB06)	fee-info.pdf	30626	no	2
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NOTICE OF ALLOWANCE AND FEE(S) DUE

27045 7590 03/13/2019
ERICSSON INC.
6300 LEGACY DRIVE
M/S EVR 1-C-11
PLANO, TX 75024

EXAMINER

CHOI, EUNSOOK

ART UNIT

PAPER NUMBER

2467

DATE MAILED: 03/13/2019

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/203,391	11/28/2018	Havish Koorapaty	P73334-US2	3937

TITLE OF INVENTION: PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	\$1000	\$0.00	\$0.00	\$1000	06/13/2019

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: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (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)

27045 7590 03/13/2019
ERICSSON INC.
6300 LEGACY DRIVE
M/S EVR 1-C-11
PLANO, TX 75024

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 transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/203,391	11/28/2018	Havish Koorapaty	P73334-US2	3937

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nonprovisional	UNDISCOUNTED	\$1000	\$0.00	\$0.00	\$1000	06/13/2019

EXAMINER	ART UNIT	CLASS-SUBCLASS
CHOI, EUNSOOK	2467	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 03-09 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 must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). 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. Fees submitted: ☐ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies _____

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

☐ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. Change in Entity Status (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

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.

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.

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. _____



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.
16/203,391	11/28/2018	Havish Koorapaty	P73334-US2	3937
27045	7590	03/13/2019	EXAMINER	
ERICSSON INC.			CHOI, EUNSOOK	
6300 LEGACY DRIVE				
M/S EVR 1-C-11			ART UNIT	
PLANO, TX 75024			PAPER NUMBER	
			2467	
DATE MAILED: 03/13/2019				

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.

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 30 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. 16/203,391	Applicant(s) Koorapaty et al.	
	Examiner EUNSOOK CHOI	Art Unit 2467	AIA (FITF) Status Yes

-- 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 interview on 3/5/2019.
☐ 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 See Continuation Sheet. 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. <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) 2. <input type="checkbox"/> Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____. 3. <input type="checkbox"/> Examiner's Comment Regarding Requirement for Deposit of Biological Material _____. 4. <input checked="" type="checkbox"/> Interview Summary (PTO-413), Paper No./Mail Date _____.	5. <input checked="" type="checkbox"/> Examiner's Amendment/Comment 6. <input checked="" type="checkbox"/> Examiner's Statement of Reasons for Allowance 7. <input type="checkbox"/> Other _____.
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/EUNSOOK CHOI/ Primary Examiner, Art Unit 2467	
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Continuation of 3. The allowed claim(s) is/are: 1-2,4-8,10-13 and 15-26

DETAILED ACTION

Notice of Pre-AIA or AIA Status

1. The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Reasons for Allowance

2. The following is an examiner's statement of reasons for allowance: none of LUNTTILA et al. (US 20180102892) , Tirola et al. (US 20180097609) and other cited art does not teach the claims as amended as a whole with the following limitation "wherein the signaling received from the network node comprises information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources.. selecting one of the two or more uplink control channel resource sets, and selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node".

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."

EXAMINER'S AMENDMENT

3. 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 Mr. Ben Westover on 3/5/2019.

The claims filed on 12/31/2018 has been amended as follows:

- Refer to the attachment.

Conclusion

4. Any inquiry concerning this communication or earlier communications from the examiner should be directed to EUNSOOK CHOI whose telephone number is (571)270-1822. The examiner can normally be reached on 8am-4:30pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Hassan Phillips can be reached on 5712723940. 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.

/EUNSOOK CHOI/
Primary Examiner, Art Unit 2467

<i>Applicant-Initiated Interview Summary</i>	Application No. 16/203,391	Applicant(s) Koorapaty et al.	
	Examiner EUNSOOK CHOI	Art Unit 2467	AIA (FITF) Status Yes

All participants (applicant, applicants representative, PTO personnel):

(1) EUNSOOK CHOI. (3) ____.

(2) Mr. Ben Westover (Reg No: 56612). (4) ____.

Date of Interview: 05 March 2019.

Type: ☒ Telephonic ☐ Video Conference
☐ Personal [copy given to: ☐ applicant ☐ applicant's representative]

Exhibit shown or demonstration conducted: ☐ Yes ☒ No.
If Yes, brief description: ____.

Issues Discussed ☐101 ☐112 ☐102 ☒103 ☐Others
(For each of the checked box(es) above, please describe below the issue and detailed description of the discussion)

Claim(s) discussed: 1.

Identification of prior art discussed: LUNTTILA and Tirola.

Substance of Interview
(For each issue discussed, provide a detailed description and indicate if agreement was reached. Some topics may include: identification or clarification of a reference or a portion thereof, claim interpretation, proposed amendments, arguments of any applied references etc...)

Applicants' representative has argued that neither LUNTTILA nor Tirola teaches "determining the uplink control channel resource to use for transmitting the uplink control information comprises determining the uplink control channel resource based on[:]] (a) signaling received from the network node and (b) resource determination performed by the wireless device based on a latest received one of the first downlink control channel message and the second downlink control channel message; and transmitting the uplink control information using the determined uplink control channel resource". Examiner has responded that (a) is taught by Tirola and (b) is taught by LUNTTILA. Claim limitation "a latest received one " is broad limitation and processed by Fig. 9 of LUNTTILA .

No agreement to further prosecute the application has met. Mr Westover suggested to incorporate claim 3 which was objected for the compact prosecution of the application..

Applicant recordation instructions: The formal written reply to the last Office action must include the substance of the interview. (See MPEP section 713.04). If a reply to the last Office action has already been filed, applicant is given a non-extendable period of the longer of one month or thirty days from this interview date, or the mailing date of this interview summary form, whichever is later, to file a statement of the substance of the interview

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

☒ Attachment

/EUNSOOK CHOI/ Primary Examiner, Art Unit 2467	
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Summary of Record of Interview Requirements

Manual of Patent Examining Procedure (MPEP), Section 713.04, Substance of Interview Must be Made of Record

A complete written statement as to the substance of any face-to-face, video conference, or telephone interview with regard to an application must be made of record in the application whether or not an agreement with the examiner was reached at the interview.

Title 37 Code of Federal Regulations (CFR) 1.133 Interviews

Paragraph (b)

In every instance where reconsideration is requested in view of an interview with an examiner, a complete written statement of the reasons presented at the interview as warranting favorable action must be filed by the applicant. An interview does not remove the necessity for reply to Office action as specified in §§ 1.111, 1.135. (35 U.S.C. 132)

37 CFR §1.2 Business to be transacted in writing.

All business with the Patent or Trademark Office should be transacted in writing. The personal attendance of applicants or their attorneys or agents at the Patent and Trademark Office is unnecessary. The action of the Patent and Trademark Office will be based exclusively on the written record in the Office. No attention will be paid to any alleged oral promise, stipulation, or understanding in relation to which there is disagreement or doubt.

The action of the Patent and Trademark Office cannot be based exclusively on the written record in the Office if that record is itself incomplete through the failure to record the substance of interviews.

It is the responsibility of the applicant or the attorney or agent to make the substance of an interview of record in the application file, unless the examiner indicates he or she will do so. It is the examiners responsibility to see that such a record is made and to correct material inaccuracies which bear directly on the question of patentability.

Examiners must complete an Interview Summary Form for each interview held where a matter of substance has been discussed during the interview by checking the appropriate boxes and filling in the blanks. Discussions regarding only procedural matters, directed solely to restriction requirements for which interview recordation is otherwise provided for in Section 812.01 of the Manual of Patent Examining Procedure, or pointing out typographical errors or unreadable script in Office actions or the like, are excluded from the interview recordation procedures below. Where the substance of an interview is completely recorded in an Examiners Amendment, no separate Interview Summary Record is required.

The Interview Summary Form shall be given an appropriate Paper No., placed in the right hand portion of the file, and listed on the "Contents" section of the file wrapper. In a personal interview, a duplicate of the Form is given to the applicant (or attorney or agent) at the conclusion of the interview. In the case of a telephone or video-conference interview, the copy is mailed to the applicants correspondence address either with or prior to the next official communication. If additional correspondence from the examiner is not likely before an allowance or if other circumstances dictate, the Form should be mailed promptly after the interview rather than with the next official communication.

The Form provides for recordation of the following information:

- Application Number (Series Code and Serial Number)
- Name of applicant
- Name of examiner
- Date of interview
- Type of interview (telephonic, video-conference, or personal)
- Name of participant(s) (applicant, attorney or agent, examiner, other PTO personnel, etc.)
- An indication whether or not an exhibit was shown or a demonstration conducted
- An identification of the specific prior art discussed
- An indication whether an agreement was reached and if so, a description of the general nature of the agreement (may be by attachment of a copy of amendments or claims agreed as being allowable). Note: Agreement as to allowability is tentative and does not restrict further action by the examiner to the contrary.
- The signature of the examiner who conducted the interview (if Form is not an attachment to a signed Office action)

It is desirable that the examiner orally remind the applicant of his or her obligation to record the substance of the interview of each case. It should be noted, however, that the Interview Summary Form will not normally be considered a complete and proper recordation of the interview unless it includes, or is supplemented by the applicant or the examiner to include, all of the applicable items required below concerning the substance of the interview.

A complete and proper recordation of the substance of any interview should include at least the following applicable items:

- 1) A brief description of the nature of any exhibit shown or any demonstration conducted, -
- 2) an identification of the claims discussed,
- 3) an identification of the specific prior art discussed,
- 4) an identification of the principal proposed amendments of a substantive nature discussed, unless these are already described on the Interview Summary Form completed by the Examiner,
- 5) a brief identification of the general thrust of the principal arguments presented to the examiner,
(The identification of arguments need not be lengthy or elaborate. A verbatim or highly detailed description of the arguments is not required. The identification of the arguments is sufficient if the general nature or thrust of the principal arguments made to the examiner can be understood in the context of the application file. Of course, the applicant may desire to emphasize and fully describe those arguments which he or she feels were or might be persuasive to the examiner.)
- 6) a general indication of any other pertinent matters discussed, and
- 7) if appropriate, the general results or outcome of the interview unless already described in the Interview Summary Form completed by the examiner.

Examiners are expected to carefully review the applicants record of the substance of an interview. If the record is not complete and accurate, the examiner will give the applicant an extendable one month time period to correct the record.

Examiner to Check for Accuracy

If the claims are allowable for other reasons of record, the examiner should send a letter setting forth the examiners version of the statement attributed to him or her. If the record is complete and accurate, the examiner should place the indication, Interview Record OK on the paper recording the substance of the interview along with the date and the examiners initials.

Notice of References Cited	Application/Control No. 16/203,391		Applicant(s)/Patent Under Reexamination Koorapaty et al.	
	Examiner EUNSOOK CHOI		Art Unit 2467	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20190045533-A1	02-2019	Chatterjee; Debdeep	H04W72/1289	1/1
*	B	US-20150181588-A1	06-2015	Song; Xinghua	H04L1/1607	370/280
*	C	US-20180102892-A1	04-2018	LUNTTILA; Timo Erkki	H04L1/1607	1/1
*	D	US-20180054280-A1	02-2018	FU; Jingxing	H04B7/0621	1/1
*	E	US-20180097609-A1	04-2018	Tirola; Esa T.	H04L5/0055	1/1
*	F	US-20140003452-A1	01-2014	Han; Seunghee	H04L1/1657	370/474
*	G	US-20180295608-A1	10-2018	NGUYEN; Phong	H04L5/00	1/1
*	H	US-20180279351-A1	09-2018	SHIMEZAWA; Kazuyuki	H04W72/0446	1/1
*	I	US-20190052332-A1	02-2019	SHIMEZAWA; Kazuyuki	H04W72/0446	1/1
	J					
	K					
	L					
	M					


FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	


*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

Issue Classification 	Application/Control No. 16/203,391	Applicant(s)/Patent Under Reexamination Koorapaty et al.
	Examiner EUNSOOK CHOI	Art Unit 2467

CPC						
Symbol					Type	Version
H04W	/	72	/	1289	F	2013-01-01
H04W	/	88	/	023	I	2013-01-01
H04L	/	1	/	1819	I	2013-01-01
H04W	/	76	/	27	I	2018-02-01
H04W	/	72	/	02	I	2013-01-01
H04L	/	5	/	0055	I	2013-01-01
H04W	/	72	/	0406	I	2013-01-01
H04W	/	72	/	0446	I	2013-01-01

CPC Combination Sets				
Symbol	Type	Set	Ranking	Version
/				

NONE (Assistant Examiner) _____ (Date) _____		Total Claims Allowed: 23	
/EUNSOOK CHOI/ Primary Examiner, Art Unit 2467 (Primary Examiner) _____ (Date) 06 March 2019		O.G. Print Claim(s) 1	O.G. Print Figure 13

Issue Classification 	Application/Control No. 16/203,391	Applicant(s)/Patent Under Reexamination Koorapaty et al.
	Examiner EUNSOOK CHOI	Art Unit 2467


INTERNATIONAL CLASSIFICATION			
CLAIMED			
H04W		72	02

NON-CLAIMED			

US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS

CROSS REFERENCES(S)						
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					


NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	23	
/EUNSOOK CHOI/	06 March 2019	O.G. Print Claim(s)	O.G. Print Figure
Primary Examiner, Art Unit 2467	(Date)	1	13

Issue Classification 	Application/Control No. 16/203,391	Applicant(s)/Patent Under Reexamination Koorapaty et al.
	Examiner EUNSOOK CHOI	Art Unit 2467

<input type="checkbox"/> Claims renumbered in the same order as presented by applicant <input type="checkbox"/> CPA <input type="checkbox"/> T.D. <input type="checkbox"/> R.1.47

CLAIMS															
Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original
1	1	8	10	16	19										
2	2	9	11	17	20										
	3	10	12	18	21										
3	4	11	13	19	22										
4	5		14	20	23										
5	6	12	15	21	24										
6	7	13	16	22	25										
7	8	14	17	23	26										
	9	15	18												

NONE (Assistant Examiner) _____ (Date) _____		Total Claims Allowed: 23	
/EUNSOOK CHOI/ Primary Examiner, Art Unit 2467 (Primary Examiner) _____ (Date) 06 March 2019		O.G. Print Claim(s) 1	O.G. Print Figure 13

<i>Search Notes</i> 	Application/Control No. 16/203,391	Applicant(s)/Patent Under Reexamination Koorapaty et al.
	Examiner EUNSOOK CHOI	Art Unit 2467

CPC - Searched*		
Symbol	Date	Examiner
Limited text search (h04w72/1289 h04w88/023 h04w76/27 h04w72/0406 h04w72/0446 h04i1/1819 h04i5/0055)	03/06/2019	EC

CPC Combination Sets - Searched*		
Symbol	Date	Examiner


US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Refer to East search	02/13/2019	EC
Refer to updated East search	03/06/2019	EC

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
	Refer to East inventor search	02/13/2019	EC
	Refer to East search	03/06/2019	EC

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<i>Index of Claims</i> 	Application/Control No. 16/203,391	Applicant(s)/Patent Under Reexamination Koorapaty et al.
	Examiner EUNSOOK CHOI	Art Unit 2467

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

CLAIMS									
<input type="checkbox"/> Claims renumbered in the same order as presented by applicant <input type="checkbox"/> CPA <input type="checkbox"/> T.D. <input type="checkbox"/> R.1.47									
CLAIM		DATE							
Final	Original	02/13/2019	03/06/2019						
	1	✓	=						
	2	✓	=						
	3	○	-						
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	21		=						
	22		=						
	23		=						
	24		=						
	25		=						
	26		=						

Listing of claims:

1. (Currently Amended) A method performed by a wireless device, ~~the method~~ comprising:
 - receiving a first downlink control channel message that schedules a first downlink shared channel transmission;
 - receiving a second downlink control channel message that schedules a second downlink shared channel transmission;
 - determining an uplink control channel resource to use for transmitting uplink control information to a network node on an uplink control channel, wherein:
 - the uplink control information comprises Hybrid Automatic Repeat Request, HARQ, feedback for both the first downlink shared channel transmission and the second downlink shared channel transmission; and wherein
 - determining the uplink control channel resource to use for transmitting the uplink control information comprises determining the uplink control channel resource based on~~[[:]]~~ (a) signaling received from the network node and (b) resource determination performed by the wireless device based on a latest received one of the first downlink control channel message and the second downlink control channel message; and
 - transmitting the uplink control information using the determined uplink control channel resource;
 - wherein the signaling received from the network node comprises information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources; and
 - wherein determining the uplink control channel resource based on (a) and (b) comprises selecting one of the two or more uplink control channel resource sets, and selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node.
2. (Original) The method of claim 1 wherein the uplink control channel is a physical uplink control channel.

3. (Canceled)

4. (Currently Amended) The method of claim [[3]] 1 wherein:

each of the first downlink control channel message and the second downlink control channel message comprises bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set; and wherein

selecting the one of the two or more uplink control channel resources comprises selecting based on the bits comprised in the latest received one of the first downlink control channel message and the second downlink control channel message.

5. (Original) The method of claim 1, wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the timing is variable between when the wireless device receives the first and second downlink control channel messages scheduling the first and second downlink shared channel transmissions and when the wireless device transmits the uplink control information.

6. (Original) The method of claim 1, wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the wireless device can receive the first and second downlink control channel messages scheduling the first and second downlink shared channel transmissions in any one of multiple control regions in the same slot.

7. (Currently Amended) A wireless device₂ comprising:

an interface; and

processing circuitry configured to cause the wireless device to:

receive a first downlink control channel that schedules a first downlink shared channel transmission;

receive a second downlink control channel that schedules a second downlink shared channel transmission;

determine an uplink control channel resource to use for transmitting uplink

control information to a network node, wherein:

the uplink control information comprises Hybrid Automatic Repeat Request, HARQ, feedback for both the first downlink shared channel transmission and the second downlink shared channel transmission^{[[;]]}, and wherein determining the uplink control channel resource to use for transmitting the uplink control information comprises determining the uplink control channel resource based on^{[[;]]} (a) signaling received from the network node and (b) resource determination performed by the wireless device based on a latest received one of the first downlink control channel and the second downlink control channel; and transmit the uplink control information using the determined uplink control channel resource;

wherein the signaling received from the network node comprises information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources; and

wherein determining the uplink control channel resource based on (a) and (b) comprises selecting one of the two or more uplink control channel resource sets, and selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node.

8. (Original) The wireless device of claim 7 wherein the uplink control channel is a physical uplink control channel.

9. (Canceled)

10. (Currently Amended) The wireless device of claim ^{[[9]]} 7 wherein:

each of the first downlink control channel message and the second downlink control channel message comprises a downlink control information message comprising bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set; and

selecting the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node comprises selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on the bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set that are comprised in the latest received one of the first downlink control channel message and the second downlink control channel message.

11. (Original) The wireless device of claim 7, wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the timing is variable between when the wireless device receives the first and second downlink control channel messages scheduling the first and second downlink shared channel transmissions and when the wireless device transmits the uplink control information.

12. (Original) The wireless device of claim 7, wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the wireless device can receive the first and second downlink control channel messages scheduling the first and second downlink shared channel transmissions in any one of multiple control regions in the same slot.

13. (Currently Amended) A wireless device comprising:

an interface; and

processing circuitry configured to cause the wireless device to:

receive a downlink control channel that schedules a downlink shared channel transmission to the wireless device;

receive, from the network node, signaling comprising information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources,

determine an uplink control channel resource to use for transmitting uplink control information to a network node, wherein the uplink control information comprises

Hybrid Automatic Repeat Request, HARQ, feedback for the downlink shared channel transmission and determining the uplink control channel resource comprises selecting the uplink control channel resource from uplink control channel resources in two or more uplink control channel resource sets based on:

- a payload size of the uplink control information;
- a starting control channel element index of a downlink control channel candidate on which the downlink control channel was received; and
- dynamic signaling received from the network node; and

transmit the uplink control information using the determined uplink control channel resource;

wherein selecting the uplink control channel resource from the two or more uplink control channel resources in the two or more uplink control channel resource sets comprises selecting one of the two or more uplink control channel resource sets, and selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node.

14. (Canceled)

15. (Currently Amended) The wireless device of claim [[14]] 13 wherein:

the downlink control channel comprises a downlink control information message comprising bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set; and

selecting the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node comprises selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on the bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set that are comprised in the downlink control channel.

16. (Currently Amended) The wireless device of claim ~~[[14]]~~ 13 wherein the processing circuitry is further configured to cause the wireless device to:

receive, from the network node, signaling comprising information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources, and

wherein selecting the uplink control channel resource from the two or more uplink control channel resources in the two or more uplink control channel resource sets comprises:

selecting one of the two or more uplink control channel resource sets based on dynamic signaling from the network node; and

selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set using an implicit determination.

17. (Original) The wireless device of claim 16 wherein the implicit determination is based on a starting control channel element index of a downlink control channel candidate on which the downlink control channel was received, a search space in which the downlink control channel was received, or a CORESET in which the downlink control channel was received.

18. (Currently Amended) The wireless device of claim ~~[[14]]~~ 13 wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the timing is variable between when the wireless device receives the downlink control channel messages scheduling the downlink shared channel transmission and when the wireless device transmits the uplink control information.

19. (Currently Amended) The wireless device of claim ~~[[14]]~~ 13 wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the wireless device can receive the downlink control channel message scheduling the downlink shared channel transmission in any one of multiple control regions in the same slot.

20. (Previously Presented) The method of claim 1, wherein determining the uplink control channel resource further comprises selecting the uplink control channel resource from uplink control channel resources in two or more uplink control channel resource sets based on:

- a payload size of the uplink control information;
- a starting control channel element index of the latest received one of the first downlink control channel message and the second downlink control channel message downlink control channel; and
- dynamic signaling received from the network node.

21. (New) A method of operating a wireless device, comprising:

receiving a downlink control channel that schedules a downlink shared channel transmission to the wireless device;

receiving, from the network node, signaling comprising information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources,

determining an uplink control channel resource to use for transmitting uplink control information to a network node, wherein the uplink control information comprises Hybrid Automatic Repeat Request, HARQ, feedback for the downlink shared channel transmission and determining the uplink control channel resource comprises selecting the uplink control channel resource from uplink control channel resources in two or more uplink control channel resource sets based on:

- a payload size of the uplink control information;
- a starting control channel element index of a downlink control channel candidate on which the downlink control channel was received; and
- dynamic signaling received from the network node; and

transmitting the uplink control information using the determined uplink control channel resource;

wherein selecting the uplink control channel resource from the two or more uplink control channel resources in the two or more uplink control channel resource sets comprises selecting one of the two or more uplink control channel resource sets, and selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network

node, one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node.

22. (New) The method of claim 21, wherein:

the downlink control channel comprises a downlink control information message comprising bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set; and

selecting the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node comprises selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on the bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set that are comprised in the downlink control channel.

23. (New) The method of claim 21 further comprising:

receiving, from the network node, signaling comprising information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources;

wherein selecting the uplink control channel resource from the two or more uplink control channel resources in the two or more uplink control channel resource sets comprises:

selecting one of the two or more uplink control channel resource sets based on dynamic signaling from the network node; and

selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set using an implicit determination.

24. (New) The method of claim 23, wherein the implicit determination is based on a starting control channel element index of a downlink control channel candidate on which the downlink control channel was received, a search space in which the downlink control channel

was received, or a CORESET in which the downlink control channel was received.

25. (New) The method of claim 21, wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the timing is variable between when the wireless device receives the downlink control channel messages scheduling the downlink shared channel transmission and when the wireless device transmits the uplink control information.

26. (New) The method of claim 21, wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the wireless device can receive the downlink control channel message scheduling the downlink shared channel transmission in any one of multiple control regions in the same slot.

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	27296386	@ad< "20171026" @rlad< "20171026"	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/03/06 13:40
L2	209	L1 and (harq same (feedback\$2 ack acknowledgement) and (scheduling schedule) same (uplink near5 control pucch) same (semi adj static semistatic) and (downlink near5 shared pdsch))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/03/06 13:40
L3	30	2 and h04w72/0406.cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/03/06 13:45
L4	26	2 and h04w72/0446.cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/03/06 14:27
L5	0	2 and h04l1/1819.cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/03/06 14:31
L6	52	2 and h04l5/0055.cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/03/06 14:32
S15	27296386	@ad< "20171026" @rlad< "20171026"	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/03/06 10:33
S16	9858	S15 and (harq same (feedback\$2 ack acknowledgement) and (scheduling schedule) same uplink near5 control and (downlink near5 shared pdsch))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/03/06 10:43
S17	655	S16 and h04w72/1289.cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/03/06 10:44
S18	2051	S15 and (harq same (feedback\$2 ack acknowledgement) and (scheduling schedule) same uplink near5 control and (downlink near5 shared pdsch)) and (semi adj static semistatic)	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/03/06 10:45

EAST Search History

S19	209	S15 and (harq same (feedback\$2 ack acknowledgement) and (scheduling schedule) same (uplink near5 control pucch) same (semi adj static semistatic) and (downlink near5 shared pdsch))	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/03/06 10:46
S20	14	S19 and h04w72/1289.cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/03/06 10:47
S21	0	S19 and h04w88/023.cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/03/06 10:57
S22	11	S19 and h04w76/27.cpc.	US-PGPUB; USPAT; EPO; JPO	OR	ON	2019/03/06 10:57

3/ 6/ 2019 2:42:45 PM

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EAST Search History**EAST Search History (Interference)**

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3/ 6/ 2019 2:42:06 PM**C:\ Users\ echoi1\ Documents\ EAST\ Workspaces\ 16203391.wsp**

Bibliographic Data

Application No: 16/203,391

Foreign Priority claimed: ☐ Yes ☒ No

35 USC 119 (a-d) conditions met: ☐ Yes ☐ No ☐ Met After Allowance

Verified and Acknowledged:

Examiner's Signature

Initials

Title:

PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/28/2018	370	2467	P73334-US2
RULE			

APPLICANTS

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Daniel Larsson LUND, SWEDEN

CONTINUING DATA

This application is a CON of PCT/IB2018/058400 10/26/2018

PCT/IB2018/058400 has PRO of 62577578 10/26/2017

FOREIGN APPLICATIONS

IF REQUIRED, FOREIGN LICENSE GRANTED**

12/19/2018

STATE OR COUNTRY

UNITED STATES

ADDRESS

ERICSSON INC.
6300 LEGACY DRIVE
M/S EVR 1-C-11
PLANO, TX 75024
UNITED STATES

FILING FEE RECEIVED

\$5,860

Applicant Initiated Interview Request Form

Application No.: 16/203,391 First Named Applicant: Havish Koorapaty
 Examiner: Eunsook Choi Art Unit: 2467 Status of Application: Pending

Tentative Participants:(1) Ben Westover (2) _____

(3) _____ (4) _____

Proposed Date of Interview: Tuesday March 5, 2019 Proposed Time: 8AM Eastern (☉AM☉PM)

Type of Interview Requested:(1) ☒ Telephonic (2) ☐ Personal (3) ☐ Video ConferenceExhibit To Be Shown or Demonstrated: ☐ YES ☒ NO

If yes, provide brief description: _____

Issues To Be Discussed

Issues (Rej., Obj., etc)	Claims/ Fig. #s	Prior Art	Discussed	Agreed	Not Agreed
(1) <u>Rejection</u>	<u>1, 2</u>	<u>Luntilla, Tirola</u>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(2) _____	_____	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(3) _____	_____	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(4) _____	_____	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

☐ Continuation Sheet Attached ☐ Proposed Amendment or Arguments AttachedBrief Description of Arguments to be Presented: Discuss first action interview program communication.

An interview was conducted on the above-identified application on _____

NOTE: This form should be completed and filed by applicant in advance of the interview (see MPEP § 713.01). If this form is signed by a registered practitioner not of record, the Office will accept this as an indication that he or she is authorized to conduct an interview on behalf of the principal (37 CFR 1.32(a)(3)) pursuant to 37 CFR 1.34. This is not a power of attorney to any above named practitioner. See the Instruction Sheet for this form, which is incorporated by reference. By signing this form, applicant or practitioner is certifying that he or she has read the Instruction Sheet. After the interview is conducted, applicant is advised to file a statement of the substance of this interview (37 CFR 1.133(b)) as soon as possible. This application will not be delayed from issue because of applicant's failure to submit a written record of this interview.

/Ben Westover/

Applicant/Applicant's Representative Signature

Examiner/SPE Signature

Ben Westover

Typed/Printed Name of Applicant or Representative

+1-469-266-7146

Applicant's/Applicant's Representative's Telephone Number

56,612

Registration Number, if applicable

This collection of information is required by 37 CFR 1.133. 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 24 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.

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

Instruction Sheet for:
APPLICANT INITIATED INTERVIEW REQUEST FORM
(Not to be Submitted to the USPTO)

1. If this form is signed by a registered practitioner not of record, the authority to submit the Applicant Initiated Interview Request Form is pursuant to limited authority to act in a representative capacity under 37 CFR 1.34 and further proof of authority to act in a representative capacity may be required. See 37 CFR 1.34.

The Office will accept the signed form as an indication that the registered practitioner not of record is authorized to conduct an interview on behalf of the principal in pursuant to 37 CFR 1.34.

For more information, see the "Conducting an Interview with a Registered Practitioner Acting in a Representative Capacity" notice which is available on the USPTO Web site at: <http://www.uspto.gov/patents/law/notices/2010.jsp>.

2. This is not a power of attorney to any named practitioner. Accordingly, any registered practitioner not of record named on the form does not have authority to sign a request to change the correspondence address, a request for express abandonment, a disclaimer, a power of attorney, or other document requiring the signature of the applicant, assignee of the entire interest or an attorney of record. If appropriate, a separate power of attorney to the named practitioner should be executed and filed in the US Patent and Trademark Office.
3. Any interview concerning an unpublished application under 35 U.S.C. § 122(b) with a registered practitioner not of record who obtains authorization through use of the PTOL-413A will be conducted based on the information and files supplied by the practitioner in view of the confidentiality requirements of 35 U.S.C. § 122(a).

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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.

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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.
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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.

Electronic Acknowledgement Receipt	
EFS ID:	35269687
Application Number:	16203391
International Application Number:	
Confirmation Number:	3937
Title of Invention:	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION
First Named Inventor/Applicant Name:	Havish Koorapaty
Customer Number:	27045
Filer:	Roger Scott Burleigh/Akiko Cline
Filer Authorized By:	Roger Scott Burleigh
Attorney Docket Number:	P73334-US2
Receipt Date:	27-FEB-2019
Filing Date:	28-NOV-2018
Time Stamp:	14:52:46
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	First Action Interview - Schedule Interview request	P73334-US2_2019-02-27_195328_Interi ew_Request.pdf	308152 d33c207089b0d5ab947640d1e13512eb0e7eb508	no	3

Warnings:

Information:	
Total Files Size (in bytes):	308152
<p>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.</p> <p><u>New Applications Under 35 U.S.C. 111</u> 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.</p> <p><u>National Stage of an International Application under 35 U.S.C. 371</u> 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.</p> <p><u>New International Application Filed with the USPTO as a Receiving Office</u> 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.</p>	



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/203,391	11/28/2018	Havish Koorapaty	P73334-US2	3937
27045	7590	02/25/2019	EXAMINER	
ERICSSON INC. 6300 LEGACY DRIVE M/S EVR 1-C-11 PLANO, TX 75024			CHOI, EUNSOOK	
			ART UNIT	PAPER NUMBER
			2467	
			NOTIFICATION DATE	DELIVERY MODE
			02/25/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

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michelle.sanderson@ericsson.com
pam.ewing@ericsson.com

First Action Interview Pilot Program Pre-Interview Communication	Application No. 16/203,391	Applicant(s) Koorapaty et al.	
	Examiner EUNSOOK CHOI	Art Unit 2467	AIA Status Yes

-The MAILING OR NOTIFICATION DATE of this communication appears on the cover sheet with the correspondence address -
 THE SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE **ONE MONTH OR THIRTY (30) DAYS**, WHICHEVER IS LONGER, FROM THE MAILING OR NOTIFICATION DATE OF THIS COMMUNICATION.
This time period for reply is extendable under 37 CFR 1.136(a) for only ONE additional MONTH.
This communication constitutes notice under 37 CFR 1.136(a)(1)(i).
 Applicant must, within the time period for reply, file: (1) A letter requesting not to have a first action interview; (2) A reply under 37 CFR 1.111 waiving the first action interview and First Action Interview Office Action; or (3) An Applicant Initiated Interview Request Form (PTOL-413A) electronically via EFS-Web, accompanied by a proposed amendment or arguments, and schedule the interview within 2 months from the filing of the request. A failure to respond to this communication will be treated as a request not to have an interview. If applicant waives the First Action Interview Office Action, the instant Pre-Interview Communication is deemed the first Office Action on the Merits. The next subsequent Office action may be made final if appropriate. See MPEP 706.07(a).

Status

1) ☒ Responsive to communication(s) filed on 1/15/2019 .
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on ____ .

Disposition of Claims

2) ☒ Claim(s) 1-20 is/are pending in the application.
 2a) Of the above claim(s) ____ is/are withdrawn from consideration.

3) ☐ Claim(s) ____ is/are allowed.

4) ☒ Claim(s) 1-2,5-8,11-13 and 20 is/are rejected.

5) ☒ Claim(s) 3-4,9-10 and 14-19 is/are objected to.

6) ☐ Claim(s) ____ are subject to restriction and/or election requirement.

Application Papers

7) ☐ The specification is objected to by the Examiner.

8) ☒ The drawing(s) filed on 11/28/2018 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

9) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
 a) ☐ All b) ☐ Some * c) ☐ None of:
 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.

Contact Information

Examiner's Telephone Number: (571)270-1822

Examiner's Typical Work Schedule: 8am-4:30pm

Supervisor's Name: Hassan Phillips Supervisor's Telephone Number: 5712723940

Attachment(s) 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892) 2) <input type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date ____ .	3) <input type="checkbox"/> Interview Summary (PTO-413) Paper No(s)/Mail Date. ____ . 4) <input type="checkbox"/> Other: ____ .
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First Action Interview Pilot Program Pre-Interview Communication			Application No. 16/203,391		Applicant(s) Koorapaty et al.	
			Examiner EUNSOOK CHOI		Art Unit 2467	AIA Status Yes
Notification of Rejection(s) and/or Objection(s)						
#	Claim(s)	Reference(s) (if applicable)	Rejection Statutory Basis	Brief Explanation of Rejection		
1	1-2,6-8 and 12	LUNTTILA, Tirola	103	LUNTTILLA (US 20180102892) teaches Fig. 8, Fig. 11 and [0080] The terminal device also determines (block 804) a HARQ-ACK codebook size based on the determined number of scheduled carriers.		
2	13 and 20	LUNTTILA, Tirola	103	Similar to claim 1 above. Refer below for additional teaching.		
3	5 and 11	LUNTTILA, Tirola	103	Fig. 11		

Expanded Discussion/Commentary		
1		Tirola et al. (US 20180097609) discloses [0082] a PUCCH resource unit is selected via explicit signaling (such as signaling included in the DCI, or via explicit higher layer signaling).
2		Tirola discloses Fig. 6 and [0084] UCI payloads. Itoreq.x bits apply a Short PUCCH and where UCI payload>x bits apply a Long PUCCH.
DATE: 13 February 2019		/EUNSOOK CHOI/ Primary Examiner, Art Unit 2467

<i>Notice of References Cited</i>	Application/Control No. 16/203,391		Applicant(s)/Patent Under Reexamination Koorapaty et al.	
	Examiner EUNSOOK CHOI		Art Unit 2467	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-20190045533-A1	02-2019	Chatterjee; Debdeep	H04W72/1289	1/1
*	B	US-20150181588-A1	06-2015	Song; Xinghua	H04L1/1607	370/280
*	C	US-20180102892-A1	04-2018	LUNTTILA; Timo Erkki	H04L1/1607	1/1
*	D	US-20180054280-A1	02-2018	FU; Jingxing	H04B7/0621	1/1
*	E	US-20180097609-A1	04-2018	Tirola; Esa T.	H04L5/0055	1/1
*	F	US-20140003452-A1	01-2014	Han; Seunghee	H04L1/1657	370/474
	G					
	H					
	I					
	J					
	K					
	L					
	M					


FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

<i>Search Notes</i> 	Application/Control No. 16/203,391	Applicant(s)/Patent Under Reexamination Koorapaty et al.
	Examiner EUNSOOK CHOI	Art Unit 2467

CPC - Searched*		
Symbol	Date	Examiner

CPC Combination Sets - Searched*		
Symbol	Date	Examiner


US Classification - Searched*			
Class	Subclass	Date	Examiner

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

Search Notes		
Search Notes	Date	Examiner
Refer to East search	02/13/2019	EC

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
	Refer to East inventor search	02/13/2019	EC

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<i>Index of Claims</i> 	Application/Control No. 16/203,391	Applicant(s)/Patent Under Reexamination Koorapaty et al.
	Examiner EUNSOOK CHOI	Art Unit 2467

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

CLAIMS										
<input type="checkbox"/> Claims renumbered in the same order as presented by applicant <input type="checkbox"/> CPA <input type="checkbox"/> T.D. <input type="checkbox"/> R.1.47										
CLAIM			DATE							
Final	Original	02/13/2019								
	1	✓								
	2	✓								
	3	○								
	4	○								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	○								
	10	○								
	11	✓								
	12	✓								
	13	✓								
	14	○								
	15	○								
	16	○								
	17	○								
	18	○								
	19	○								
	20	✓								

EAST Search History**EAST Search History (Prior Art)**

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	0	"16203391"	US-PGPUB; USPAT	OR	OFF	2019/02/12 06:50
S2	27257097	@ad<"20171026" @rlad<"20171026"	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/02/12 07:54
S3	11010	S2 and harq same (feedback\$2 ack acknowledgement) and (scheduling schedule) same uplink near5 control	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/02/12 07:57
S4	324	S2 and (harq same (feedback\$2 ack acknowledgement) and (scheduling schedule) same uplink near5 control).clm.	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/02/12 07:57
S5	110	S2 and (harq same (feedback\$2 ack acknowledgement) and (scheduling schedule) same uplink near5 control and (downlink near5 shared pdsch)).clm.	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/02/12 07:58
S6	3	S2 and (harq same (feedback\$2 ack acknowledgement) and (scheduling schedule) same uplink near5 control and (downlink near5 shared pdsch) and payload).clm.	US-PGPUB; USPAT; EPO; JPO	OR	OFF	2019/02/12 08:47
S7	934	(Koorapaty-Havish\$ Falahati-Sorour\$ Baldemair-Robert\$ Larsson-Daniel\$).in.	US-PGPUB; USPAT	OR	OFF	2019/02/12 16:10

2/13/2019 9:25:38 AM**C:\Users\echoi1\Documents\EAST\Workspaces\16203391.wsp**

Bibliographic Data

Application No: 16/203,391

Foreign Priority claimed: ☐ Yes ☒ No

35 USC 119 (a-d) conditions met: ☐ Yes ☐ No ☐ Met After Allowance

Verified and Acknowledged:

Examiner's Signature

Initials

Title:

PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
11/28/2018	370	2467	P73334-US2
RULE			

APPLICANTS

TELEFONAKTIEBOLAGET L M ERICSSON (PUBL), Stockholm, SWEDEN

INVENTORS

Havish Koorapaty SARATOGA, CA, UNITED STATES

Sorour Falahati STOCKHOLM, SWEDEN

Robert Baldemair SOLNA, SWEDEN

Daniel Larsson LUND, SWEDEN

CONTINUING DATA

This application is a CON of PCT/IB2018/058400 10/26/2018

PCT/IB2018/058400 has PRO of 62577578 10/26/2017

FOREIGN APPLICATIONS

IF REQUIRED, FOREIGN LICENSE GRANTED**

12/19/2018

STATE OR COUNTRY

UNITED STATES

ADDRESS

ERICSSON INC.
6300 LEGACY DRIVE
M/S EVR 1-C-11
PLANO, TX 75024
UNITED STATES

FILING FEE RECEIVED

\$5,860

EAST Search History**EAST Search History (Interference)**

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S8	376	(Koorapaty-Havish\$ Falahati-Sorour\$ Baldemair-Robert\$ Larsson-Daniel\$).in.	USPAT	OR	OFF	2019/02/12 16:11
S9	934	(Koorapaty-Havish\$ Falahati-Sorour\$ Baldemair-Robert\$ Larsson-Daniel\$).in.	US-PGPUB; USPAT	OR	OFF	2019/02/12 16:11
S10	0	S9 and (uplink near3 control near3 channel same harq near4 (feedback ack) same shard near3 channel).clm.	US-PGPUB; USPAT	OR	OFF	2019/02/12 16:16
S11	10	S9 and (uplink near3 control near3 channel same harq near4 (feedback ack)).clm.	US-PGPUB; USPAT	OR	OFF	2019/02/12 16:18
S12	5	S9 and (uplink near3 control near3 channel with harq near4 (feedback ack)).clm.	US-PGPUB; USPAT	OR	OFF	2019/02/12 16:19

2/13/2019 9:26:17 AM**C:\Users\echoi1\Documents\EAST\Workspaces\16203391.wsp**



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
16/203,391	11/28/2018	Havish Koorapaty	P73334-US2	3937
27045	7590	01/15/2019	EXAMINER	
ERICSSON INC. 6300 LEGACY DRIVE M/S EVR 1-C-11 PLANO, TX 75024			ART UNIT	PAPER NUMBER
			2414	
			NOTIFICATION DATE	DELIVERY MODE
			01/15/2019	ELECTRONIC

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.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

michelle.sanderson@ericsson.com
pam.ewing@ericsson.com

<i>Decision Granting Request for Prioritized Examination (Track I)</i>	Application No. 16/203,391	Applicant(s) Koorapaty et al.	
	Examiner BRIAN W BROWN	Art Unit OPET	AIA (First Inventor to File) Status Yes
<p>1. THE REQUEST FILED <u>28 November 2018</u> IS GRANTED .</p> <p>The above-identified application has met the requirements for prioritized examination</p> <p>A. <input checked="" type="checkbox"/> for an original nonprovisional application (Track I).</p> <p>B. <input type="checkbox"/> for an application undergoing continued examination (RCE).</p> <p>2. The above-identified application will undergo prioritized examination. The application will be accorded special status throughout its entire course of prosecution until one of the following occurs:</p> <p>A. filing a <u>petition for extension of time</u> to extend the time period for filing a reply;</p> <p>B. filing an <u>amendment to amend the application to contain more than four independent claims, more than thirty total claims</u>, or a multiple dependent claim;</p> <p>C. filing a <u>request for continued examination</u> ;</p> <p>D. filing a notice of appeal;</p> <p>E. filing a request for suspension of action;</p> <p>F. mailing of a notice of allowance;</p> <p>G. mailing of a final Office action;</p> <p>H. completion of examination as defined in 37 CFR 41.102; or</p> <p>I. abandonment of the application.</p> <p>Telephone inquiries with regard to this decision should be directed to BRIAN BROWN at (571)272-5338. In his/her absence, calls may be directed to Petition Help Desk at (571) 272-3282.</p>			
/BRIAN W BROWN/ Petitions Examiner, OPET			

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent application of :
Havish Koorapaty et al. : Group Art Unit: 2414
Application No. 16/203,391 : Examiner: To be determined
Filed: November 28, 2018 : Confirmation No. 3937

PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION

PRELIMINARY AMENDMENT

U.S. Patent and Trademark Office
E-FILING
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Prior to the examination, Applicants submit the following:

Amendments to the Claims reflected in the listing of claims which begins on page 2 of this paper; and

Remarks which begin on page 9 of this paper.

Amendments to the Claims

This listing of the claims replaces all prior versions and listings of claims in the Application.

Listing of claims:

1. (Currently Amended) A method performed by a wireless device, the method comprising:

- receiving a first downlink control channel message that schedules a first downlink shared channel transmission;
- receiving a second downlink control channel message that schedules a second downlink shared channel transmission;
- determining an uplink control channel resource to use for transmitting uplink control information to a network node on an uplink control channel, wherein:
 - the uplink control information comprises Hybrid Automatic Repeat Request, HARQ, feedback for both the first downlink shared channel transmission and the second downlink shared channel transmission; and wherein
 - determining the uplink control channel resource for transmitting the uplink control information comprises determining the uplink control channel resource based on: (a) signaling received from the network node and (b) resource determination performed by the wireless device based on a latest received one of the first downlink control channel message and the second downlink control channel message; and
- transmitting the uplink control information using the determined uplink control channel resource.

2. (Original) The method of claim 1 wherein the uplink control channel is a physical uplink control channel.

3. (Original) The method of claim 1 wherein:

the signaling received from the network node comprises information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources; and

determining the uplink control channel resource based on: (a) the signaling received from the network node and (b) resource determination performed by the wireless device based on the latest received one of the first downlink control channel message and the second downlink control channel message comprises:

selecting one of the two or more uplink control channel resource sets;

selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node.

4. (Currently Amended) The method of claim 3 wherein:

each of the first downlink control channel message and the second downlink control channel message comprises ~~a downlink control information message comprising~~ bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set; and wherein

~~selecting the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node comprises selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on the bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set that are~~ comprised in the latest received one of the first downlink control channel message and the second downlink control channel message.

5. (Original) The method of claim 1, wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the timing is variable between when the wireless device receives the first and second downlink control channel messages scheduling the first and second downlink shared channel transmissions

and when the wireless device transmits the uplink control information.

6. (Original) The method of claim 1, wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the wireless device can receive the first and second downlink control channel messages scheduling the first and second downlink shared channel transmissions in any one of multiple control regions in the same slot.

7. (Original) A wireless device comprising:

an interface; and

processing circuitry configured to cause the wireless device to:

- receive a first downlink control channel that schedules a first downlink shared channel transmission;
- receive a second downlink control channel that schedules a second downlink shared channel transmission;
- determine an uplink control channel resource to use for transmitting uplink control information to a network node, wherein:
 - the uplink control information comprises Hybrid Automatic Repeat Request, HARQ, feedback for both the first downlink shared channel transmission and the second downlink shared channel transmission; and
 - determining the uplink control channel resource for transmitting the uplink control information comprises determining the uplink control channel resource based on: (a) signaling received from the network node and (b) resource determination performed by the wireless device based on a latest received one of the first downlink control channel and the second downlink control channel; and
- transmit the uplink control information using the determined uplink control channel resource.

8. (Original) The wireless device of claim 7 wherein the uplink control channel is a physical uplink control channel.

9. (Original) The wireless device of claim 7, wherein:

the signaling received from the network node comprises information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources; and

determining the uplink control channel resource based on: (a) the signaling received from the network node and (b) resource determination performed by the wireless device based on the latest received one of the first downlink control channel message and the second downlink control channel message comprises:

- selecting one of the two or more uplink control channel resource sets;
- selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node.

10. (Original) The wireless device of claim 9 wherein:

each of the first downlink control channel message and the second downlink control channel message comprises a downlink control information message comprising bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set; and

selecting the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node comprises selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on the bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set that are comprised in the latest received one of the first downlink control channel message and the second downlink control channel message.

11. (Original) The wireless device of claim 7, wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the timing is variable between when the wireless device receives the first and second downlink

control channel messages scheduling the first and second downlink shared channel transmissions and when the wireless device transmits the uplink control information.

12. (Original) The wireless device of claim 7, wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the wireless device can receive the first and second downlink control channel messages scheduling the first and second downlink shared channel transmissions in any one of multiple control regions in the same slot.

13. (Original) A wireless device comprising:

an interface; and

processing circuitry configured to cause the wireless device to:

- receive a downlink control channel that schedules a downlink shared channel transmission to the wireless device;
- determine an uplink control channel resource to use for transmitting uplink control information to a network node, wherein the uplink control information comprises Hybrid Automatic Repeat Request, HARQ, feedback for the downlink shared channel transmission and determining the uplink control channel resource comprises selecting the uplink control channel resource from uplink control channel resources in two or more uplink control channel resource sets based on:
 - a payload size of the uplink control information;
 - a starting control channel element index of a downlink control channel candidate on which the downlink control channel was received; and
 - dynamic signaling received from the network node; and
- transmit the uplink control information using the determined uplink control channel resource.

14. (Original) The wireless device of claim 13, wherein the processing circuitry is further configured to cause the wireless device to:

- receive, from the network node, signaling comprising information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising

- two or more uplink control channel resources,
- wherein selecting the uplink control channel resource from the two or more uplink control channel resources in the two or more uplink control channel resource sets comprises:
 - selecting one of the two or more uplink control channel resource sets; and
 - selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node.

15. (Original) The wireless device of claim 14 wherein:
the downlink control channel comprises a downlink control information message comprising bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set; and
selecting the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node comprises selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on the bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set that are comprised in the downlink control channel.

16. (Original) The wireless device of claim 14 wherein the processing circuitry is further configured to cause the wireless device to:

- receive, from the network node, signaling comprising information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources, and
- wherein selecting the uplink control channel resource from the two or more uplink control channel resources in the two or more uplink control channel resource sets comprises:
 - selecting one of the two or more uplink control channel resource sets based on

dynamic signaling from the network node; and

- selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set using an implicit determination.

17. (Original) The wireless device of claim 16 wherein the implicit determination is based on a starting control channel element index of a downlink control channel candidate on which the downlink control channel was received, a search space in which the downlink control channel was received, or a CORESET in which the downlink control channel was received.

18. (Original) The wireless device of claim 14 wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the timing is variable between when the wireless device receives the downlink control channel messages scheduling the downlink shared channel transmission and when the wireless device transmits the uplink control information.

19. (Original) The wireless device of claim 14 wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the wireless device can receive the downlink control channel message scheduling the downlink shared channel transmission in any one of multiple control regions in the same slot.

20. (New) The method of claim 1, wherein determining the uplink control channel resource further comprises selecting the uplink control channel resource from uplink control channel resources in two or more uplink control channel resource sets based on:

- a payload size of the uplink control information;
- a starting control channel element index of the latest received one of the first downlink control channel message and the second downlink control channel message downlink control channel; and
- dynamic signaling received from the network node.

Remarks

Claims 1-20 are pending. Claims 1 and 4 have been amended and Claim 20 has been newly added. No new matter has been added.

In the event that any fee is required, the Commissioner is hereby authorized to charge any additional fee to Deposit Account No. 50-1379.

If the Examiner has any questions or requires any additional information that would further or expedite the prosecution of this Application, Applicants request that the Examiner contact Applicants' representative for a telephonic interview.

Respectfully submitted,

/Ben Westover/

Ben Westover
Reg. No. 56,612

Customer No. 27045

Ericsson Inc.
6300 Legacy Drive, M/S EVR 1-C-11
Plano, Texas 75024

469-266-7146
ben.westover@ericsson.com

Date: December 31, 2018

Electronic Acknowledgement Receipt	
EFS ID:	34726848
Application Number:	16203391
International Application Number:	
Confirmation Number:	3937
Title of Invention:	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION
First Named Inventor/Applicant Name:	Havish Koorapaty
Customer Number:	27045
Filer:	Roger Scott Burleigh/Akiko Cline
Filer Authorized By:	Roger Scott Burleigh
Attorney Docket Number:	P73334-US2
Receipt Date:	31-DEC-2018
Filing Date:	28-NOV-2018
Time Stamp:	13:35:08
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		P73334-US2_2018-12-31_185409_PreliminaryAmendment.pdf	138828	yes	9
			72d2304949f70c5120933d8942629c87717894c5		

Multipart Description/PDF files in .zip description			
Document Description	Start	End	
Preliminary Amendment	1	1	
Claims	2	8	
Applicant Arguments/Remarks Made in an Amendment	9	9	

Warnings:

Information:

Total Files Size (in bytes):	138828
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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.



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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
16/203,391	11/28/2018	2414	1720	P73334-US2	19	3

CONFIRMATION NO. 3937

FILING RECEIPT



27045
ERICSSON INC.
6300 LEGACY DRIVE
M/S EVR 1-C-11
PLANO, TX 75024

Date Mailed: 12/20/2018

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)

Havish Koorapaty, SARATOGA, CA;
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Robert Baldemair, SOLNA, SWEDEN;
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Applicant(s)

TELEFONAKTIEBOLAGET L M ERICSSON (PUBL), Stockholm, SWEDEN;

Power of Attorney: The patent practitioners associated with Customer Number 27045

Domestic Priority data as claimed by applicant

This application is a CON of PCT/IB2018/058400 10/26/2018
which claims benefit of 62/577,578 10/26/2017

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 Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 12/19/2018

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/203,391**

Projected Publication Date: 05/02/2019

Non-Publication Request: No

Early Publication Request: No
Title

PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION

Preliminary Class

370

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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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.

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Title 37, Code of Federal Regulations, 5.11 & 5.15

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NOT GRANTED

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875						Application or Docket Number 16/203,391				
APPLICATION AS FILED - PART I										
(Column 1)		(Column 2)		SMALL ENTITY		OTHER THAN SMALL ENTITY				
FOR	NUMBER FILED	NUMBER EXTRA	RATE(\$)	FEE(\$)		RATE(\$)	FEE(\$)			
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	300			
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A			N/A	660			
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	760			
TOTAL CLAIMS (37 CFR 1.16(j))	19	minus 20 = *			OR	x 100 =	0.00			
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3	minus 3 = *			OR	x 460 =	0.00			
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			
			TOTAL			TOTAL	1720			
* If the difference in column 1 is less than zero, enter "0" in column 2.										
APPLICATION AS AMENDED - PART II										
(Column 1)		(Column 2)		(Column 3)		SMALL ENTITY		OTHER THAN SMALL ENTITY		
AMENDMENT A		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)	ADDITIONAL FEE(\$)
	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))							OR		
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	
AMENDMENT B		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)	ADDITIONAL FEE(\$)		RATE(\$)	ADDITIONAL FEE(\$)
	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))							OR		
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	
<p>* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.</p> <p>** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".</p> <p>*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".</p> <p>The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.</p>										

**CERTIFICATION AND REQUEST FOR PRIORITIZED EXAMINATION
UNDER 37 CFR 1.102(e)** (Page 1 of 1)

First Named Inventor:	Havish Koorapaty	Nonprovisional Application Number (if known):	P73334-US2
Title of Invention:	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION		

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS PRIORITIZED EXAMINATION FOR THE ABOVE-IDENTIFIED APPLICATION.

1. The processing fee set forth in 37 CFR 1.17(i)(1) and the prioritized examination fee set forth in 37 CFR 1.17(c) have been filed with the request. The publication fee requirement is met because that fee, set forth in 37 CFR 1.18(d), is currently \$0. The basic filing fee, search fee, and examination fee are filed with the request or have been already been paid. I understand that any required excess claims fees or application size fee must be paid for the application.
2. I understand that the application may not contain, or be amended to contain, more than four independent claims, more than thirty total claims, or any multiple dependent claims, and that any request for an extension of time will cause an outstanding Track I request to be dismissed.
3. The applicable box is checked below:
 - I. ☒ **Original Application (Track One) - Prioritized Examination under § 1.102(e)(1)**
 - i. (a) The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a). This certification and request is being filed with the utility application via EFS-Web.
---OR---
(b) The application is an original nonprovisional plant application filed under 35 U.S.C. 111(a). This certification and request is being filed with the plant application in paper.
 - ii. An executed inventor's oath or declaration under 37 CFR 1.63 or 37 CFR 1.64 for each inventor, or the application data sheet meeting the conditions specified in 37 CFR 1.53(f)(3)(i) is filed with the application.
 - II. ☐ **Request for Continued Examination - Prioritized Examination under § 1.102(e)(2)**
 - i. A request for continued examination has been filed with, or prior to, this form.
 - ii. If the application is a utility application, this certification and request is being filed via EFS-Web.
 - iii. The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a), or is a national stage entry under 35 U.S.C. 371.
 - iv. This certification and request is being filed prior to the mailing of a first Office action responsive to the request for continued examination.
 - v. No prior request for continued examination has been granted prioritized examination status under 37 CFR 1.102(e)(2).

Signature <u>/Ben Westover/</u>	Date <u>November 28, 2018</u>
Name (Print/Typed) <u>Ben Westover</u>	Practitioner Registration Number <u>56,612</u>
Note: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required.*	
<input type="checkbox"/> *Total of _____ forms are submitted.	

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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.

Doc Code: FAI.REQ

Document Description: Request First Action Interview

PTO/SB/413C (05-11)

Approved for use through 01/31/2013. OMB 0651-0031

U.S. Patent and Trademark Office; U. S. DEPARTMENT OF COMMERCE

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REQUEST FOR FIRST ACTION INTERVIEW (FULL PILOT PROGRAM)		
Attorney Docket Number: P73334-US2	Application Number (if known):	Filing date: November 28, 2018
First Named Inventor: Havish Koorapaty	Title: PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION	
<p>APPLICANT HEREBY REQUESTS A FIRST ACTION INTERVIEW IN THE ABOVE-IDENTIFIED APPLICATION. See Instruction Sheet on page 2.</p> <p>1. The application must contain three (3) or fewer independent claims and twenty (20) or fewer total claims.</p> <p>2. The application must not contain any multiple dependent claims.</p> <p>3. By filing this request:</p> <p>Applicant is agreeing to make an election without traverse if the Office determines that the claims are not obviously directed to a single invention; and</p> <p>Applicant is agreeing not to request for a refund of the search fee and any excess claims fee paid in the application after the mailing or notification of the pre-interview communication prepared by the examiner.</p> <p>4. Other attachments: _____</p>		
Signature /Ben Westover/		Date November 28, 2018
Name (Print/Typed) Ben Westover		Registration Number 56,612
<p>Note: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.</p>		
<p><input type="checkbox"/> *Total of _____ forms are submitted.</p>		

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 12 hours 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.

Instruction Sheet for Request for First Action Interview (Full Pilot Program)
(Not to be Submitted to the USPTO)

A grantable request must meet the following conditions:

1. The application must be a new non-reissue utility application filed under 35 U.S.C. 111(a) or an international application that has entered the national stage in compliance with 35 U.S.C. 371(c).
2. The application must contain three (3) or fewer independent claims and twenty (20) or fewer total claims. The application may not contain any multiple dependent claims.
3. The request must be filed electronically using the Office's electronic filing system, EFS-Web.
4. The claims must be directed to a single invention. If the Office determines that the claims are directed to multiple inventions (*e.g.*, in a restriction requirement), the applicant must make an election without traverse.
5. The request must be filed at least one day before a first Office action on the merits of the application appears in the Patent Application Information Retrieval (PAIR) system (*i.e.*, at least one day prior to the date when a first Office action on the merits, notice of allowability or allowance, or action under Ex parte Quayle, 1935 Dec. Comm'r Pat. 11 (1935) appears in the PAIR system). Applicant may check the status of the application using the PAIR system.
6. The request for a first action interview must include a statement that applicant agrees not to file a request for a refund of the search fee and any excess claims fees paid in the application after the mailing or notification of the Pre-Interview Communication. Any petition for express abandonment under 37 CFR 1.138(d), and request for a refund of the search fee and any excess claims fees, filed after the mailing or notification of the Pre-Interview Communication will not be granted.

For more information, see notice "Full First Action Interview Pilot Program" available on the USPTO web site at http://www.uspto.gov/patents/init_events/faipp_full.jsp

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.

Doc Code: FAI.REQ

Document Description: Request First Action Interview

PTO/SB/413C (05-11)

Approved for use through 01/31/2013. OMB 0651-0031

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.

REQUEST FOR FIRST ACTION INTERVIEW (FULL PILOT PROGRAM)		
Attorney Docket Number: P73334-US2	Application Number (if known):	Filing date: November 28, 2018
First Named Inventor: Havish Koorapaty	Title: PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION	
<p>APPLICANT HEREBY REQUESTS A FIRST ACTION INTERVIEW IN THE ABOVE-IDENTIFIED APPLICATION. See Instruction Sheet on page 2.</p> <p>1. The application must contain three (3) or fewer independent claims and twenty (20) or fewer total claims.</p> <p>2. The application must not contain any multiple dependent claims.</p> <p>3. By filing this request:</p> <p>Applicant is agreeing to make an election without traverse if the Office determines that the claims are not obviously directed to a single invention; and</p> <p>Applicant is agreeing not to request for a refund of the search fee and any excess claims fee paid in the application after the mailing or notification of the pre-interview communication prepared by the examiner.</p> <p>4. Other attachments: _____</p>		
Signature /Ben Westover/		Date November 28, 2018
Name (Print/Typed) Ben Westover		Registration Number 56,612
<p>Note: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.</p>		
<p><input type="checkbox"/> *Total of _____ forms are submitted.</p>		

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 12 hours 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.

Instruction Sheet for Request for First Action Interview (Full Pilot Program)
(Not to be Submitted to the USPTO)

A grantable request must meet the following conditions:

1. The application must be a new non-reissue utility application filed under 35 U.S.C. 111(a) or an international application that has entered the national stage in compliance with 35 U.S.C. 371(c).
2. The application must contain three (3) or fewer independent claims and twenty (20) or fewer total claims. The application may not contain any multiple dependent claims.
3. The request must be filed electronically using the Office's electronic filing system, EFS-Web.
4. The claims must be directed to a single invention. If the Office determines that the claims are directed to multiple inventions (*e.g.*, in a restriction requirement), the applicant must make an election without traverse.
5. The request must be filed at least one day before a first Office action on the merits of the application appears in the Patent Application Information Retrieval (PAIR) system (*i.e.*, at least one day prior to the date when a first Office action on the merits, notice of allowability or allowance, or action under Ex parte Quayle, 1935 Dec. Comm'r Pat. 11 (1935) appears in the PAIR system). Applicant may check the status of the application using the PAIR system.
6. The request for a first action interview must include a statement that applicant agrees not to file a request for a refund of the search fee and any excess claims fees paid in the application after the mailing or notification of the Pre-Interview Communication. Any petition for express abandonment under 37 CFR 1.138(d), and request for a refund of the search fee and any excess claims fees, filed after the mailing or notification of the Pre-Interview Communication will not be granted.

For more information, see notice "Full First Action Interview Pilot Program" available on the USPTO web site at http://www.uspto.gov/patents/init_events/faipp_full.jsp

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.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	P73334-US2
		Application Number	
Title of Invention	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION		
<p>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.</p> <p>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.</p>			

Secrecy Order 37 CFR 5.2:

☐ 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		
	Havish		Koorapaty			
Residence Information (Select One) <input checked="" type="radio"/> US Residency <input type="radio"/> Non US Residency <input type="radio"/> Active US Military Service						
City	SARATOGA	State/Province	CA	Country of Residence ⁱ	US	
Mailing Address of Inventor:						
Address 1	13425 Kodiak Place					
Address 2						
City	SARATOGA	State/Province	CA			
Postal Code	95070	Country ⁱ	US			
Inventor	2				Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Sorour		Falahati			
Residence Information (Select One) <input type="radio"/> US Residency <input checked="" type="radio"/> Non US Residency <input type="radio"/> Active US Military Service						
City	STOCKHOLM	Country of Residence ⁱ	SE			
Mailing Address of Inventor:						
Address 1	Wargentinsgatan 6					
Address 2						
City	STOCKHOLM	State/Province				
Postal Code	SE-112 29	Country ⁱ	SE			
Inventor	3				Remove	
Legal Name						
Prefix	Given Name	Middle Name	Family Name	Suffix		
	Robert		Baldemair			

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	P73334-US2
		Application Number	
Title of Invention	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION		

Residence Information (Select One) <input type="radio"/> US Residency <input checked="" type="radio"/> Non US Residency <input type="checkbox"/> Active US Military Service			
City	SOLNA	Country of Residence ⁱ	SE

Mailing Address of Inventor:			
Address 1	Honnörsgatan 16		
Address 2			
City	SOLNA	State/Province	
Postal Code	SE-170 69	Country ⁱ	SE
Inventor	4	<input type="button" value="Remove"/>	

Legal Name				
Prefix	Given Name	Middle Name	Family Name	Suffix
	Daniel		Larsson	

Residence Information (Select One) <input type="radio"/> US Residency <input checked="" type="radio"/> Non US Residency <input type="checkbox"/> Active US Military Service			
City	LUND	Country of Residence ⁱ	SE

Mailing Address of Inventor:			
Address 1	Skyttelinjen 125		
Address 2			
City	LUND	State/Province	
Postal Code	SE-226 49	Country ⁱ	SE
All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the Add button. <input type="button" value="Add"/>			

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below. For further information see 37 CFR 1.33(a).	
<input type="checkbox"/> An Address is being provided for the correspondence information of this application.	
Customer Number	27045
Email Address	patent.development@ericsson.com <input type="button" value="Add Email"/> <input type="button" value="Remove Email"/>

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	P73334-US2
		Application Number	
Title of Invention	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION		

Application Information:

Title of the Invention	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION		
Attorney Docket Number	P73334-US2	Small Entity Status Claimed	<input type="checkbox"/>
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	12	Suggested Figure for Publication (if any)	13

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

<input type="checkbox"/> Request Early Publication (Fee required at time of Request 37 CFR 1.219)
<input type="checkbox"/> 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.

Representative Information:

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:	<input checked="" type="radio"/> Customer Number	<input type="radio"/> US Patent Practitioner	<input type="radio"/> Limited Recognition (37 CFR 11.9)
Customer Number	27045		

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	P73334-US2
		Application Number	
Title of Invention	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim 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.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending	<input type="button" value="Remove"/>	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	PCT/IB2018/058400	2018-10-26
Prior Application Status	Expired	<input type="button" value="Remove"/>	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
PCT/IB2018/058400	Claims benefit of provisional	62577578	2017-10-26
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button. <input type="button" value="Add"/>			

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. 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(i)(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).

Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)	<input type="button" value="Remove"/>
Additional Foreign Priority Data may be generated within this form by selecting the Add button. <input type="button" value="Add"/>				

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.

NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	P73334-US2
		Application Number	
Title of Invention	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION		

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is 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 State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	P73334-US2
		Application Number	
Title of Invention	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION		

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		<input type="button" value="Remove"/>
<p>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.</p>			
		<input type="button" value="Clear"/>	
<input type="radio"/> 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:			
<div style="border: 1px solid black; height: 20px; width: 100%;"></div>			
Name of the Deceased or Legally Incapacitated Inventor: <div style="border: 1px solid black; width: 400px; height: 20px;"></div>			
If the Applicant is an Organization check here. <input checked="" type="checkbox"/>			
Organization Name	TELEFONAKTIEBOLAGET L M ERICSSON (PUBL)		
Mailing Address Information For Applicant:			
Address 1	SE-164 83		
Address 2			
City	Stockholm	State/Province	
Country	SE	Postal Code	SE-164 83
Phone Number		Fax Number	
Email Address			
Additional Applicant Data may be generated within this form by selecting the Add button. <input type="button" value="Add"/>			

Assignee Information including Non-Applicant Assignee 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.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	P73334-US2
		Application Number	
Title of Invention	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION		

Assignee 1				
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.				
				<input type="button" value="Remove"/>
If the Assignee or Non-Applicant Assignee is an Organization check here.				<input type="checkbox"/>
Prefix	Given Name	Middle Name	Family Name	Suffix
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
Mailing Address Information For Assignee including Non-Applicant Assignee:				
Address 1		<input type="text"/>		
Address 2		<input type="text"/>		
City	<input type="text"/>	State/Province	<input type="text"/>	
Country i	<input type="text"/>	Postal Code	<input type="text"/>	
Phone Number	<input type="text"/>	Fax Number	<input type="text"/>	
Email Address	<input type="text"/>			
Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button.				<input type="button" value="Add"/>

Signature:

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	P73334-US2
		Application Number	
Title of Invention	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION		

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PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATIONRelated Applications

[0001] This application is a continuation of International Patent Application No. PCT/IB2018/058400, filed October 26, 2018, which claims the benefit of provisional patent application serial number 62/577,578, filed October 26, 2017, the disclosure of which is hereby incorporated herein by reference in its entirety.

Technical Field

[0002] The present disclosure relates to a cellular communications network and, more specifically, Physical Uplink Control Channel (PUCCH) resource allocation.

Background

[0003] Operation of New Radio (NR) requires the transmission of various control information from the wireless device (e.g., User Equipment (UE)) to the network. Examples of such Uplink Control Information (UCI) are Hybrid Automatic Repeat Request (HARQ) Acknowledgements (ACKs), Channel State Information (CSI), and Scheduling Request (SR). The UCI can be transmitted on a separate control channel (e.g., occurring either at the end of the slot interval or during the slot interval), or the UCI can be multiplexed with data and transmitted on a data channel. For example, the separate control channel could be a Physical Uplink Control Channel (PUCCH). As another example, the data channel could be a Physical Uplink Shared Channel (PUSCH), e.g., supporting “UCI on PUSCH.”

PUCCH Format

[0004] There are multiple formats defined for PUCCH that can be used to transmit control information, as shown in the table below.

Table 1: Possible PUCCH format definitions

PUCCH format	Number of symbols in a slot	Number of UCI bits
0	1 – 2	≤ 2
1	4 – 14	≤ 2
2	1 – 2	> 2
3	4 – 14	> 2
4	4 – 14	> 2

[0005] PUCCH formats 0 and 2 are referred to as short PUCCH formats since they are transmitted only over 1 or two Orthogonal Frequency Division Multiplexing (OFDM) symbols in a slot. PUCCH formats 1, 3, and 4 are referred to as long PUCCH formats since they can be transmitted in up to 14 OFDM symbols (without slot aggregation) and even across multiple slots if PUCCH slot aggregation is configured. As shown in the table, each both long and short PUCCH formats are subdivided depending on the number of UCI bits they may contain.

[0006] A single slot may contain multiple transmissions of a single PUCCH format as well as multiple PUCCH formats which may or may not be transmitted by the same UE. For instance, a slot spanning 14 OFDM symbols may contain a long PUCCH spanning 12 OFDM symbols followed by a short PUCCH spanning two OFDM symbols.

[0007] The different PUCCH formats are used for different purposes. The PUCCH formats that contain 2 bits or less can generally multiplex multiple UEs in the same time and frequency resources with the long PUCCH being able to multiplex more users than the short PUCCH. PUCCH format 4 can multiplex multiple UEs with each UE having more than 2 bits.

PUCCH Resources

[0008] A PUCCH resource that is used by a UE to transmit UCI may be defined by the Physical Resource Blocks (PRBs), the OFDM symbols, the sequences along with their cyclic shifts, and Orthogonal Cover Codes (OCCs) used. It should be noted that OCCs, sequences, and cyclic shifts are applicable only for some PUCCH formats.

[0009] In any given slot, the UE may have to transmit one or more of the following:

- HARQ ACKs
- CSI
- SRs

[0010] CSI information may be scheduled to be transmitted periodically, e.g., once every N slots. SR is transmitted by the UE when the UE has some data to be sent. HARQ ACK information is transmitted to acknowledge whether Physical Downlink Shared Channel (PDSCH) transmissions in the downlink were successfully received or not. HARQ ACKs may consist of a single bit to acknowledge an entire transport block or multiple bits, each representing a Code Block Group (CBG), i.e., a set of code blocks among the code blocks that comprise a transport block.

Determination of PUCCH Resources

[0011] The PUCCH resource to be used for each of the different types of UCI can generally be controlled by the NR base station (gNB). This can be done via explicit resource assignments

either through semi-static configuration (e.g., Radio Resource Control (RRC) signaling) or through dynamic signaling of Downlink Control Information (DCI) messages.

[0012] In addition, the UE can also determine PUCCH resources implicitly. For example, the PUCCH resource can be determined based on the number of UCI bits to be transmitted in a slot. PUCCH resources for HARQ ACK transmission for a scheduled PDSCH may also be determined implicitly by the Control Channel Element (CCE) at which the received control channel message (PDCCH) scheduling the PDSCH begins. This approach is used in Long Term Evolution (LTE). Such implicit resource determination can reduce the overhead incurred for dynamic signaling and help to avoid collisions between the PUCCH resources determined by different UEs for transmission of UCI.

[0013] Since the gNB is generally aware of the number of bits to be transmitted by the UE, or which resources to expect autonomous transmissions by the UE such as SR, the gNB is aware of the resources on which all the UCI information must be received. There are certain error cases where a mismatch can occur between the UE and the gNB on the resources to be used for PUCCH transmission, e.g., when certain downlink assignments for PDSCH are missed. However, such mismatches occur with a very small probability and can sometimes be handled either by the gNB performing decoding on multiple hypothesized PUCCH resources.

[0014] There is a need for improved systems and methods for PUCCH resource determination, particularly ones that provide additional flexibility.

Summary

[0015] Systems and methods for determining an uplink control channel resource to use for transmitting uplink control information to a network node are disclosed. In some embodiments, a method performed by a wireless device comprises receiving a first downlink control channel message that schedules a first downlink shared channel transmission, receiving a second downlink control channel message that schedules a second downlink shared channel transmission, and determining an uplink control channel resource to use for transmitting uplink control information to a network node. The uplink control information comprises Hybrid Automatic Repeat Request (HARQ) feedback for both the first downlink transmission and the second downlink transmission, and determining the uplink control channel resource for transmitting the uplink control information comprises determining the uplink control channel resource based on: (a) signaling received from the network node and (b) resource determination performed by the wireless device based on a latest received one of the first downlink control channel message and the second downlink control channel message. The method further comprises transmitting the uplink control information using the determined uplink control

channel resource.

[0016] In some embodiments, the uplink control channel is a physical uplink control channel.

[0017] In some embodiments, the signaling received from the network node comprises information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources, and determining the uplink control channel resource based on: (a) the signaling received from the network node and (b) resource determination performed by the wireless device based on the latest received one of the first downlink control channel and the second downlink control channel messages comprises selecting one of the two or more uplink control channel resource sets and selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node. In some embodiments, each of the first downlink control channel message and the second downlink control channel message comprises a downlink control information message comprising bits for use to select one of the uplink control channel resources from the selected uplink control channel resource set, and selecting the one of the uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node comprises selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, the one of the uplink control channel resources from the selected uplink control channel resource set based on the bits for use to select one of the uplink control channel resources from the selected uplink control channel resource set that are comprised in the latest one of the first downlink control channel and the second downlink control channel.

[0018] In some embodiments, the determining which resources of the control channel to use is performed when the timing is variable between when the wireless device receives a message scheduling a downlink transmission and when the wireless device transmits the uplink control information.

[0019] In some embodiments, the determining which resources of the control channel to use is performed when the wireless device can receive a message scheduling a downlink transmission in any one of multiple control regions in the same slot.

[0020] In some other embodiments, a method performed by a wireless device comprises receiving a downlink control channel that schedules a downlink shared channel transmission to the wireless device and determining an uplink control channel resource to use for transmitting uplink control information to a network node, wherein the uplink control information comprises HARQ feedback for the downlink shared channel transmission and determining the uplink

control channel resource comprises selecting the uplink control channel resource from uplink control channel resources in two or more uplink control channel resource sets based on a payload size of the uplink control information, a starting control channel element index of a downlink control channel candidate on which the downlink control channel was received, and dynamic signaling received from the network node. The method further comprises transmitting the uplink control information using the determined uplink control channel resource.

[0021] In some embodiments, the method further comprises receiving, from the network node, signaling comprising information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources. Further, selecting the uplink control channel resource from the uplink control channel resources in the two or more uplink control channel resource sets comprises selecting one of the two or more uplink control channel resource sets and selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node. In some embodiments, the downlink control channel comprises a downlink control information message comprising bits for use to select one of the uplink control channel resources from the selected uplink control channel resource set, and selecting the one of the uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node comprises selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, the one of the uplink control channel resources from the selected uplink control channel resource set based on the bits for use to select one of the uplink control channel resources from the selected uplink control channel resource set that are comprised in the downlink control channel.

[0022] In some embodiments, the method further comprises receiving, from the network node, signaling comprising information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources. Further, selecting the uplink control channel resource from the uplink control channel resources in the two or more uplink control channel resource sets comprises selecting one of the two or more uplink control channel resource sets based on dynamic signaling from the network node and selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the uplink control channel resources from the selected uplink control channel resource set using an implicit determination. In some embodiments, the implicit determination is based on a starting control channel element index of a downlink control channel candidate on which the downlink control channel was received, a

search space in which the downlink control channel was received, or a CORESET in which the downlink control channel was received.

[0023] In some embodiments, the determining which resources of the control channel to use is performed when the timing is variable between when the wireless device receives a message scheduling a downlink transmission and when the wireless device transmits the uplink control information.

[0024] In some embodiments, the determining which resources of the control channel to use is performed when the wireless device can receive a message scheduling a downlink transmission in any one of multiple control regions in the same slot.

[0025] Embodiments of a wireless device are also disclosed. In some embodiments, a wireless device comprises an interface and processing circuitry configured to cause the wireless device to receive a first downlink control channel that schedules a first downlink shared channel transmission, receive a second downlink control channel that schedules a second downlink shared channel transmission, and determine an uplink control channel resource to use for transmitting uplink control information to a network node. The uplink control information comprises HARQ feedback for both the first downlink transmission and the second downlink transmission, and determining the uplink control channel resource for transmitting the uplink control information comprises determining the uplink control channel resource based on: (a) signaling received from the network node and (b) resource determination performed by the wireless device based on a latest received one of the first downlink control channel and the second downlink control channel. The processing circuitry is further configured to cause the wireless device to transmit the uplink control information using the determined uplink control channel resource.

[0026] In some embodiments, a wireless device comprises an interface and processing circuitry configured to cause the wireless device to receive a downlink control channel that schedules a downlink shared channel transmission to the wireless device and determine an uplink control channel resource to use for transmitting uplink control information to a network node. The uplink control information comprises HARQ feedback for the downlink shared channel transmission. In order to determine the uplink control channel resource, the processing circuitry is further configured to cause the wireless device to select the uplink control channel resource from uplink control channel resources in two or more uplink control channel resource sets based on a payload size of the uplink control information, a starting control channel element index of a downlink control channel candidate on which the downlink control channel was received, and dynamic signaling received from the network node. The processing circuitry is further configured to cause the wireless device to transmit the uplink control information using

the determined uplink control channel resource.

Brief Description of the Drawings

[0027] The accompanying drawing figures incorporated in and forming a part of this specification illustrate several aspects of the disclosure, and together with the description serve to explain the principles of the disclosure.

[0028] Figure 1 illustrates an example wireless network in accordance with at least some aspects of the embodiments disclosed herein;

[0029] Figure 2 illustrates one embodiment of a User Equipment (UE) in accordance with various aspects described herein;

[0030] Figure 3 a schematic block diagram illustrating a virtualization environment in which functions implemented by some embodiments disclosed herein may be virtualized;

[0031] Figure 4 illustrates a telecommunication network connected via an intermediate network to a host computer in accordance with some embodiments of the present disclosure;

[0032] Figure 5 is a generalized block diagram of a host computer communicating via a base station with a UE over a partially wireless connection in accordance with some embodiments of the present disclosure;

[0033] Figure 6 is a flowchart illustrating a method implemented in a communication system in accordance with one embodiment of the present disclosure;

[0034] Figure 7 is a flowchart illustrating a method implemented in a communication system in accordance with one embodiment of the present disclosure;

[0035] Figure 8 is a flowchart illustrating a method implemented in a communication system in accordance with one embodiment on the present disclosure;

[0036] Figure 9 is a flowchart illustrating a method implemented in a communication system in accordance with one embodiment of the present disclosure;

[0037] Figure 10 is a flow chart that illustrates the operation of a UE in accordance with at least some aspects of the embodiments disclosed herein;

[0038] Figure 11 is a flow chart that illustrates at least some aspects of one embodiment of the present disclosure;

[0039] Figure 12 is a flow chart that illustrates at least some aspects of one embodiment of the present disclosure;

[0040] Figure 13 is a flow chart that illustrates at least some aspects of one embodiment of the present disclosure; and

[0041] Figure 14 illustrates a schematic block diagram of an apparatus in a wireless network (for example, the wireless network shown in Figure 1).

Detailed Description

[0042] The embodiments set forth below represent information to enable those skilled in the art to practice the embodiments and illustrate the best mode of practicing the embodiments. Upon reading the following description in light of the accompanying drawing figures, those skilled in the art will understand the concepts of the disclosure and will recognize applications of these concepts not particularly addressed herein. It should be understood that these concepts and applications fall within the scope of the disclosure.

[0043] Generally, all terms used herein are to be interpreted according to their ordinary meaning in the relevant technical field, unless a different meaning is clearly given and/or is implied from the context in which it is used. All references to a/an/the element, apparatus, component, means, step, etc. are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any methods disclosed herein do not have to be performed in the exact order disclosed, unless a step is explicitly described as following or preceding another step and/or where it is implicit that a step must follow or precede another step. Any feature of any of the embodiments disclosed herein may be applied to any other embodiment, wherever appropriate. Likewise, any advantage of any of the embodiments may apply to any other embodiments, and vice versa. Other objectives, features, and advantages of the enclosed embodiments will be apparent from the following description.

[0044] Some of the embodiments contemplated herein will now be described more fully with reference to the accompanying drawings. Other embodiments, however, are contained within the scope of the subject matter disclosed herein, the disclosed subject matter should not be construed as limited to only the embodiments set forth herein; rather, these embodiments are provided by way of example to convey the scope of the subject matter to those skilled in the art.

[0045] There currently exist certain challenge(s) with respect to Physical Uplink Control Channel (PUCCH) resource determination. For example, existing solutions for determination of PUCCH resources use either explicit signaling such as a combination of semi-static (e.g., Radio Resource Control (RRC)) and dynamic (Downlink Control Information (DCI) messages) signaling or a combination of explicit signaling and implicit determination (e.g., use of starting Control Channel Element (CCE) index for Physical Downlink Control Channel (PDCCH)). The use of implicit methods for determination of PUCCH resources is used to reduce the signaling overhead and/or minimize collisions between the PUCCH resources for different User Equipments (UEs). The existing solutions that use implicit determination of PUCCH resources in this manner work well in systems such as Long Term Evolution (LTE) where the timing of the PUCCH carrying Hybrid Automatic Repeat Request (HARQ) Acknowledgement (HARQ

ACK) feedback for a scheduled Physical Downlink Shared Channel (PDSCH) transmission is fixed. However, existing methods for implicit determination of PUCCH resources do not work well when the timing of transmissions between the reception of the PDCCH scheduling the PDSCH and the transmission of HARQ ACK feedback on the PUCCH is not fixed but is variable. Also, existing methods do not work well when the PDCCH scheduling the PDSCH can be received in any one of multiple control regions in the same slot.

[0046] Certain aspects of the present disclosure and their embodiments may provide solutions to these or other challenges. For example, in some embodiments, the UE uses a combination of explicit signaling and implicit resource determination to handle flexible timing of HARQ ACK feedback and the reception of PDCCH in different control regions (e.g., CORESETs) in a slot. The explicit signaling consists of a combination of RRC signaling (semi-static) and fields in DCI messages (dynamic).

[0047] In some embodiments, the RRC signaling can be used to configure different sets of PUCCH resources for different CORESETs in one or more slots from which implicit determination can be used to determine a PUCCH resource so that the resources in different sets are orthogonal to each other.

[0048] In other embodiments, the RRC signaling can be used to configure the same resource set for many more UEs than there are resources in the set with the UEs chosen having a lower probability of transmitting together. This could be because these UEs have very high data rate requirements so that they will likely not share resources with other UEs in the same slot.

[0049] In some embodiments, the dynamic signaling can be used to indicate a starting index relative to which PUCCH resources can be implicitly determined.

[0050] In some embodiments, the dynamic signaling can be used to indicate the slot index and/or PUCCH format to use.

[0051] In some embodiments, a common indexing method is used across multiple control regions for downlink and across multiple slots to avoid ambiguities in implicit PUCCH resource determination. In some embodiments, HARQ feedback for PDSCH received after an uplink grant for Uplink Control Information (UCI) on Physical Uplink Shared Channel (PUSCH) is treated differently than HARQ feedback for PDSCH received before the uplink grant. One example of different treatment is that a potential Code Block Group (CBG) configuration is not applied but transport block based feedback is used instead.

[0052] Certain embodiments may provide one or more of the following technical advantage(s). For example, certain embodiments may include the technical advantage of minimizing overhead for PUCCH resource allocation while keeping collisions between PUCCH resources assigned to different UEs to a minimum.

[0053] The general problem can be described as follows. In a given slot, a UE may have to transmit periodic or aperiodic Channel State Information (CSI) and/or HARQ ACK and/or Scheduling Requests (SRs). The UE must determine a PUCCH resource for this which includes a PUCCH format in a set of Physical Resource Blocks (PRBs) and Orthogonal Frequency Division Multiplexing (OFDM) symbols and potentially sequences, cyclic shifts, and Orthogonal Cover Codes (OCCs) depending on the PUCCH format used. The PUCCH resource is determined based on explicit signaling from the base station (i.e., the next generation Node B (gNB) in New Radio (NR) terminology) and possibly some implicit methods. The HARQ ACK transmissions may be for PDSCH transmissions that are received in one of multiple slots including in slot n . The following discussion provides examples of embodiments that enable determining of the PUCCH resource while minimizing overhead for dynamic signaling and collisions between the determined PUCCH resources for different UEs.

[0054] The embodiments are illustrated using the following example. A set of three slots, numbered n , $n+1$, and $n+2$, is considered. Slot n is a slot with only downlink transmissions, slot $n+1$ carries downlink transmissions followed by uplink transmissions, and slot $n+2$ carries only uplink transmissions. Slot $n+1$ can be used for transmissions of PUCCH formats 0 and 2, i.e., short PUCCH for up to 2 bits and for more than 2 bits. Slot $n+2$ can be used for transmissions of PUCCH formats 1 and 3 (long PUCCH for up to 2 bits and greater than 2 bits) followed by PUCCH formats 0 and 2 (short PUCCH formats for up to 2 bits and greater than 2 bits).

[0055] HARQ ACK for PDSCH received in slots n and $n+1$ can be sent in any of the PUCCH resources in slot $n+1$ or slot $n+2$ depending on the payload size including the HARQ ACK as well as potential CSI and SR transmissions. The first PUCCH resource that can be used in time is limited by the processing capability of the UE, i.e. how long time it takes to prepare a HARQ feedback transmission after the corresponding downlink transmission has been received.

Embodiment 1

[0056] In this embodiment, the set of all CORESETs across multiple slots are indexed using a common scheme and mapped to all the PUCCH resources across multiple slots that are also indexed using a common scheme. In the three slot example considered, all the PDCCH candidates in all the CORESETs in slots n and $n+1$ configured to the UE have a unique index. Similarly, all the PUCCH resources in slots $n+1$ and $n+2$ have a unique index. The PDCCH candidate indices are mapped to the PUCCH resource indices so that the resource where HARQ ACK transmissions should occur can be determined implicitly. The mapping from the PDCCH candidates to the PUCCH resources is semi-statically configured to each UE via RRC signaling. The semi-statically configured mapping depends on the number of CORESETs configured to the

UE as well as on the upcoming slots carrying uplink transmissions in which PUCCH resources may be available.

[0057] It may be noted that, in this embodiment, delays in HARQ ACK feedback is controlled dynamically by choosing the appropriate PDCCH candidate for scheduling. The mapping of PDCCH candidates to PUCCH resources can be changed semi-statically, but not dynamically. This of course creates some scheduling constraints. Furthermore, it is not expected that a UE will be able to perform blind decodes to exhaustively search all candidates, which creates further restrictions in scheduling. For examples that provide greater flexibility to choose delay or other parameters dynamically, see embodiments 3-8 discussed below.

[0058] To make the above solution more dynamic, it can be considered to configure a UE with multiple such mappings and use dynamic information in the DCI to select one of the configured mappings.

[0059] For the case where RRC configuration information is not available, e.g., after initial access or during RRC reconfigurations, a default mapping is specified.

Embodiment 2

[0060] This embodiment is a simplification of Embodiment 1 where the indexing of PDCCH resources and PUCCH resources does not have to be unique. Instead, the RRC signaling can be used to configure different sets of PUCCH resources from which implicit determination can be used to determine a PUCCH resource, for different CORESETs in one or more slots so that the resources in the different sets corresponding to different CORESETs are orthogonal to each other. A default mapping for PUCCH resources can be configured when the CORESET is first configured. This default mapping may be used during RRC reconfigurations when the mapping to be used may be ambiguous.

[0061] After initial access when an RRC configuration is not available, a default mapping of PUCCH resources for the CORESET carrying the common search space where the Remaining System Information (RMSI) is received is specified.

Embodiment 3

[0062] In this embodiment, the UE is semi-statically configured with multiple PUCCH resource sets, where each of the elements of each of the PUCCH resource sets corresponds to a single PUCCH resource. A PUCCH resource set is chosen implicitly by the UE based on the UCI payload and one or more of the following when HARQ ACK feedback is part of the UCI:

- the CORESET where the PDCCH scheduling the PDSCH (i.e., the PDSCH transmission for which HARQ ACK feedback is to be provided) is received;

- the search space within the above CORESET (i.e., the search space within the above CORESET in which the PDCCH scheduling the PDSCH is received);
- the starting CCE index of the PDCCH candidate within the above search space (i.e., the starting CCE index of the PDCCH candidate within the above search space in which the PDCCH scheduling the PDSCH is received).

[0063] How the UE implicitly determines the PUCCH resource set based on the above factors can also be configured semi-statically. Dynamic signaling is used to select a PUCCH resource from within the implicitly selected PUCCH resource set.

[0064] An example PUCCH resource determination procedure as per this embodiment for the considered scenario with three slots is described as follows. First, a UE is semi-statically configured to choose a PUCCH resource set for each PDCCH candidate across all the CORESETs configured to the UE. A default mapping is configured for each CORESET that may be used during RRC reconfigurations. All the PUCCH resource sets have at least one entry corresponding to a short PUCCH format in slot $n+1$, a short PUCCH format in $n+2$, and a long PUCCH format in slot $n+2$. Then, a PUCCH resource for a PDSCH received in a particular slot is determined using the steps below:

- Whether a PUCCH format of up to 2 bits or greater than 2 bits is used is determined by the UE implicitly based on the payload size.
- The CCE index, the search space of the successfully received PDCCH, and optionally the identifier (Radio Network Temporary Identifier (RNTI)) used to scramble the PDCCH is then used to determine a single PUCCH resource set within the group of configured PUCCH resource sets corresponding to the chosen PUCCH format.
- Dynamic signaling (2 bits) in the DCI message is used to determine a single PUCCH resource from within the chosen PUCCH resource set.

[0065] This embodiment gives the gNB more flexibility to control the latency of the HARQ ACK feedback. To illustrate this, consider the following example configuration of PDCCH candidates, blind decodes, and PUCCH resources within the three slot example.

[0066] After initial access when an RRC configuration is not available, a default mapping of a PUCCH resource set for each of the PDCCH candidates in the CORESET carrying the common search space where the RMSI is received is specified. To handle the case where RRC configuration information is ambiguous during RRC reconfigurations, a default mapping of PUCCH resource sets for each of the PDCCH candidates in the CORESET is configured as part of the CORESET configuration.

[0067] Let us consider that slot n has two CORESETs configured to four different UEs. Each CORESET has two PDCCH candidates. The four PDCCH candidates are numbered 1, 2,

3, and 4 with PDCCH candidates 1 and 2 in the first CORESET and PDCCH candidates 3 and 4 in the second CORESET. Let us consider four PUCCH resources, A, B, C, and D with PUCCH resources A and B in slot $n+1$ and PUCCH resources C and D in slot $n+2$. Now, let's consider that there are four UEs, U1, U2, U3, and U4 with two blind decode PDCCH candidates each configured as follows:

UE	Blind decode candidates
U1	1, 3
U2	2, 4
U3	1, 4
U4	2, 3

[0068] Let us consider that the mapping as per Embodiment 1 from PDCCH candidate to PUCCH resources is $\{1, 2, 3, 4\} \Rightarrow \{A, B, C, D\}$. Then, let us consider that UEs U1 and U3 are scheduled together. It is clear that once U1 is scheduled in PDCCH candidate 1, U3 can only be scheduled in PDCCH candidate 4; and since PDCCH candidate 4 is mapped to PUCCH resource D in slot $n+2$, U3 must suffer a two slot delay in getting its HARQ feedback.

[0069] Now let us consider that the mapping as per Embodiment 2 from PDCCH candidates to resources sets is $\{1, 2, 3, 4\} \Rightarrow \{\{A, C\}, \{B, D\}, \{B, D\}, \{A, C\}\}$. Then if we consider, as in the case of the example for Embodiment 1 above that UEs U1 and U3 are scheduled together, U1 uses PUCCH resource set $\{A, C\}$ and U3 uses PUCCH resource set $\{B, D\}$. Now with a single bit sent in the DCI message scheduling the PDSCH for each UE, the gNB can direct U1 to choose PUCCH resource A and U3 to choose PUCCH resource B, and the gNB can get HARQ ACK feedback for U3 in slot $n+1$ instead of slot $n+2$.

[0070] It will be apparent to those skilled in the art that this type of flexibility is provided by the inclusion of multiple alternatives in the PUCCH resource set chosen by the implicit determination and that the PUCCH resource sets can be configured to provide other types of flexibility. For instance, the PUCCH resource set could have multiple entries corresponding to different PUCCH formats so that the gNB can dynamically direct the UE to choose between the different formats, or the different entries in the chosen PUCCH set could correspond to PUCCH resources in different OFDM symbols within the same slot.

Embodiment 4

[0071] This embodiment differs from Embodiment 3 in that the dynamic signaling is used to first select a PUCCH resource set whose entries are restricted to a particular slot and a short or

long PUCCH format with implicit PUCCH resource determination then being used to determine the PUCCH resource from within the PUCCH resource set. The steps for PUCCH resource determination for the considered scenario may be delineated as follows:

- Whether a PUCCH format of up to 2 bits or greater than 2 bits is used is determined by the UE implicitly based on the payload size.
- Dynamic signaling in the DCI message is used to choose between certain PUCCH resource sets that are configured semi-statically. For example, the DCI message may be used to determine whether a PUCCH resource set in slot $n+1$ or slot $n+2$ is used and to determine whether the PUCCH resource set includes entries corresponding to short or long PUCCH. In this example, all the PUCCH resource sets therefore have entries only corresponding to a single PUCCH format.
- The CCE index, the search space of the successfully received PDCCH, and optionally the identifier (RNTI) used to scramble the PDCCH is then used to determine a single PUCCH resource within the group of PUCCH resource sets corresponding to the chosen PUCCH format.

[0072] After initial access when an RRC configuration is not available, a set of default PUCCH resource sets from which a PUCCH resource set is chosen by the DCI signaling is specified. In addition, for each of these PUCCH resource sets, default mappings of PUCCH resources for each of the PDCCH candidates in the CORESET carrying the common search space where the remaining system information (RMSI) is received may be specified. To handle the case where RRC configuration information is ambiguous during RRC reconfigurations, a default mapping of PUCCH resource sets for each of the chosen values via DCI signaling and a mapping of PUCCH resources within each of these PUCCH resource sets for each of the PDCCH candidates in the CORESET is configured as part of the CORESET configuration.

[0073] It may be noted that for the considered example, in this embodiment, there are four PUCCH resource sets configured to a UE with each PUCCH resource set potentially having a large set of PUCCH resources with the number of PUCCH resources correlated to the number of PDCCH candidates available for scheduling PDCCH at the gNB. In contrast, in Embodiment 3, each resource set only has a maximum of four entries from which the 2 bits of DCI signaling choose a single PUCCH resource after implicit determination is used to choose a PUCCH resource set.

[0074] In variations of this embodiment, the DCI signaling may be used to choose between PUCCH resource sets in other ways including the following:

- Starting indices of PUCCH resource sets. For instance, using the common PUCCH resource and PDCCH candidate numbering scheme in Embodiment 1, the DCI signaling

may be used to choose between one of four configured starting indices for the set of PUCCH resources from which implicit determination is used to choose a PUCCH resource.

- PUCCH resources in different PUCCHs in the same slot. For example, the DCI signaling could be used to choose between PUCCHs in different OFDM symbols or different PRBs.
- Different frequency hopping configurations including no hopping. The DCI signaling could be used to choose whether frequency hopping should be used and if it is used where the location of the hop may be relative to the beginning of the PUCCH.

[0075] It should be clear to those skilled in the art that other partitions of the available resources can be executed with the DCI signaling to indicate which set should be used for PUCCH resource determination by other means such as the location of the received PDCCH.

Embodiment 5

[0076] In any of the above embodiments, the number of supported UEs can be much greater than the number of PUCCH resources available, with statistical multiplexing benefits allowing a larger number of UEs to be supported while keeping the probability of blocking and collisions to an acceptably low value. In this embodiment, UEs chosen to be configured to map to the same PUCCH resources or PUCCH resource sets have a lower probability of transmitting together. This could, for example, be because these UEs have very high data rate requirements so that they will likely not share resources with other UEs in the same slot.

Embodiment 6

[0077] In case the UE is configured with multiple downlink component carriers and/or bandwidth parts for which feedback transmissions compete for the same PUCCH resources, the indexing of CORESETs/PDCCH candidates is done across all configured downlink carriers and/or bandwidth parts. Instead of configured downlink carriers and/or bandwidth parts, it is possible to only consider activated downlink carriers and/or bandwidth parts. This embodiment can be used with the methods taught in any of the previous embodiments.

[0078] Another manner in case the UE is configured with multiple downlink component carriers and/or bandwidth parts is that the PUCCH resources are selected from the CORESETs/PDCCH located on the primary cell in case the primary cell is only scheduled and, if at least one secondary cell is scheduled, the PUCCH resources are selected from a different PUCCH resource set. For the second case, the PUCCH resource candidates can be selected based on the carrier with the smallest carrier index across all the scheduled secondary cells.

Another way is that if the primary cell is included the resource candidates are purely selected from the primary cells' resource set.

[0079] This embodiment can be used with the methods taught in any of the previous embodiments.

Embodiment 7

[0080] In another embodiment, the resource candidates that are selected for PUCCH resources are based on PDCCH scheduled in the latest slot, latest scheduled PDCCH, or all scheduled PDCCHs.

[0081] For example, if a UE receives a PDCCH which points to a PUCCH resource using any one of the previous embodiments and the UE receives a PDCCH at a later time, this latest scheduled PDCCH can override the PUCCH resource assignment as per the previously received PDCCH, and the HARQ feedback can be sent for both the PDSCHs corresponding to the prior and latest PDCCH using the PUCCH resources determined based on the latest received PDCCH. In other words, a UE receives a first PDCCH scheduling a first PDSCH transmission and a second PDCCH scheduling a second PDSCH transmission. The second PDCCH is received later than the first PDCCH. If HARQ ACK feedback for both the first and second PDSCH transmissions is to be provided in the same PUCCH resource, then the UE determines the PUCCH resource based on the latest PDCCH, which in this example is the second PDCCH. The PUCCH resource can be determined based on the latest PDCCH using any of the embodiments described above.

[0082] Similarly, the PUCCH resources can be based on all the PDCCHs in the latest slot or on all the scheduled outstanding PDCCHs.

[0083] As a part of this embodiment, a field is included in the DCI message that indicates which of the above methods should be used for PUCCH resource determination.

[0084] This embodiment can be used with the methods taught in any of the previous embodiments.

Embodiment 8

[0085] In this embodiment, different UEs that are sharing a common pool of PUCCH resources are configured with CORESETs and indexing mechanisms for PDCCH messages and PUCCH resources in a consistent way so that any overlapped resources both for PDCCH and PUCCH have the same index for different UEs. As an example, consider two UEs that have two CORESETs each, with the first CORESET of the two UEs using the same physical resources, but the second CORESET of the two UEs using different resources. The first CORESETs for

the two UEs may have X CCEs indexed from $\{0, 1, \dots, X-1\}$. The second CORESET of the first UE may have Y CCEs indexed as $\{X, X+1, \dots, X+Y-1\}$ while the second CORESET of the second UE may have Z CCEs indexed as $\{Y, Y+1, \dots, X+Y+Z-1\}$. Thus, the PUCCH resources for different UEs can be mapped to the indexed CCEs so that any conflicts between the two UEs for PUCCH resources are avoided as long as they received PDCCHs starting in different CCE indices even though the CORESET configurations are not the same.

[0086] As a part of this embodiment, the CORESET configuration therefore includes a starting CCE index to be used by a UE for the CCEs in each CORESET.

[0087] This embodiment can be used with the methods taught in any of the previous embodiments.

[0088] Certain of the above-described embodiments may use multiple slot mapping or single slot mapping, depending on the scheme. As an example, for the scheme of example Embodiment 1, if the PDSCH assignments for multiple slots are acknowledged in PUCCH resources in the same slot, then PDCCHs should be indexed in a consistent way. As another example, the special case in example Embodiment 2 (which uses CORESET or slot based partitioning of PUCCH resources) can be used to do things purely on a slot basis.

[0089] Although the subject matter described herein may be implemented in any appropriate type of system using any suitable components, the embodiments disclosed herein are described in relation to a wireless network, such as the example wireless network illustrated in Figure 1. For simplicity, the wireless network of Figure 1 only depicts network 106, network nodes 160 and 160b, and Wireless Devices (WDs) 110, 110b, and 110c. In practice, a wireless network may further include any additional elements suitable to support communication between wireless devices or between a wireless device and another communication device, such as a landline telephone, a service provider, or any other network node or end device. Of the illustrated components, network node 160 and WD 110 are depicted with additional detail. The wireless network may provide communication and other types of services to one or more wireless devices to facilitate the wireless devices' access to and/or use of the services provided by, or via, the wireless network.

[0090] The wireless network may comprise and/or interface with any type of communication, telecommunication, data, cellular, and/or radio network or other similar type of system. In some embodiments, the wireless network may be configured to operate according to specific standards or other types of predefined rules or procedures. Thus, particular embodiments of the wireless network may implement communication standards, such as Global System for Mobile Communications (GSM), Universal Mobile Telecommunications System (UMTS), LTE, and/or other suitable Second, Third, Fourth, or Fifth Generation (2G, 3G, 4G, or

5G) standards; Wireless Local Area Network (WLAN) standards, such as the IEEE 802.11 standards; and/or any other appropriate wireless communication standard, such as the Worldwide Interoperability for Microwave Access (WiMax), Bluetooth, Z-Wave, and/or ZigBee standards.

[0091] Network 106 may comprise one or more backhaul networks, core networks, Internet Protocol (IP) networks, Public Switched Telephone Networks (PSTNs), packet data networks, optical networks, Wide Area Networks (WANs), Local Area Networks (LANs), WLANs, wired networks, wireless networks, metropolitan area networks, and other networks to enable communication between devices.

[0092] Network node 160 and WD 110 comprise various components described in more detail below. These components work together in order to provide network node and/or wireless device functionality, such as providing wireless connections in a wireless network. In different embodiments, the wireless network may comprise any number of wired or wireless networks, network nodes, base stations, controllers, wireless devices, relay stations, and/or any other components or systems that may facilitate or participate in the communication of data and/or signals whether via wired or wireless connections.

[0093] As used herein, network node refers to equipment capable, configured, arranged, and/or operable to communicate directly or indirectly with a wireless device and/or with other network nodes or equipment in the wireless network to enable and/or provide wireless access to the wireless device and/or to perform other functions (e.g., administration) in the wireless network. Examples of network nodes include, but are not limited to, Access Points (APs) (e.g., radio access points), Base Stations (BSs) (e.g., radio base stations, Node Bs, evolved Node Bs (eNBs) and NR Node Bs (gNBs)). Base stations may be categorized based on the amount of coverage they provide (or, stated differently, their transmit power level) and may then also be referred to as femto base stations, pico base stations, micro base stations, or macro base stations. A base station may be a relay node or a relay donor node controlling a relay. A network node may also include one or more (or all) parts of a distributed radio base station such as centralized digital units and/or Remote Radio Units (RRUs), sometimes referred to as Remote Radio Heads (RRHs). Such RRUs may or may not be integrated with an antenna as an antenna integrated radio. Parts of a distributed radio base station may also be referred to as nodes in a Distributed Antenna System (DAS). Yet further examples of network nodes include Multi-Standard Radio (MSR) equipment such as MSR BSs, network controllers such as Radio Network Controllers (RNCs) or Base Station Controllers (BSCs), Base Transceiver Stations (BTSs), transmission points, transmission nodes, Multi-Cell/Multicast Coordination Entities (MCEs), core network nodes (e.g., Mobile Switching Centers (MSCs), Mobility Management Entities (MMEs)),

Operation and Maintenance (O&M) nodes, Operations Support System (OSS) nodes, Self Optimized Network (SON) nodes, positioning nodes (e.g., Evolved-Serving Mobile Location Centers (E-SMLCs), and/or Minimization of Drive Tests (MDTs). As another example, a network node may be a virtual network node as described in more detail below. More generally, however, network nodes may represent any suitable device (or group of devices) capable, configured, arranged, and/or operable to enable and/or provide a wireless device with access to the wireless network or to provide some service to a wireless device that has accessed the wireless network.

[0094] In Figure 1, network node 160 includes processing circuitry 170, device readable medium 180, interface 190, auxiliary equipment 184, power source 186, power circuitry 187, and antenna 162. Although network node 160 illustrated in the example wireless network of Figure 1 may represent a device that includes the illustrated combination of hardware components, other embodiments may comprise network nodes with different combinations of components. It is to be understood that a network node comprises any suitable combination of hardware and/or software needed to perform the tasks, features, functions, and methods disclosed herein. Moreover, while the components of network node 160 are depicted as single boxes located within a larger box, or nested within multiple boxes, in practice, a network node may comprise multiple different physical components that make up a single illustrated component (e.g., device readable medium 180 may comprise multiple separate hard drives as well as multiple Random Access Memory (RAM) modules).

[0095] Similarly, network node 160 may be composed of multiple physically separate components (e.g., a Node B component and a RNC component, or a BTS component and a BSC component, etc.), which may each have their own respective components. In certain scenarios in which network node 160 comprises multiple separate components (e.g., BTS and BSC components), one or more of the separate components may be shared among several network nodes. For example, a single RNC may control multiple Node Bs. In such a scenario, each unique Node B and RNC pair may in some instances be considered a single separate network node. In some embodiments, network node 160 may be configured to support multiple Radio Access Technologies (RATs). In such embodiments, some components may be duplicated (e.g., separate device readable medium 180 for the different RATs) and some components may be reused (e.g., the same antenna 162 may be shared by the RATs). Network node 160 may also include multiple sets of the various illustrated components for different wireless technologies integrated into network node 160, such as, for example, GSM, Wideband Code Division Multiple Access (WCDMA), LTE, NR, WiFi, or Bluetooth wireless technologies. These wireless technologies may be integrated into the same or different chip or set of chips and other

components within network node 160.

[0096] Processing circuitry 170 is configured to perform any determining, calculating, or similar operations (e.g., certain obtaining operations) described herein as being provided by a network node. These operations performed by processing circuitry 170 may include processing information obtained by processing circuitry 170 by, for example, converting the obtained information into other information, comparing the obtained information or converted information to information stored in the network node, and/or performing one or more operations based on the obtained information or converted information, and as a result of said processing making a determination.

[0097] Processing circuitry 170 may comprise a combination of one or more of a microprocessor, controller, microcontroller, central processing unit, digital signal processor, application-specific integrated circuit, field programmable gate array, or any other suitable computing device, resource, or combination of hardware, software, and/or encoded logic operable to provide, either alone or in conjunction with other network node 160 components, such as device readable medium 180, network node 160 functionality. For example, processing circuitry 170 may execute instructions stored in device readable medium 180 or in memory within processing circuitry 170. Such functionality may include providing any of the various wireless features, functions, or benefits discussed herein. In some embodiments, processing circuitry 170 may include a System on a Chip (SOC).

[0098] In some embodiments, processing circuitry 170 may include one or more of Radio Frequency (RF) transceiver circuitry 172 and baseband processing circuitry 174. In some embodiments, RF transceiver circuitry 172 and baseband processing circuitry 174 may be on separate chips (or sets of chips), boards, or units, such as radio units and digital units. In alternative embodiments, part or all of RF transceiver circuitry 172 and baseband processing circuitry 174 may be on the same chip or set of chips, boards, or units.

[0099] In certain embodiments, some or all of the functionality described herein as being provided by a network node, base station, eNB, or other such network device may be performed by processing circuitry 170 executing instructions stored on device readable medium 180 or memory within processing circuitry 170. In alternative embodiments, some or all of the functionality may be provided by processing circuitry 170 without executing instructions stored on a separate or discrete device readable medium, such as in a hard-wired manner. In any of those embodiments, whether executing instructions stored on a device readable storage medium or not, processing circuitry 170 can be configured to perform the described functionality. The benefits provided by such functionality are not limited to processing circuitry 170 alone or to other components of network node 160, but are enjoyed by network node 160 as a whole, and/or

by end users and the wireless network generally.

[0100] Device readable medium 180 may comprise any form of volatile or non-volatile computer readable memory including, without limitation, persistent storage, solid-state memory, remotely mounted memory, magnetic media, optical media, RAM, Read Only Memory (ROM), mass storage media (for example, a hard disk), removable storage media (for example, a flash drive, a Compact Disk (CD), or a Digital Video Disk (DVD)), and/or any other volatile or non-volatile, non-transitory device readable and/or computer-executable memory devices that store information, data, and/or instructions that may be used by processing circuitry 170. Device readable medium 180 may store any suitable instructions, data or information, including a computer program, software, an application including one or more of logic, rules, code, tables, etc. and/or other instructions capable of being executed by processing circuitry 170 and, utilized by network node 160. Device readable medium 180 may be used to store any calculations made by processing circuitry 170 and/or any data received via interface 190. In some embodiments, processing circuitry 170 and device readable medium 180 may be considered to be integrated.

[0101] Interface 190 is used in the wired or wireless communication of signaling and/or data between network node 160, network 106, and/or WDs 110. As illustrated, interface 190 comprises port(s)/terminal(s) 194 to send and receive data, for example to and from network 106 over a wired connection. Interface 190 also includes radio front end circuitry 192 that may be coupled to, or in certain embodiments a part of, antenna 162. Radio front end circuitry 192 comprises filters 198 and amplifiers 196. Radio front end circuitry 192 may be connected to antenna 162 and processing circuitry 170. Radio front end circuitry may be configured to condition signals communicated between antenna 162 and processing circuitry 170. Radio front end circuitry 192 may receive digital data that is to be sent out to other network nodes or WDs via a wireless connection. Radio front end circuitry 192 may convert the digital data into a radio signal having the appropriate channel and bandwidth parameters using a combination of filters 198 and/or amplifiers 196. The radio signal may then be transmitted via antenna 162. Similarly, when receiving data, antenna 162 may collect radio signals which are then converted into digital data by radio front end circuitry 192. The digital data may be passed to processing circuitry 170. In other embodiments, the interface may comprise different components and/or different combinations of components.

[0102] In certain alternative embodiments, network node 160 may not include separate radio front end circuitry 192; instead, processing circuitry 170 may comprise radio front end circuitry and may be connected to antenna 162 without separate radio front end circuitry 192. Similarly, in some embodiments, all or some of RF transceiver circuitry 172 may be considered a part of interface 190. In still other embodiments, interface 190 may include one or more ports or

terminals 194, radio front end circuitry 192, and RF transceiver circuitry 172, as part of a radio unit (not shown), and interface 190 may communicate with baseband processing circuitry 174, which is part of a digital unit (not shown).

[0103] Antenna 162 may include one or more antennas, or antenna arrays, configured to send and/or receive wireless signals. Antenna 162 may be coupled to radio front end circuitry 190 and may be any type of antenna capable of transmitting and receiving data and/or signals wirelessly. In some embodiments, antenna 162 may comprise one or more omni-directional, sector, or panel antennas operable to transmit/receive radio signals between, for example, 2 gigahertz (GHz) and 66 GHz. An omni-directional antenna may be used to transmit/receive radio signals in any direction, a sector antenna may be used to transmit/receive radio signals from devices within a particular area, and a panel antenna may be a line of sight antenna used to transmit/receive radio signals in a relatively straight line. In some instances, the use of more than one antenna may be referred to as Multiple Input Multiple Output (MIMO). In certain embodiments, antenna 162 may be separate from network node 160 and may be connectable to network node 160 through an interface or port.

[0104] Antenna 162, interface 190, and/or processing circuitry 170 may be configured to perform any receiving operations and/or certain obtaining operations described herein as being performed by a network node. Any information, data, and/or signals may be received from a wireless device, another network node, and/or any other network equipment. Similarly, antenna 162, interface 190, and/or processing circuitry 170 may be configured to perform any transmitting operations described herein as being performed by a network node. Any information, data, and/or signals may be transmitted to a wireless device, another network node and/or any other network equipment.

[0105] Power circuitry 187 may comprise, or be coupled to, power management circuitry and is configured to supply the components of network node 160 with power for performing the functionality described herein. Power circuitry 187 may receive power from power source 186. Power source 186 and/or power circuitry 187 may be configured to provide power to the various components of network node 160 in a form suitable for the respective components (e.g., at a voltage and current level needed for each respective component). Power source 186 may either be included in, or external to, power circuitry 187 and/or network node 160. For example, network node 160 may be connectable to an external power source (e.g., an electricity outlet) via an input circuitry or interface such as an electrical cable, whereby the external power source supplies power to power circuitry 187. As a further example, power source 186 may comprise a source of power in the form of a battery or battery pack which is connected to, or integrated in, power circuitry 187. The battery may provide backup power should the external power source

fail. Other types of power sources, such as photovoltaic devices, may also be used.

[0106] Alternative embodiments of network node 160 may include additional components beyond those shown in Figure 1 that may be responsible for providing certain aspects of the network node's functionality, including any of the functionality described herein and/or any functionality necessary to support the subject matter described herein. For example, network node 160 may include user interface equipment to allow input of information into network node 160 and to allow output of information from network node 160. This may allow a user to perform diagnostic, maintenance, repair, and other administrative functions for network node 160.

[0107] As used herein, WD refers to a device capable, configured, arranged, and/or operable to communicate wirelessly with network nodes and/or other wireless devices. Unless otherwise noted, the term WD may be used interchangeably herein with UE. Communicating wirelessly may involve transmitting and/or receiving wireless signals using electromagnetic waves, radio waves, infrared waves, and/or other types of signals suitable for conveying information through air. In some embodiments, a WD may be configured to transmit and/or receive information without direct human interaction. For instance, a WD may be designed to transmit information to a network on a predetermined schedule, when triggered by an internal or external event, or in response to requests from the network. Examples of a WD include, but are not limited to, a smart phone, a mobile phone, a cell phone, a Voice over IP (VoIP) phone, a wireless local loop phone, a desktop computer, a Personal Digital Assistant (PDA), a wireless cameras, a gaming console or device, a music storage device, a playback appliance, a wearable terminal device, a wireless endpoint, a mobile station, a tablet, a laptop, a Laptop Embedded Equipment (LEE), a Laptop Mounted Equipment (LME), a smart device, a wireless Customer Premise Equipment (CPE), a vehicle-mounted wireless terminal device, etc. A WD may support Device-to-Device (D2D) communication, for example by implementing a Third Generation Partnership Project (3GPP) standard for sidelink communication, Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Vehicle-to-Everything (V2X) and may in this case be referred to as a D2D communication device. As yet another specific example, in an Internet of Things (IoT) scenario, a WD may represent a machine or other device that performs monitoring and/or measurements, and transmits the results of such monitoring and/or measurements to another WD and/or a network node. The WD may in this case be a Machine-to-Machine (M2M) device, which may in a 3GPP context be referred to as a Machine Type Communication (MTC) device. As one particular example, the WD may be a UE implementing the 3GPP Narrowband IoT (NB-IoT) standard. Particular examples of such machines or devices are sensors, metering devices such as power meters, industrial machinery, or home or personal appliances (e.g., refrigerators,

televisions, etc.) personal wearables (e.g., watches, fitness trackers, etc.). In other scenarios, a WD may represent a vehicle or other equipment that is capable of monitoring and/or reporting on its operational status or other functions associated with its operation. A WD as described above may represent the endpoint of a wireless connection, in which case the device may be referred to as a wireless terminal. Furthermore, a WD as described above may be mobile, in which case it may also be referred to as a mobile device or a mobile terminal.

[0108] As illustrated, wireless device 110 includes antenna 111, interface 114, processing circuitry 120, device readable medium 130, user interface equipment 132, auxiliary equipment 134, power source 136, and power circuitry 137. WD 110 may include multiple sets of one or more of the illustrated components for different wireless technologies supported by WD 110, such as, for example, GSM, WCDMA, LTE, NR, WiFi, WiMAX, or Bluetooth wireless technologies, just to mention a few. These wireless technologies may be integrated into the same or different chips or set of chips as other components within WD 110.

[0109] Antenna 111 may include one or more antennas or antenna arrays, configured to send and/or receive wireless signals, and is connected to interface 114. In certain alternative embodiments, antenna 111 may be separate from WD 110 and be connectable to WD 110 through an interface or port. Antenna 111, interface 114, and/or processing circuitry 120 may be configured to perform any receiving or transmitting operations described herein as being performed by a WD. Any information, data, and/or signals may be received from a network node and/or another WD. In some embodiments, radio front end circuitry and/or antenna 111 may be considered an interface.

[0110] As illustrated, interface 114 comprises radio front end circuitry 112 and antenna 111. Radio front end circuitry 112 comprise one or more filters 118 and amplifiers 116. Radio front end circuitry 114 is connected to antenna 111 and processing circuitry 120, and is configured to condition signals communicated between antenna 111 and processing circuitry 120. Radio front end circuitry 112 may be coupled to or a part of antenna 111. In some embodiments, WD 110 may not include separate radio front end circuitry 112; rather, processing circuitry 120 may comprise radio front end circuitry and may be connected to antenna 111. Similarly, in some embodiments, some or all of RF transceiver circuitry 122 may be considered a part of interface 114. Radio front end circuitry 112 may receive digital data that is to be sent out to other network nodes or WDs via a wireless connection. Radio front end circuitry 112 may convert the digital data into a radio signal having the appropriate channel and bandwidth parameters using a combination of filters 118 and/or amplifiers 116. The radio signal may then be transmitted via antenna 111. Similarly, when receiving data, antenna 111 may collect radio signals which are then converted into digital data by radio front end circuitry 112. The digital data may be passed

to processing circuitry 120. In other embodiments, the interface may comprise different components and/or different combinations of components.

[0111] Processing circuitry 120 may comprise a combination of one or more of a microprocessor, controller, microcontroller, Central Processing Unit (CPU), Digital Signal Processor (DSP), Application Specific Integrated Circuit (ASIC), Field Programmable Gate Array (FPGA), or any other suitable computing device, resource, or combination of hardware, software, and/or encoded logic operable to provide, either alone or in conjunction with other WD 110 components, such as device readable medium 130, WD 110 functionality. Such functionality may include providing any of the various wireless features or benefits discussed herein. For example, processing circuitry 120 may execute instructions stored in device readable medium 130 or in memory within processing circuitry 120 to provide the functionality disclosed herein.

[0112] As illustrated, processing circuitry 120 includes one or more of RF transceiver circuitry 122, baseband processing circuitry 124, and application processing circuitry 126. In other embodiments, the processing circuitry may comprise different components and/or different combinations of components. In certain embodiments processing circuitry 120 of WD 110 may comprise a SOC. In some embodiments, RF transceiver circuitry 122, baseband processing circuitry 124, and application processing circuitry 126 may be on separate chips or sets of chips. In alternative embodiments, part or all of baseband processing circuitry 124 and application processing circuitry 126 may be combined into one chip or set of chips, and RF transceiver circuitry 122 may be on a separate chip or set of chips. In still alternative embodiments, part or all of RF transceiver circuitry 122 and baseband processing circuitry 124 may be on the same chip or set of chips, and application processing circuitry 126 may be on a separate chip or set of chips. In yet other alternative embodiments, part or all of RF transceiver circuitry 122, baseband processing circuitry 124, and application processing circuitry 126 may be combined in the same chip or set of chips. In some embodiments, RF transceiver circuitry 122 may be a part of interface 114. RF transceiver circuitry 122 may condition RF signals for processing circuitry 120.

[0113] In certain embodiments, some or all of the functionality described herein as being performed by a WD may be provided by processing circuitry 120 executing instructions stored on device readable medium 130, which in certain embodiments may be a computer-readable storage medium. In alternative embodiments, some or all of the functionality may be provided by processing circuitry 120 without executing instructions stored on a separate or discrete device readable storage medium, such as in a hard-wired manner. In any of those particular embodiments, whether executing instructions stored on a device readable storage medium or

not, processing circuitry 120 can be configured to perform the described functionality. The benefits provided by such functionality are not limited to processing circuitry 120 alone or to other components of WD 110, but are enjoyed by WD 110 as a whole, and/or by end users and the wireless network generally.

[0114] Processing circuitry 120 may be configured to perform any determining, calculating, or similar operations (e.g., certain obtaining operations) described herein as being performed by a WD. These operations, as performed by processing circuitry 120, may include processing information obtained by processing circuitry 120 by, for example, converting the obtained information into other information, comparing the obtained information or converted information to information stored by WD 110, and/or performing one or more operations based on the obtained information or converted information, and as a result of said processing making a determination.

[0115] Device readable medium 130 may be operable to store a computer program, software, an application including one or more of logic, rules, code, tables, etc. and/or other instructions capable of being executed by processing circuitry 120. Device readable medium 130 may include computer memory (e.g., RAM or ROM), mass storage media (e.g., a hard disk), removable storage media (e.g., a CD or a DVD), and/or any other volatile or non-volatile, non-transitory device readable and/or computer executable memory devices that store information, data, and/or instructions that may be used by processing circuitry 120. In some embodiments, processing circuitry 120 and device readable medium 130 may be considered to be integrated.

[0116] User interface equipment 132 may provide components that allow for a human user to interact with WD 110. Such interaction may be of many forms, such as visual, audial, tactile, etc. User interface equipment 132 may be operable to produce output to the user and to allow the user to provide input to WD 110. The type of interaction may vary depending on the type of user interface equipment 132 installed in WD 110. For example, if WD 110 is a smart phone, the interaction may be via a touch screen; if WD 110 is a smart meter, the interaction may be through a screen that provides usage (e.g., the number of gallons used) or a speaker that provides an audible alert (e.g., if smoke is detected). User interface equipment 132 may include input interfaces, devices and circuits, and output interfaces, devices and circuits. User interface equipment 132 is configured to allow input of information into WD 110, and is connected to processing circuitry 120 to allow processing circuitry 120 to process the input information. User interface equipment 132 may include, for example, a microphone, a proximity or other sensor, keys/buttons, a touch display, one or more cameras, a Universal Serial Bus (USB) port, or other input circuitry. User interface equipment 132 is also configured to allow output of information

from WD 110, and to allow processing circuitry 120 to output information from WD 110. User interface equipment 132 may include, for example, a speaker, a display, vibrating circuitry, a USB port, a headphone interface, or other output circuitry. Using one or more input and output interfaces, devices, and circuits, of user interface equipment 132, WD 110 may communicate with end users and/or the wireless network, and allow them to benefit from the functionality described herein.

[0117] Auxiliary equipment 134 is operable to provide more specific functionality which may not be generally performed by WDs. This may comprise specialized sensors for doing measurements for various purposes, interfaces for additional types of communication such as wired communications, etc. The inclusion and type of components of auxiliary equipment 134 may vary depending on the embodiment and/or scenario.

[0118] Power source 136 may, in some embodiments, be in the form of a battery or battery pack. Other types of power sources, such as an external power source (e.g., an electricity outlet), photovoltaic devices or power cells, may also be used. WD 110 may further comprise power circuitry 137 for delivering power from power source 136 to the various parts of WD 110 which need power from power source 136 to carry out any functionality described or indicated herein. Power circuitry 137 may in certain embodiments comprise power management circuitry. Power circuitry 137 may additionally or alternatively be operable to receive power from an external power source; in which case WD 110 may be connectable to the external power source (such as an electricity outlet) via input circuitry or an interface such as an electrical power cable. Power circuitry 137 may also in certain embodiments be operable to deliver power from an external power source to power source 136. This may be, for example, for the charging of power source 136. Power circuitry 137 may perform any formatting, converting, or other modification to the power from power source 136 to make the power suitable for the respective components of WD 110 to which power is supplied.

[0119] Figure 2 illustrates one embodiment of a UE in accordance with various aspects described herein. As used herein, a user equipment or UE may not necessarily have a user in the sense of a human user who owns and/or operates the relevant device. Instead, a UE may represent a device that is intended for sale to, or operation by, a human user but which may not, or which may not initially, be associated with a specific human user (e.g., a smart sprinkler controller). Alternatively, a UE may represent a device that is not intended for sale to, or operation by, an end user but which may be associated with or operated for the benefit of a user (e.g., a smart power meter). UE 2200 may be any UE identified by the 3GPP, including a NB-IoT UE, a MTC UE, and/or an enhanced MTC (eMTC) UE. UE 200, as illustrated in Figure 2, is one example of a WD configured for communication in accordance with one or more

communication standards promulgated by the 3GPP, such as 3GPP's GSM, UMTS, LTE, and/or 5G standards. As mentioned previously, the terms WD and UE may be used interchangeably. Accordingly, although Figure 2 is a UE, the components discussed herein are equally applicable to a WD, and vice-versa.

[0120] In Figure 2, UE 200 includes processing circuitry 201 that is operatively coupled to input/output interface 205, RF interface 209, network connection interface 211, memory 215 including RAM 217, ROM 219, and storage medium 221 or the like, communication subsystem 231, power source 233, and/or any other component, or any combination thereof. Storage medium 221 includes operating system 223, application program 225, and data 227. In other embodiments, storage medium 221 may include other similar types of information. Certain UEs may utilize all of the components shown in Figure 2, or only a subset of the components. The level of integration between the components may vary from one UE to another UE. Further, certain UEs may contain multiple instances of a component, such as multiple processors, memories, transceivers, transmitters, receivers, etc.

[0121] In Figure 2, processing circuitry 201 may be configured to process computer instructions and data. Processing circuitry 201 may be configured to implement any sequential state machine operative to execute machine instructions stored as machine-readable computer programs in the memory, such as one or more hardware-implemented state machines (e.g., in discrete logic, FPGA, ASIC, etc.); programmable logic together with appropriate firmware; one or more stored program, general-purpose processors, such as a microprocessor or DSP, together with appropriate software; or any combination of the above. For example, the processing circuitry 201 may include two CPUs. Data may be information in a form suitable for use by a computer.

[0122] In the depicted embodiment, input/output interface 205 may be configured to provide a communication interface to an input device, output device, or input and output device. UE 200 may be configured to use an output device via input/output interface 205. An output device may use the same type of interface port as an input device. For example, a USB port may be used to provide input to and output from UE 200. The output device may be a speaker, a sound card, a video card, a display, a monitor, a printer, an actuator, an emitter, a smartcard, another output device, or any combination thereof. UE 200 may be configured to use an input device via input/output interface 205 to allow a user to capture information into UE 200. The input device may include a touch-sensitive or presence-sensitive display, a camera (e.g., a digital camera, a digital video camera, a web camera, etc.), a microphone, a sensor, a mouse, a trackball, a directional pad, a trackpad, a scroll wheel, a smartcard, and the like. The presence-sensitive display may include a capacitive or resistive touch sensor to sense input from a user. A sensor

may be, for instance, an accelerometer, a gyroscope, a tilt sensor, a force sensor, a magnetometer, an optical sensor, a proximity sensor, another like sensor, or any combination thereof. For example, the input device may be an accelerometer, a magnetometer, a digital camera, a microphone, and an optical sensor.

[0123] In Figure 2, RF interface 209 may be configured to provide a communication interface to RF components such as a transmitter, a receiver, and an antenna. Network connection interface 211 may be configured to provide a communication interface to network 243a. Network 243a may encompass wired and/or wireless networks such as a LAN, a WAN, a computer network, a wireless network, a telecommunications network, another like network or any combination thereof. For example, network 243a may comprise a Wi-Fi network. Network connection interface 211 may be configured to include a receiver and a transmitter interface used to communicate with one or more other devices over a communication network according to one or more communication protocols, such as Ethernet, Transmission Control Protocol (TCP) / IP, Synchronous Optical Networking (SONET), Asynchronous Transfer Mode (ATM), or the like. Network connection interface 211 may implement receiver and transmitter functionality appropriate to the communication network links (e.g., optical, electrical, and the like). The transmitter and receiver functions may share circuit components, software or firmware, or alternatively may be implemented separately.

[0124] RAM 217 may be configured to interface via bus 202 to processing circuitry 201 to provide storage or caching of data or computer instructions during the execution of software programs such as the operating system, application programs, and device drivers. ROM 219 may be configured to provide computer instructions or data to processing circuitry 201. For example, ROM 219 may be configured to store invariant low-level system code or data for basic system functions such as basic input and output (I/O), startup, or reception of keystrokes from a keyboard that are stored in a non-volatile memory. Storage medium 221 may be configured to include memory such as RAM, ROM, Programmable ROM (PROM), Erasable PROM (EPROM), Electrically EPROM (EEPROM), magnetic disks, optical disks, floppy disks, hard disks, removable cartridges, or flash drives. In one example, storage medium 221 may be configured to include operating system 223, application program 225 such as a web browser application, a widget or gadget engine or another application, and data file 227. Storage medium 221 may store, for use by UE 200, any of a variety of various operating systems or combinations of operating systems.

[0125] Storage medium 221 may be configured to include a number of physical drive units, such as Redundant Array of Independent Disks (RAID), floppy disk drive, flash memory, USB flash drive, external hard disk drive, thumb drive, pen drive, key drive, High-Density Digital

Versatile Disc (HD-DVD) optical disc drive, internal hard disk drive, Blu-Ray optical disc drive, Holographic Digital Data Storage (HDDS) optical disc drive, external mini Dual In-Line Memory Module (DIMM), synchronous dynamic RAM (SDRAM), external micro-DIMM SDRAM, smartcard memory such as a Subscriber Identity Module (SIM) or a Removable User Identity Module (RUIM), other memory, or any combination thereof. Storage medium 221 may allow UE 200 to access computer-executable instructions, application programs or the like, stored on transitory or non-transitory memory media, to off-load data, or to upload data. An article of manufacture, such as one utilizing a communication system may be tangibly embodied in storage medium 221, which may comprise a device readable medium.

[0126] In Figure 2, processing circuitry 201 may be configured to communicate with network 243b using communication subsystem 231. Network 243a and network 243b may be the same network or networks or different network or networks. Communication subsystem 231 may be configured to include one or more transceivers used to communicate with network 243b. For example, communication subsystem 231 may be configured to include one or more transceivers used to communicate with one or more remote transceivers of another device capable of wireless communication such as another WD, UE, or base station of a Radio Access Network (RAN) according to one or more communication protocols, such as IEEE 802.2, Code Division Multiplexing Access (CDMA), WCDMA, GSM, LTE, UTRAN, WiMax, or the like. Each transceiver may include transmitter 233 and/or receiver 235 to implement transmitter or receiver functionality, respectively, appropriate to the RAN links (e.g., frequency allocations and the like). Further, transmitter 233 and receiver 235 of each transceiver may share circuit components, software or firmware, or alternatively may be implemented separately.

[0127] In the illustrated embodiment, the communication functions of communication subsystem 231 may include data communication, voice communication, multimedia communication, short-range communications such as Bluetooth, near-field communication, location-based communication such as the use of the Global Positioning System (GPS) to determine a location, another like communication function, or any combination thereof. For example, communication subsystem 231 may include cellular communication, Wi-Fi communication, Bluetooth communication, and GPS communication. Network 243b may encompass wired and/or wireless networks such as a LAN, a WAN, a computer network, a wireless network, a telecommunications network, another like network or any combination thereof. For example, network 243b may be a cellular network, a Wi-Fi network, and/or a near-field network. Power source 213 may be configured to provide Alternating Current (AC) or Direct Current (DC) power to components of UE 200.

[0128] The features, benefits and/or functions described herein may be implemented in one

of the components of UE 200 or partitioned across multiple components of UE 200. Further, the features, benefits, and/or functions described herein may be implemented in any combination of hardware, software or firmware. In one example, communication subsystem 231 may be configured to include any of the components described herein. Further, processing circuitry 201 may be configured to communicate with any of such components over bus 202. In another example, any of such components may be represented by program instructions stored in memory that when executed by processing circuitry 201 perform the corresponding functions described herein. In another example, the functionality of any of such components may be partitioned between processing circuitry 201 and communication subsystem 231. In another example, the non-computationally intensive functions of any of such components may be implemented in software or firmware and the computationally intensive functions may be implemented in hardware.

[0129] Figure 3 is a schematic block diagram illustrating a virtualization environment 300 in which functions implemented by some embodiments may be virtualized. In the present context, virtualizing means creating virtual versions of apparatuses or devices which may include virtualizing hardware platforms, storage devices and networking resources. As used herein, virtualization can be applied to a node (e.g., a virtualized base station or a virtualized radio access node) or to a device (e.g., a UE, a wireless device or any other type of communication device) or components thereof and relates to an implementation in which at least a portion of the functionality is implemented as one or more virtual components (e.g., via one or more applications, components, functions, virtual machines or containers executing on one or more physical processing nodes in one or more networks).

[0130] In some embodiments, some or all of the functions described herein may be implemented as virtual components executed by one or more virtual machines implemented in one or more virtual environments 300 hosted by one or more of hardware nodes 330. Further, in embodiments in which the virtual node is not a radio access node or does not require radio connectivity (e.g., a core network node), then the network node may be entirely virtualized.

[0131] The functions may be implemented by one or more applications 320 (which may alternatively be called software instances, virtual appliances, network functions, virtual nodes, virtual network functions, etc.) operative to implement some of the features, functions, and/or benefits of some of the embodiments disclosed herein. Applications 320 are run in virtualization environment 300 which provides hardware 330 comprising processing circuitry 360 and memory 390. Memory 390 contains instructions 395 executable by processing circuitry 360 whereby application 320 is operative to provide one or more of the features, benefits, and/or functions disclosed herein.

[0132] Virtualization environment 300, comprises general-purpose or special-purpose network hardware devices 330 comprising a set of one or more processors or processing circuitry 360, which may be Commercial Off-The-Shelf (COTS) processors, dedicated ASICs, or any other type of processing circuitry including digital or analog hardware components or special purpose processors. Each hardware device may comprise memory 390-1 which may be non-persistent memory for temporarily storing instructions 395 or software executed by processing circuitry 360. Each hardware device may comprise one or more Network Interface Controllers (NICs) 370, also known as network interface cards, which include physical network interface 380. Each hardware device may also include non-transitory, persistent, machine-readable storage media 390-2 having stored therein software 395 and/or instructions executable by processing circuitry 360. Software 395 may include any type of software including software for instantiating one or more virtualization layers 350 (also referred to as hypervisors), software to execute virtual machines 340 as well as software allowing it to execute functions, features and/or benefits described in relation with some embodiments described herein.

[0133] Virtual machines 340, comprise virtual processing, virtual memory, virtual networking or interface and virtual storage, and may be run by a corresponding virtualization layer 350 or hypervisor. Different embodiments of the instance of virtual appliance 320 may be implemented on one or more of virtual machines 340, and the implementations may be made in different ways.

[0134] During operation, processing circuitry 360 executes software 395 to instantiate the hypervisor or virtualization layer 350, which may sometimes be referred to as a Virtual Machine Monitor (VMM). Virtualization layer 350 may present a virtual operating platform that appears like networking hardware to virtual machine 340.

[0135] As shown in Figure 3, hardware 330 may be a standalone network node with generic or specific components. Hardware 330 may comprise antenna 3225 and may implement some functions via virtualization. Alternatively, hardware 330 may be part of a larger cluster of hardware (e.g. such as in a data center or CPE) where many hardware nodes work together and are managed via Management and Orchestration (MANO) 3100, which, among others, oversees lifecycle management of applications 320.

[0136] Virtualization of the hardware is in some contexts referred to as Network Function Virtualization (NFV). NFV may be used to consolidate many network equipment types onto industry standard high volume server hardware, physical switches, and physical storage, which can be located in data centers, and CPE.

[0137] In the context of NFV, virtual machine 340 may be a software implementation of a physical machine that runs programs as if they were executing on a physical, non-virtualized

machine. Each of virtual machines 340, and that part of hardware 330 that executes that virtual machine, be it hardware dedicated to that virtual machine and/or hardware shared by that virtual machine with others of the virtual machines 340, forms a separate Virtual Network Elements (VNE).

[0138] Still in the context of NFV, Virtual Network Function (VNF) is responsible for handling specific network functions that run in one or more virtual machines 340 on top of hardware networking infrastructure 330 and corresponds to application 320 in Figure 3.

[0139] In some embodiments, one or more radio units 3200 that each include one or more transmitters 3220 and one or more receivers 3210 may be coupled to one or more antennas 3225. Radio units 3200 may communicate directly with hardware nodes 330 via one or more appropriate network interfaces and may be used in combination with the virtual components to provide a virtual node with radio capabilities, such as a radio access node or a base station.

[0140] In some embodiments, some signaling can be effected with the use of control system 3230 which may alternatively be used for communication between the hardware nodes 330 and radio units 3200.

[0141] With reference to Figure 4, in accordance with an embodiment, a communication system includes telecommunication network 410, such as a 3GPP-type cellular network, which comprises access network 411, such as a radio access network, and core network 414. Access network 411 comprises a plurality of base stations 412a, 412b, 412c, such as Node Bs, eNBs, gNBs, or other types of wireless access points, each defining a corresponding coverage area 413a, 413b, 413c. Each base station 412a, 412b, 412c is connectable to core network 414 over a wired or wireless connection 415. A first UE 491 located in coverage area 413c is configured to wirelessly connect to, or be paged by, the corresponding base station 412c. A second UE 492 in coverage area 413a is wirelessly connectable to the corresponding base station 412a. While a plurality of UEs 491, 492 are illustrated in this example, the disclosed embodiments are equally applicable to a situation where a sole UE is in the coverage area or where a sole UE is connecting to the corresponding base station 412.

[0142] Telecommunication network 410 is itself connected to host computer 430, which may be embodied in the hardware and/or software of a standalone server, a cloud-implemented server, a distributed server or as processing resources in a server farm. Host computer 430 may be under the ownership or control of a service provider, or may be operated by the service provider or on behalf of the service provider. Connections 421 and 422 between telecommunication network 410 and host computer 430 may extend directly from core network 414 to host computer 430 or may go via an optional intermediate network 420. Intermediate network 420 may be one of, or a combination of more than one of, a public, private or hosted

network; intermediate network 420, if any, may be a backbone network or the Internet; in particular, intermediate network 420 may comprise two or more sub-networks (not shown).

[0143] The communication system of Figure 4 as a whole enables connectivity between the connected UEs 491, 492 and host computer 430. The connectivity may be described as an Over-the-Top (OTT) connection 450. Host computer 430 and the connected UEs 491, 492 are configured to communicate data and/or signaling via OTT connection 450, using access network 411, core network 414, any intermediate network 420 and possible further infrastructure (not shown) as intermediaries. OTT connection 450 may be transparent in the sense that the participating communication devices through which OTT connection 450 passes are unaware of routing of uplink and downlink communications. For example, base station 412 may not or need not be informed about the past routing of an incoming downlink communication with data originating from host computer 430 to be forwarded (e.g., handed over) to a connected UE 491. Similarly, base station 412 need not be aware of the future routing of an outgoing uplink communication originating from the UE 491 towards the host computer 430.

[0144] Example implementations, in accordance with an embodiment, of the UE, base station and host computer discussed in the preceding paragraphs will now be described with reference to Figure 5. In communication system 500, host computer 510 comprises hardware 515 including communication interface 516 configured to set up and maintain a wired or wireless connection with an interface of a different communication device of communication system 500. Host computer 510 further comprises processing circuitry 518, which may have storage and/or processing capabilities. In particular, processing circuitry 518 may comprise one or more programmable processors, application-specific integrated circuits, field programmable gate arrays or combinations of these (not shown) adapted to execute instructions. Host computer 510 further comprises software 511, which is stored in or accessible by host computer 510 and executable by processing circuitry 518. Software 511 includes host application 512. Host application 512 may be operable to provide a service to a remote user, such as UE 530 connecting via OTT connection 550 terminating at UE 530 and host computer 510. In providing the service to the remote user, host application 512 may provide user data which is transmitted using OTT connection 550.

[0145] Communication system 500 further includes base station 520 provided in a telecommunication system and comprising hardware 525 enabling it to communicate with host computer 510 and with UE 530. Hardware 525 may include communication interface 526 for setting up and maintaining a wired or wireless connection with an interface of a different communication device of communication system 500, as well as radio interface 527 for setting up and maintaining at least wireless connection 570 with UE 530 located in a coverage area (not

shown in Figure 5) served by base station 520. Communication interface 526 may be configured to facilitate connection 560 to host computer 510. Connection 560 may be direct or it may pass through a core network (not shown in Figure 5) of the telecommunication system and/or through one or more intermediate networks outside the telecommunication system. In the embodiment shown, hardware 525 of base station 520 further includes processing circuitry 528, which may comprise one or more programmable processors, ASICs, FPGAs, or combinations of these (not shown) adapted to execute instructions. Base station 520 further has software 521 stored internally or accessible via an external connection.

[0146] Communication system 500 further includes UE 530 already referred to. Its hardware 535 may include radio interface 537 configured to set up and maintain wireless connection 570 with a base station serving a coverage area in which UE 530 is currently located. Hardware 535 of UE 530 further includes processing circuitry 538, which may comprise one or more programmable processors, ASICs, FPGAs, or combinations of these (not shown) adapted to execute instructions. UE 530 further comprises software 531, which is stored in or accessible by UE 530 and executable by processing circuitry 538. Software 531 includes client application 532. Client application 532 may be operable to provide a service to a human or non-human user via UE 530, with the support of host computer 510. In host computer 510, an executing host application 512 may communicate with the executing client application 532 via OTT connection 550 terminating at UE 530 and host computer 510. In providing the service to the user, client application 532 may receive request data from host application 512 and provide user data in response to the request data. OTT connection 550 may transfer both the request data and the user data. Client application 532 may interact with the user to generate the user data that it provides.

[0147] It is noted that host computer 510, base station 520 and UE 530 illustrated in Figure 5 may be similar or identical to host computer 430, one of base stations 412a, 412b, 412c and one of UEs 491, 492 of Figure 4, respectively. This is to say, the inner workings of these entities may be as shown in Figure 5 and independently, the surrounding network topology may be that of Figure 4.

[0148] In Figure 5, OTT connection 550 has been drawn abstractly to illustrate the communication between host computer 510 and UE 530 via base station 520, without explicit reference to any intermediary devices and the precise routing of messages via these devices. Network infrastructure may determine the routing, which it may be configured to hide from UE 530 or from the service provider operating host computer 510, or both. While OTT connection 550 is active, the network infrastructure may further take decisions by which it dynamically changes the routing (e.g., on the basis of load balancing consideration or reconfiguration of the

network).

[0149] Wireless connection 570 between UE 530 and base station 520 is in accordance with the teachings of the embodiments described throughout this disclosure. One or more of the various embodiments improve the performance of OTT services provided to UE 530 using OTT connection 550, in which wireless connection 570 forms the last segment. More precisely, the teachings of these embodiments may improve the power consumption (e.g., by reducing overhead messaging required for PUCCH resource allocation) and thereby provide benefits such as extended battery lifetime. As another example, the teachings of these embodiments may reduce collisions between PUCCH resources used by different wireless devices, which may allow for reduced latency and thereby provide benefits such as reduced user waiting time.

[0150] A measurement procedure may be provided for the purpose of monitoring data rate, latency and other factors on which the one or more embodiments improve. There may further be an optional network functionality for reconfiguring OTT connection 550 between host computer 510 and UE 530, in response to variations in the measurement results. The measurement procedure and/or the network functionality for reconfiguring OTT connection 550 may be implemented in software 511 and hardware 515 of host computer 510 or in software 531 and hardware 535 of UE 530, or both. In embodiments, sensors (not shown) may be deployed in or in association with communication devices through which OTT connection 550 passes; the sensors may participate in the measurement procedure by supplying values of the monitored quantities exemplified above, or supplying values of other physical quantities from which software 511, 531 may compute or estimate the monitored quantities. The reconfiguring of OTT connection 550 may include message format, retransmission settings, preferred routing etc.; the reconfiguring need not affect base station 520, and it may be unknown or imperceptible to base station 520. Such procedures and functionalities may be known and practiced in the art. In certain embodiments, measurements may involve proprietary UE signaling facilitating host computer 510's measurements of throughput, propagation times, latency and the like. The measurements may be implemented in that software 511 and 531 causes messages to be transmitted, in particular empty or 'dummy' messages, using OTT connection 550 while it monitors propagation times, errors etc.

[0151] Figure 6 is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station, and a UE which may be those described with reference to Figures 4 and 5. For simplicity of the present disclosure, only drawing references to Figure 6 will be included in this section. In step 610, the host computer provides user data. In substep 611 (which may be optional) of step 610, the host computer provides the user data by executing a

host application. In step 620, the host computer initiates a transmission carrying the user data to the UE. In step 630 (which may be optional), the base station transmits to the UE the user data which was carried in the transmission that the host computer initiated, in accordance with the teachings of the embodiments described throughout this disclosure. In step 640 (which may also be optional), the UE executes a client application associated with the host application executed by the host computer.

[0152] Figure 7 is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station, and a UE which may be those described with reference to Figures 4 and 5. For simplicity of the present disclosure, only drawing references to Figure 7 will be included in this section. In step 710 of the method, the host computer provides user data. In an optional substep (not shown) the host computer provides the user data by executing a host application. In step 720, the host computer initiates a transmission carrying the user data to the UE. The transmission may pass via the base station, in accordance with the teachings of the embodiments described throughout this disclosure. In step 730 (which may be optional), the UE receives the user data carried in the transmission.

[0153] Figure 8 is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station, and a UE which may be those described with reference to Figures 4 and 5. For simplicity of the present disclosure, only drawing references to Figure 8 will be included in this section. In step 810 (which may be optional), the UE receives input data provided by the host computer. Additionally or alternatively, in step 820, the UE provides user data. In substep 821 (which may be optional) of step 820, the UE provides the user data by executing a client application. In substep 811 (which may be optional) of step 810, the UE executes a client application which provides the user data in reaction to the received input data provided by the host computer. In providing the user data, the executed client application may further consider user input received from the user. Regardless of the specific manner in which the user data was provided, the UE initiates, in substep 830 (which may be optional), transmission of the user data to the host computer. In step 840 of the method, the host computer receives the user data transmitted from the UE, in accordance with the teachings of the embodiments described throughout this disclosure.

[0154] Figure 9 is a flowchart illustrating a method implemented in a communication system, in accordance with one embodiment. The communication system includes a host computer, a base station, and a UE which may be those described with reference to Figures 4 and 5. For simplicity of the present disclosure, only drawing references to Figure 9 will be

included in this section. In step 910 (which may be optional), in accordance with the teachings of the embodiments described throughout this disclosure, the base station receives user data from the UE. In step 920 (which may be optional), the base station initiates transmission of the received user data to the host computer. In step 930 (which may be optional), the host computer receives the user data carried in the transmission initiated by the base station.

[0155] Any appropriate steps, methods, features, functions, or benefits disclosed herein may be performed through one or more functional units or modules of one or more virtual apparatuses. Each virtual apparatus may comprise a number of these functional units. These functional units may be implemented via processing circuitry, which may include one or more microprocessor or microcontrollers, as well as other digital hardware, which may include DSPs, special-purpose digital logic, and the like. The processing circuitry may be configured to execute program code stored in memory, which may include one or several types of memory such as ROM, RAM, cache memory, flash memory devices, optical storage devices, etc. Program code stored in memory includes program instructions for executing one or more telecommunications and/or data communications protocols as well as instructions for carrying out one or more of the techniques described herein. In some implementations, the processing circuitry may be used to cause the respective functional unit to perform corresponding functions according one or more embodiments of the present disclosure.

[0156] Figure 10 depicts a method in a wireless device. In accordance with particular embodiments, the method begins at step 1002 with determining which resources of a control channel (e.g., PUCCH) to use for transmitting uplink control information (e.g., HARQ ACK) to a network node. The determination may be based on any suitable information, for example, such as described with respect to example embodiments 1-8 above. In certain embodiments, the control channel resources to be used for transmitting the uplink control information are determined based on signaling received from the network node (e.g., RRC and/or DCI signaling) and implicit resource determination performed by the wireless device. The method proceeds to step 1004 with transmitting the uplink control information using the determined resources of the control channel (the resources determined in step 1002).

[0157] While Figure 10 illustrates the general operation of a wireless device (e.g., a UE), Figures 11 through 13 show some specific examples with respect to Embodiments 3, 4, and 7 described above. Figure 11 is a flow chart that illustrates at least some aspects of Embodiment 3 described above. As illustrated, the UE receives, from the network node, signaling comprising information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources (step 1100). The UE receives a downlink control channel that schedules a downlink shared channel transmission

to the UE (step 1102). The UE determines an uplink control channel resource to use for transmitting UCI to a network node (step 1104). The details of the determining step 1104 are as described above with respect to Embodiment 3. As discussed above, the UCI comprises HARQ feedback for the downlink shared channel transmission. As discussed above, determining the uplink control channel resource comprises selecting the uplink control channel resource from uplink control channel resources in two or more uplink control channel resource sets based on the UCI payload and one or more of the following when HARQ ACK feedback is part of the UCI:

- the CORESET where the downlink control channel scheduling the physical downlink shared channel transmission (i.e., the physical downlink shared channel transmission for which HARQ ACK feedback is to be provided) is received;
- the search space within the above CORESET (i.e., the search space within the above CORESET in which the downlink control channel scheduling the physical downlink shared channel transmission is received);
- the starting CCE index of the downlink control channel candidate within the above search space (i.e., the starting CCE index of the downlink control channel candidate within the above search space in which the downlink control channel scheduling the physical downlink shared channel transmission is received).

[0158] More specifically, in Embodiment 3, the UE selects one of the two or more uplink control channel resource sets (step 1104A). As described above, this selection is based on the UCI payload and one or more of the following when HARQ ACK feedback is part of the UCI:

- the CORESET where the downlink control channel scheduling the physical downlink shared channel transmission (i.e., the physical downlink shared channel transmission for which HARQ ACK feedback is to be provided) is received;
- the search space within the above CORESET (i.e., the search space within the above CORESET in which the downlink control channel scheduling the physical downlink shared channel transmission is received);
- the starting CCE index of the downlink control channel candidate within the above search space (i.e., the starting CCE index of the downlink control channel candidate within the above search space in which the downlink control channel scheduling the physical downlink shared channel transmission is received).

In some embodiments, the selection of the uplink control channel resource set is based on the CCE index, the search space of the successfully received PDCCH, and optionally the identifier (Radio Network Temporary Identifier (RNTI)) used to scramble the PDCCH is then used to determine a single PUCCH resource set within the group of configured PUCCH resource sets

corresponding to the chosen PUCCH format. The UE selects, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node (step 1104B). The UE transmits the UCI using the determined uplink control channel resource (step 1106).

[0159] Figure 12 is a flow chart that illustrates at least some aspects of Embodiment 4 described above. As illustrated, the UE receives, from the network node, signaling comprising information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources (step 1200). The UE receives a downlink control channel that schedules a downlink shared channel transmission to the UE (step 1202). The UE determines an uplink control channel resource to use for transmitting UCI to a network node (step 1204). The details of the determining step 1204 are as described above with respect to Embodiment 4. As discussed above, the UCI comprises HARQ feedback for the downlink shared channel transmission. As discussed above, determining the uplink control channel resource comprises selecting the uplink control channel resource from uplink control channel resources in two or more uplink control channel resource sets based on the UCI payload and one or more of the following when HARQ ACK feedback is part of the UCI:

- the CORESET where the downlink control channel scheduling the physical downlink shared channel transmission (i.e., the physical downlink shared channel transmission for which HARQ ACK feedback is to be provided) is received;
- the search space within the above CORESET (i.e., the search space within the above CORESET in which the downlink control channel scheduling the physical downlink shared channel transmission is received);
- the starting CCE index of the downlink control channel candidate within the above search space (i.e., the starting CCE index of the downlink control channel candidate within the above search space in which the downlink control channel scheduling the physical downlink shared channel transmission is received).

[0160] More specifically, in Embodiment 4, the UE selects one of the uplink control channel resource sets based on dynamic signaling from the network node (step 1204A). The UE selects, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the uplink control channel resources from the selected uplink control channel resource set using an implicit determination (step 1204B). As described above, this implicit determination is based on the CCE index, the search space of the successfully received PDCCH, and optionally the identifier (RNTI) used to scramble the PDCCH is then used to

determine a single PUCCH resource within the group of PUCCH resource sets corresponding to the chosen PUCCH format. The UE transmits the UCI using the determined uplink control channel resource (step 1206).

[0161] Figure 13 is a flow chart that illustrates at least some aspects of Embodiment 7 described above. As illustrated, the UE receives, from the network node, a first downlink control channel message that schedules a first downlink shared channel transmission to the UE (step 1300) and a second downlink control channel message that schedules a second downlink shared channel transmission to the UE (step 1302). The UE determines an uplink control channel resource to use for transmitting UCI to a network node (step 1304). The details of the determining step 1304 are as described above with respect to Embodiment 7. As discussed above, the UCI comprises HARQ feedback for the downlink shared channel transmission. As discussed above, the uplink channel resource to use for transmitting the UCI is determined based on signaling received from the network node and a latest received one of the first and second downlink control channel messages. The UE transmits the UCI using the determined uplink control channel resource (step 1306).

[0162] Figure 14 illustrates a schematic block diagram of an apparatus 1400 in a wireless network (for example, the wireless network shown in Figure 1). The apparatus may be implemented in a wireless device or network node (e.g., wireless device 110 or network node 160 shown in Figure 1). Apparatus 1400 is operable to carry out the example method described with reference to Figure 10 and possibly any other processes or methods disclosed herein. It is also to be understood that the method of Figure 10 is not necessarily carried out solely by apparatus 1400. At least some operations of the method can be performed by one or more other entities.

[0163] Virtual apparatus 1400 may comprise processing circuitry, which may include one or more microprocessor or microcontrollers, as well as other digital hardware, which may include DSPs, special-purpose digital logic, and the like. The processing circuitry may be configured to execute program code stored in memory, which may include one or several types of memory such as ROM, RAM, cache memory, flash memory devices, optical storage devices, etc. Program code stored in memory includes program instructions for executing one or more telecommunications and/or data communications protocols as well as instructions for carrying out one or more of the techniques described herein, in several embodiments. In some implementations, the processing circuitry may be used to cause PUCCH resource selection unit 1402, UCI transmitting unit 1404, and any other suitable units of apparatus 1400 to perform corresponding functions according one or more embodiments of the present disclosure.

[0164] As illustrated in Figure 14, apparatus 1400 includes PUCCH resource selection unit

1402 and UCI transmitting unit 1404. PUCCH resource selection unit 1402 is configured to determine which resources of a control channel to use for transmitting uplink control information to a network node. The determination may be based on any suitable information, for example, such as described with respect to example embodiments 1-8 above. UCI transmitting unit 1404 is configured to transmit the uplink control information using the resources determined by PUCCH resource selection unit 1402.

[0165] The term unit may have conventional meaning in the field of electronics, electrical devices and/or electronic devices and may include, for example, electrical and/or electronic circuitry, devices, modules, processors, memories, logic solid state and/or discrete devices, computer programs or instructions for carrying out respective tasks, procedures, computations, outputs, and/or displaying functions, and so on, as such as those that are described herein.

[0166] Some example embodiments are:

Group A Embodiments

[0167] Embodiment 1: A method performed by a wireless device, the method comprising: determining which resources of a control channel to use for transmitting uplink control information to a network node, the resources determined based on a combination of signaling received from the network node and implicit resource determination performed by the wireless device; and transmitting the uplink control information using the determined resources of the control channel.

[0168] Embodiment 2: The method of the previous embodiment, wherein the control channel comprises a Physical Uplink Control Channel (PUCCH) and wherein the uplink control information comprises one or more of Hybrid Automatic Repeat Request (HARQ) Acknowledgements (ACKs), Channel State Information (CSI), and/or Scheduling Requests (SRs).

[0169] Embodiment 3: The method of any of the previous embodiments, wherein the determining which resources of the control channel to use is performed when the timing is variable between when the wireless device receives a message scheduling a downlink transmission and when the wireless device transmits the uplink control information.

[0170] Embodiment 4: The method of any of the previous embodiments, wherein the determining which resources of the control channel to use is performed when the wireless device can receive a message scheduling a downlink transmission in any one of multiple control regions in the same slot.

[0171] Embodiment 5: The method of any of the previous embodiments, wherein the signaling received from the network node for determining which resources of the control

channel to use comprises semi-static signaling.

[0172] Embodiment 6: The method of the previous embodiment, wherein the semi-static signaling comprises Radio Resource Control (RRC) signaling.

[0173] Embodiment 7: The method of any of the previous embodiments, wherein the signaling received from the network node for determining which resources of the control channel to use comprises dynamic signaling.

[0174] Embodiment 8: The method of the previous embodiment, wherein the dynamic signaling comprises Downlink Control Information (DCI).

[0175] Embodiment 9: The method of any of the previous embodiments, wherein the signaling received from the network node comprises RRC signaling that configures different sets of PUCCH resources for different CORESETs in one or more slots from which the implicit resource determination can be used to determine a PUCCH resource so that the resources in different sets are orthogonal to each other.

[0176] Embodiment 10: The method of any of the previous embodiments, wherein the signaling received from the network node comprises dynamic signaling that indicates a starting index relative to which PUCCH resources can be implicitly determined.

[0177] Embodiment 11: The method of any of the previous embodiments, wherein the signaling received from the network node comprises dynamic signaling that indicates the slot index and/or PUCCH format to use.

[0178] Embodiment 12: The method of any of the previous embodiments, wherein the uplink control information comprises periodic uplink control information.

[0179] Embodiment 13: The method of any of the previous embodiments, wherein the uplink control information comprises aperiodic uplink control information.

[0180] Embodiment 14: The method of any of the previous embodiments, further comprising: providing user data; and forwarding the user data to a host computer via the transmission to the base station.

Group B Embodiments

[0181] Embodiment 15: A method performed by a base station, the method comprising: signaling information to a wireless device, wherein the information, when combined with implicit resource determination performed by the wireless device, assists the wireless device in determining which resources of a control channel to use for transmitting uplink control information to the base station.

[0182] Embodiment 16: The method of the previous embodiment, further comprising receiving the uplink control information from the wireless device via the resources of the control

channel determined in part based on the signaling information.

[0183] Embodiment 17: The method of any of the previous embodiments, further comprising determining the information to signal to the wireless device.

[0184] Embodiment 18: The method of any of the previous embodiments, wherein the control channel comprises a Physical Uplink Control Channel (PUCCH) and wherein the uplink control information comprises one or more of Hybrid Automatic Repeat Request (HARQ) Acknowledgements (ACKs), Channel State Information (CSI), and/or Scheduling Requests (SRs).

[0185] Embodiment 19: The method of any of the previous embodiments, further comprising determining to signal the information to the wireless device if the timing is variable between when the base station sends a message scheduling a downlink transmission and when the wireless device transmits the uplink control information.

[0186] Embodiment 20: The method of any of the previous embodiments, further comprising determining to signal the information to the wireless device if the base station can send a message scheduling a downlink transmission in any one of multiple control regions in the same slot.

[0187] Embodiment 21: The method of any of the previous embodiments, wherein the signaling sent to the wireless device for determining which resources of the control channel to use comprises semi-static signaling.

[0188] Embodiment 22: The method of any of the previous embodiments, wherein the signaling sent to the wireless device for determining which resources of the control channel to use comprises dynamic signaling.

[0189] Embodiment 23: The method of any of the previous embodiments, wherein the signaling sent to the wireless device comprises Radio Resource Control (RRC) signaling that configures different sets of Physical Uplink Control Channel (PUCCH) resources for different CORESETs in one or more slots from which the implicit resource determination can be used by the wireless device to determine a PUCCH resource so that the resources in different sets are orthogonal to each other.

[0190] Embodiment 24: The method of any of the previous embodiments, wherein the signaling sent to the wireless device comprises dynamic signaling that indicates a starting index relative to which PUCCH resources can be implicitly determined.

[0191] Embodiment 25: The method of any of the previous embodiments, wherein the signaling sent to the wireless device comprises dynamic signaling that indicates the slot index and/or PUCCH format to use.

[0192] Embodiment 26: The method of any of the previous embodiments, wherein the

uplink control information comprises periodic uplink control information.

[0193] Embodiment 27: The method of any of the previous embodiments, wherein the uplink control information comprises aperiodic uplink control information.

[0194] Embodiment 28: The method of any of the previous embodiments, further comprising: obtaining user data; and forwarding the user data to a host computer or a wireless device.

Group C Embodiments

[0195] Embodiment 29: A wireless device, the wireless device comprising: processing circuitry configured to perform any of the steps of any of the Group A embodiments; and power supply circuitry configured to supply power to the wireless device.

[0196] Embodiment 30: A base station, the base station comprising: processing circuitry configured to perform any of the steps of any of the Group B embodiments; and power supply circuitry configured to supply power to the base station.

[0197] Embodiment 31: A User Equipment (UE), the UE comprising: an antenna configured to send and receive wireless signals; radio front-end circuitry connected to the antenna and to processing circuitry, and configured to condition signals communicated between the antenna and the processing circuitry; the processing circuitry being configured to perform any of the steps of any of the Group A embodiments; an input interface connected to the processing circuitry and configured to allow input of information into the UE to be processed by the processing circuitry; an output interface connected to the processing circuitry and configured to output information from the UE that has been processed by the processing circuitry; and a battery connected to the processing circuitry and configured to supply power to the UE.

[0198] Embodiment 32: A communication system including a host computer comprising: processing circuitry configured to provide user data; and a communication interface configured to forward the user data to a cellular network for transmission to a User Equipment (UE), wherein the cellular network comprises a base station having a radio interface and processing circuitry, the base station's processing circuitry configured to perform any of the steps of any of the Group B embodiments.

[0199] Embodiment 33: The communication system of the previous embodiment further including the base station.

[0200] Embodiment 34: The communication system of the previous 2 embodiments, further including the UE, wherein the UE is configured to communicate with the base station.

[0201] Embodiment 35: The communication system of the previous 3 embodiments, wherein: the processing circuitry of the host computer is configured to execute a host

application, thereby providing the user data; and the UE comprises processing circuitry configured to execute a client application associated with the host application.

[0202] Embodiment 36: A method implemented in a communication system including a host computer, a base station, and a User Equipment (UE), the method comprising: at the host computer, providing user data; and at the host computer, initiating a transmission carrying the user data to the UE via a cellular network comprising the base station, wherein the base station performs any of the steps of any of the Group B embodiments.

[0203] Embodiment 37: The method of the previous embodiment, further comprising, at the base station, transmitting the user data.

[0204] Embodiment 38: The method of the previous 2 embodiments, wherein the user data is provided at the host computer by executing a host application, the method further comprising, at the UE, executing a client application associated with the host application.

[0205] Embodiment 39: A User Equipment (UE) configured to communicate with a base station, the UE comprising a radio interface and processing circuitry configured to perform the method of the previous 3 embodiments.

[0206] Embodiment 40: A communication system including a host computer comprising: processing circuitry configured to provide user data; and a communication interface configured to forward user data to a cellular network for transmission to a User Equipment (UE), wherein the UE comprises a radio interface and processing circuitry, the UE's components configured to perform any of the steps of any of the Group A embodiments.

[0207] Embodiment 41: The communication system of the previous embodiment, wherein the cellular network further includes a base station configured to communicate with the UE.

[0208] Embodiment 42: The communication system of the previous 2 embodiments, wherein: the processing circuitry of the host computer is configured to execute a host application, thereby providing the user data; and the UE's processing circuitry is configured to execute a client application associated with the host application. Embodiment 43: A method implemented in a communication system including a host computer, a base station, and a User Equipment (UE), the method comprising: at the host computer, providing user data; and at the host computer, initiating a transmission carrying the user data to the UE via a cellular network comprising the base station, wherein the UE performs any of the steps of any of the Group A embodiments.

[0209] Embodiment 44: The method of the previous embodiment, further comprising at the UE, receiving the user data from the base station.

[0210] Embodiment 45: A communication system including a host computer comprising: a communication interface configured to receive user data originating from a transmission from a

User Equipment (UE) to a base station, wherein the UE comprises a radio interface and processing circuitry, the UE's processing circuitry configured to perform any of the steps of any of the Group A embodiments.

[0211] Embodiment 46: The communication system of the previous embodiment, further including the UE.

[0212] Embodiment 47: The communication system of the previous 2 embodiments, further including the base station, wherein the base station comprises a radio interface configured to communicate with the UE and a communication interface configured to forward to the host computer the user data carried by a transmission from the UE to the base station.

[0213] Embodiment 48: The communication system of the previous 3 embodiments, wherein: the processing circuitry of the host computer is configured to execute a host application; and the UE's processing circuitry is configured to execute a client application associated with the host application, thereby providing the user data.

[0214] Embodiment 49: The communication system of the previous 4 embodiments, wherein: the processing circuitry of the host computer is configured to execute a host application, thereby providing request data; and the UE's processing circuitry is configured to execute a client application associated with the host application, thereby providing the user data in response to the request data.

[0215] Embodiment 50: A method implemented in a communication system including a host computer, a base station, and a User Equipment (UE), the method comprising: at the host computer, receiving user data transmitted to the base station from the UE, wherein the UE performs any of the steps of any of the Group A embodiments.

[0216] Embodiment 51: The method of the previous embodiment, further comprising, at the UE, providing the user data to the base station.

[0217] Embodiment 52: The method of the previous 2 embodiments, further comprising: at the UE, executing a client application, thereby providing the user data to be transmitted; and at the host computer, executing a host application associated with the client application.

[0218] Embodiment 53: The method of the previous 3 embodiments, further comprising: at the UE, executing a client application; and at the UE, receiving input data to the client application, the input data being provided at the host computer by executing a host application associated with the client application, wherein the user data to be transmitted is provided by the client application in response to the input data.

[0219] Embodiment 54: A communication system including a host computer comprising a communication interface configured to receive user data originating from a transmission from a User Equipment (UE) to a base station, wherein the base station comprises a radio interface and

processing circuitry, the base station's processing circuitry configured to perform any of the steps of any of the Group B embodiments.

[0220] Embodiment 55: The communication system of the previous embodiment further including the base station.

[0221] Embodiment 56: The communication system of the previous 2 embodiments, further including the UE, wherein the UE is configured to communicate with the base station.

[0222] Embodiment 57: The communication system of the previous 3 embodiments, wherein: the processing circuitry of the host computer is configured to execute a host application; and the UE is configured to execute a client application associated with the host application, thereby providing the user data to be received by the host computer.

[0223] Embodiment 58: A method implemented in a communication system including a host computer, a base station, and a User Equipment (UE), the method comprising: at the host computer, receiving, from the base station, user data originating from a transmission which the base station has received from the UE, wherein the UE performs any of the steps of any of the Group A embodiments.

[0224] Embodiment 59: The method of the previous embodiment, further comprising at the base station, receiving the user data from the UE.

[0225] Embodiment 60: The method of the previous 2 embodiments, further comprising at the base station, initiating a transmission of the received user data to the host computer.

[0226] At least some of the following abbreviations may be used in this disclosure. If there is an inconsistency between abbreviations, preference should be given to how it is used above. If listed multiple times below, the first listing should be preferred over any subsequent listing(s).

- 2G Second Generation
- 3G Third Generation
- 3GPP Third Generation Partnership Project
- 4G Fourth Generation
- 5G Fifth Generation
- AC Alternating Current
- ACK Acknowledgement
- AP Access Point
- ASIC Application Specific Integrated Circuit
- ATM Asynchronous Transfer Mode
- BS Base Station
- BSC Base Station Controller

• BTS	Base Transceiver Station
• CBG	Code Block Group
• CCE	Control Channel Element
• CD	Compact Disk
• CDMA	Code Division Multiplexing Access
• COTS	Commercial Off-The-Shelf
• CPE	Customer Premise Equipment
• CPU	Central Processing Unit
• CSI	Channel State Information
• D2D	Device-to-Device
• DAS	Distributed Antenna System
• DC	Direct Current
• DCI	Downlink Control Information
• DIMM	Dual In-Line Memory Module
• DSP	Digital Signal Processor
• DVD	Digital Video Disk
• E-SMLC	Evolved-Serving Mobile Location Centre
• EEPROM	Electrically Erasable Programmable Read Only Memory
• eMTC	Enhanced Machine Type Communication
• eNB	Evolved Node B
• EPROM	Erasable Programmable Read Only Memory
• FPGA	Field Programmable Gate Array
• GHz	Gigahertz
• gNB	Base station in New Radio
• GPS	Global Positioning System
• GSM	Global System for Mobile Communications
• HARQ	Hybrid Automatic Repeat Request
• HDDS	Holographic Digital Data Storage
• HD-DVD	High-Density Digital Versatile Disc
• I/O	Input and Output
• IoT	Internet of Things
• IP	Internet Protocol
• LAN	Local Area Network
• LEE	Laptop Embedded Equipment

• LME	Laptop Mounted Equipment
• LTE	Long Term Evolution
• M2M	Machine-to-Machine
• MANO	Management and Orchestration
• MCE	Multi-Cell/Multicast Coordination Entity
• MDT	Minimization of Drive Tests
• MIMO	Multiple Input Multiple Output
• MME	Mobility Management Entity
• MSC	Mobile Switching Center
• MSR	Multi-Standard Radio
• MTC	Machine Type Communication
• NB-IoT	Narrowband Internet of Things
• NFV	Network Function Virtualization
• NIC	Network Interface Controller
• NR	New Radio
• O&M	Operation and Maintenance
• OCC	Orthogonal Cover Code
• OFDM	Orthogonal Frequency Division Multiplexing
• OSS	Operations Support System
• OTT	Over-the-Top
• PDA	Personal Digital Assistant
• PDCCH	Physical Downlink Control Channel
• PDSCH	Physical Downlink Shared Channel
• PRB	Physical Resource Block
• PROM	Programmable Read Only Memory
• PSTN	Public Switched Telephone Network
• PUCCH	Physical Uplink Control Channel
• PUSCH	Physical Uplink Shared Channel
• RAID	Redundant Array of Independent Disks
• RAM	Random Access Memory
• RAN	Radio Access Network
• RAT	Radio Access Technology
• RF	Radio Frequency
• RMSI	Remaining System Information

- RNC Radio Network Controller
- RNTI Radio Network Temporary Identifier
- ROM Read Only Memory
- RRC Radio Resource Control
- RRH Remote Radio Head
- RRU Remote Radio Unit
- RUIM Removable User Identity
- SDRAM Synchronous Dynamic Random Access Memory
- SIM Subscriber Identity Module
- SOC System on a Chip
- SON Self Optimized Network
- SONET Synchronous Optical Networking
- SR Scheduling Request
- TCP Transmission Control Protocol
- UCI Uplink Control Information
- UE User Equipment
- UMTS Universal Mobile Telecommunication System
- USB Universal Serial Bus
- V2I Vehicle-to-Infrastructure
- V2V Vehicle-to-Vehicle
- V2X Vehicle-to-Everything
- VMM Virtual Machine Monitor
- VNE Virtual Network Element
- VNF Virtual Network Function
- VoIP Voice over Internet Protocol
- WAN Wide Area Network
- WCDMA Wideband Code Division Multiple Access
- WD Wireless Device
- WiMax Worldwide Interoperability for Microwave Access
- WLAN Wireless Local Area Network

[0227] Those skilled in the art will recognize improvements and modifications to the embodiments of the present disclosure. All such improvements and modifications are considered within the scope of the concepts disclosed herein.

Claims

What is claimed is:

1. A method performed by a wireless device, the method comprising:
 - receiving a first downlink control channel message that schedules a first downlink shared channel transmission;
 - receiving a second downlink control channel message that schedules a second downlink shared channel transmission;
 - determining an uplink control channel resource to use for transmitting uplink control information to a network node on an uplink control channel, wherein:
 - the uplink control information comprises Hybrid Automatic Repeat Request, HARQ, feedback for both the first downlink shared channel transmission and the second downlink shared channel transmission; and
 - determining the uplink control channel resource for transmitting the uplink control information comprises determining the uplink control channel resource based on: (a) signaling received from the network node and (b) resource determination performed by the wireless device based on a latest received one of the first downlink control channel message and the second downlink control channel message; and
 - transmitting the uplink control information using the determined uplink control channel resource.
2. The method of claim 1 wherein the uplink control channel is a physical uplink control channel.
3. The method of claim 1 wherein:
 - the signaling received from the network node comprises information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources; and
 - determining the uplink control channel resource based on: (a) the signaling received from the network node and (b) resource determination performed by the wireless device based on the latest received one of the first downlink control channel message and the second downlink control channel message comprises:
 - selecting one of the two or more uplink control channel resource sets;

selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node.

4. The method of claim 3 wherein:

each of the first downlink control channel message and the second downlink control channel message comprises a downlink control information message comprising bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set; and

selecting the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node comprises selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on the bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set that are comprised in the latest received one of the first downlink control channel message and the second downlink control channel message.

5. The method of claim 1, wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the timing is variable between when the wireless device receives the first and second downlink control channel messages scheduling the first and second downlink shared channel transmissions and when the wireless device transmits the uplink control information.

6. The method of claim 1, wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the wireless device can receive the first and second downlink control channel messages scheduling the first and second downlink shared channel transmissions in any one of multiple control regions in the same slot.

7. A wireless device comprising:

an interface; and

processing circuitry configured to cause the wireless device to:

- receive a first downlink control channel that schedules a first downlink shared channel transmission;
- receive a second downlink control channel that schedules a second downlink shared channel transmission;
- determine an uplink control channel resource to use for transmitting uplink control information to a network node, wherein:
 - the uplink control information comprises Hybrid Automatic Repeat Request, HARQ, feedback for both the first downlink shared channel transmission and the second downlink shared channel transmission; and
 - determining the uplink control channel resource for transmitting the uplink control information comprises determining the uplink control channel resource based on: (a) signaling received from the network node and (b) resource determination performed by the wireless device based on a latest received one of the first downlink control channel and the second downlink control channel; and
- transmit the uplink control information using the determined uplink control channel resource.

8. The wireless device of claim 7 wherein the uplink control channel is a physical uplink control channel.

9. The wireless device of claim 7, wherein:

the signaling received from the network node comprises information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources; and

determining the uplink control channel resource based on: (a) the signaling received from the network node and (b) resource determination performed by the wireless device based on the latest received one of the first downlink control channel message and the second downlink control channel message comprises:

selecting one of the two or more uplink control channel resource sets;

selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node.

10. The wireless device of claim 9 wherein:

each of the first downlink control channel message and the second downlink control channel message comprises a downlink control information message comprising bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set; and

selecting the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node comprises selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on the bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set that are comprised in the latest received one of the first downlink control channel message and the second downlink control channel message.

11. The wireless device of claim 7, wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the timing is variable between when the wireless device receives the first and second downlink control channel messages scheduling the first and second downlink shared channel transmissions and when the wireless device transmits the uplink control information.

12. The wireless device of claim 7, wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the wireless device can receive the first and second downlink control channel messages scheduling the first and second downlink shared channel transmissions in any one of multiple control regions in the same slot.

13. A wireless device comprising:

an interface; and

processing circuitry configured to cause the wireless device to:

- receive a downlink control channel that schedules a downlink shared channel transmission to the wireless device;
- determine an uplink control channel resource to use for transmitting uplink control information to a network node, wherein the uplink control information comprises Hybrid Automatic Repeat Request, HARQ, feedback for the downlink shared

channel transmission and determining the uplink control channel resource comprises selecting the uplink control channel resource from uplink control channel resources in two or more uplink control channel resource sets based on:

- a payload size of the uplink control information;
- a starting control channel element index of a downlink control channel candidate on which the downlink control channel was received; and
- dynamic signaling received from the network node; and
- transmit the uplink control information using the determined uplink control channel resource.

14. The wireless device of claim 13, wherein the processing circuitry is further configured to cause the wireless device to:

- receive, from the network node, signaling comprising information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources,
- wherein selecting the uplink control channel resource from the two or more uplink control channel resources in the two or more uplink control channel resource sets comprises:
 - selecting one of the two or more uplink control channel resource sets; and
 - selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node.

15. The wireless device of claim 14 wherein:

the downlink control channel comprises a downlink control information message comprising bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel resource set; and

selecting the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on dynamic signaling from the network node comprises selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, the one of the two or more uplink control channel resources from the selected uplink control channel resource set based on the bits for use to select one of the two or more uplink control channel resources from the selected uplink control channel

resource set that are comprised in the downlink control channel.

16. The wireless device of claim 14 wherein the processing circuitry is further configured to cause the wireless device to:

- receive, from the network node, signaling comprising information that provides a semi-static configuration of two or more uplink control channel resource sets each comprising two or more uplink control channel resources, and
- wherein selecting the uplink control channel resource from the two or more uplink control channel resources in the two or more uplink control channel resource sets comprises:
 - selecting one of the two or more uplink control channel resource sets based on dynamic signaling from the network node; and
 - selecting, as the uplink control channel resource to use for transmitting the uplink control information to the network node, one of the two or more uplink control channel resources from the selected uplink control channel resource set using an implicit determination.

17. The wireless device of claim 16 wherein the implicit determination is based on a starting control channel element index of a downlink control channel candidate on which the downlink control channel was received, a search space in which the downlink control channel was received, or a CORESET in which the downlink control channel was received.

18. The wireless device of claim 14 wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the timing is variable between when the wireless device receives the downlink control channel messages scheduling the downlink shared channel transmission and when the wireless device transmits the uplink control information.

19. The wireless device of claim 14 wherein determining the uplink control channel resource to use comprises determining the uplink control channel resource to use when the wireless device can receive the downlink control channel message scheduling the downlink shared channel transmission in any one of multiple control regions in the same slot.

Abstract

Systems and methods for determining an uplink control channel resource to use for transmitting uplink control information to a network node are disclosed. In some embodiments, a method performed by a wireless device comprises receiving a first downlink control channel message that schedules a first downlink shared channel transmission, receiving a second downlink control channel message that schedules a second downlink shared channel transmission, and determining an uplink control channel resource to use for transmitting uplink control information to a network node. The uplink control information comprises Hybrid Automatic Repeat Request (HARQ) feedback for both the first downlink transmission and the second downlink transmission, and determining the uplink control channel resources for transmitting the uplink control information comprises determining the uplink control channel resources based on: (a) signaling received from the network node and (b) resource determination performed by the wireless device based on a latest received one of the first downlink control channel message and the second downlink control channel message. The method further comprises transmitting the uplink control information using the determined uplink control channel resource.

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) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA/82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	
Filing Date	November 28, 2018
First Named Inventor	Havish Koorapaty
Title	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION
Art Unit	TBD
Examiner Name	TBD
Attorney Docket Number	P73334-US2

SIGNATURE of Applicant or Patent Practitioner

Signature	/Ben Westover/	Date (Optional)	November 28, 2018
Name	Ben Westover	Registration Number	56612
Title (if Applicant is a juristic entity)	Attorney of record		
Applicant Name (if Applicant is a juristic entity)	TELEFONAKTIEBOLAGET LM ERICSSON (PUBL)		

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

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*Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.131, 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.

Doc Code: PA.
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
Approved for use through 01/31/2018, OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number

Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)



I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above:

27045

OR



I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:



The address associated with the above-mentioned Customer Number

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27045

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Email

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

TELEFONAKTIEBOLAGET L M ERICSSON (PUBL)



Inventor or Joint Inventor (title not required below)



Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)



Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)



Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature

Date (Optional)

Name

Roger S. Burleigh

Title

Director, Patent Unit U.S.A.

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

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**DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN
APPLICATION DATA SHEET (37 CFR 1.76)**

Title of Invention	UPLINK CONTROL CHANNEL POWER CONTROL ADJUSTMENT IN A NETWORK WITH DIFFERENT PROCESSING TIMES	
<p>As the below named inventor, I hereby declare that:</p> <p>This declaration is directed to: <input type="checkbox"/> The attached application, or <input checked="" type="checkbox"/> United States application or PCT international application number <u>PCT/IB2018/058400</u> filed on <u>October 26, 2018</u></p> <p>The above-identified application was made or authorized to be made by me.</p> <p>I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.</p> <p>I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.</p> <p style="text-align: center;">WARNING:</p> <p>Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.</p>		
LEGAL NAME OF INVENTOR		
Inventor: <u>KOORAPATY, Havish</u>		Date (Optional): _____
Signature: <u><i>Havish Koorapaty</i></u>		
<p>Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.</p>		

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. 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 1 minute 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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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	UPLINK CONTROL CHANNEL POWER CONTROL ADJUSTMENT IN A NETWORK WITH DIFFERENT PROCESSING TIMES
---------------------------	---

As the below named inventor, I hereby declare that:

This declaration is directed to: ☐ The attached application, or
☒ United States application or PCT international application number PCT/IB2018/058400
 filed on October 26, 2018

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTOR

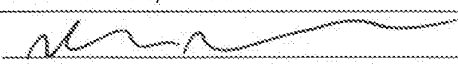
Inventor: FALAHATI, Sorour Date (Optional): _____
 Signature: *S. Falahati*

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

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**DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN
APPLICATION DATA SHEET (37 CFR 1.76)**

Title of Invention	UPLINK CONTROL CHANNEL POWER CONTROL ADJUSTMENT IN A NETWORK WITH DIFFERENT PROCESSING TIMES
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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	UPLINK CONTROL CHANNEL POWER CONTROL ADJUSTMENT IN A NETWORK WITH DIFFERENT PROCESSING TIMES
-----------------------	---

As the below named inventor, I hereby declare that:

This declaration is directed to: ☐ The attached application, or

☒ United States application or PCT international application number PCT/IB2018/058400
filed on October 26, 2018

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTORInventor: LARSSON, Daniel Date (Optional): _____Signature: 

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. 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 1 minute 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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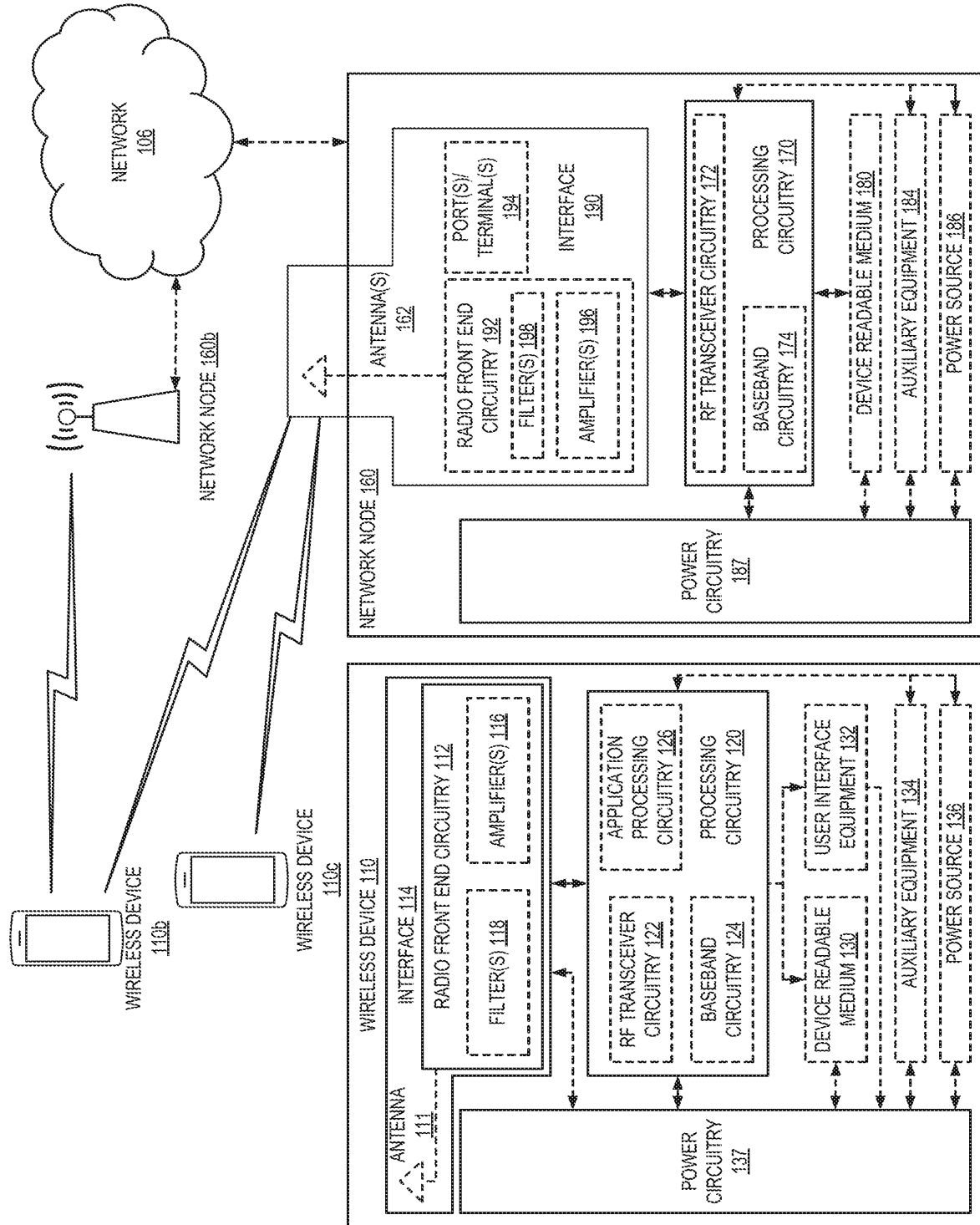


FIG. 1

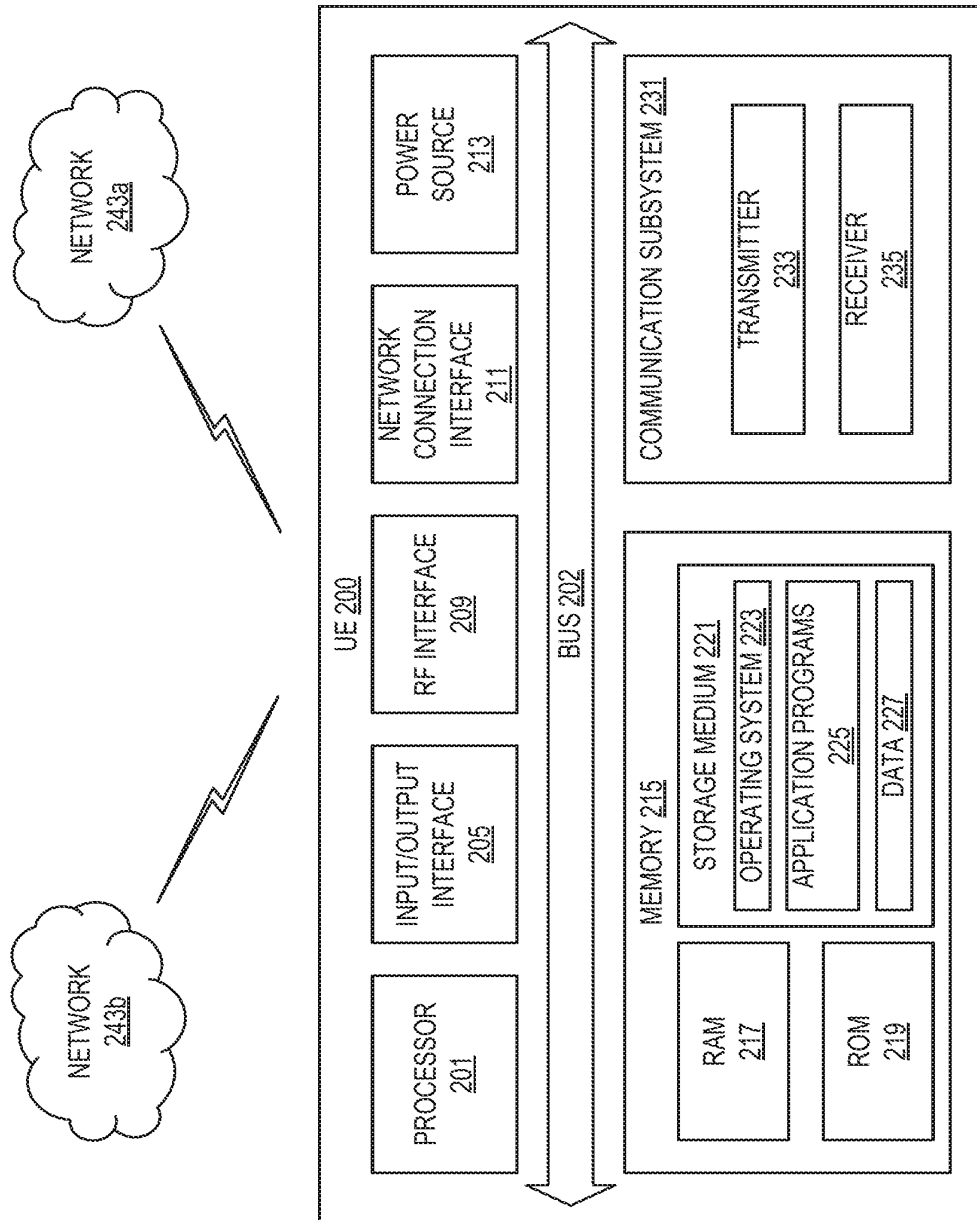


FIG. 2

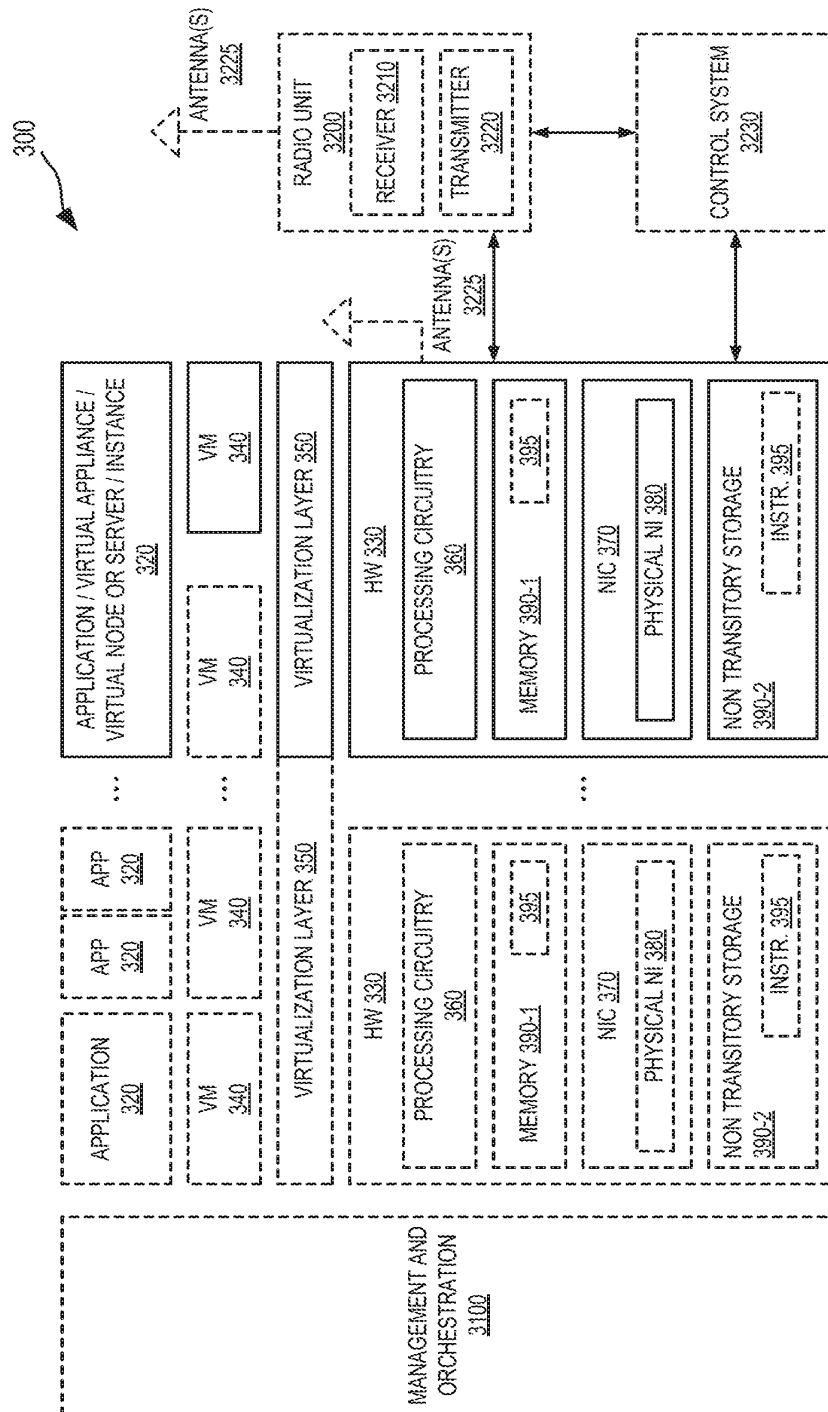
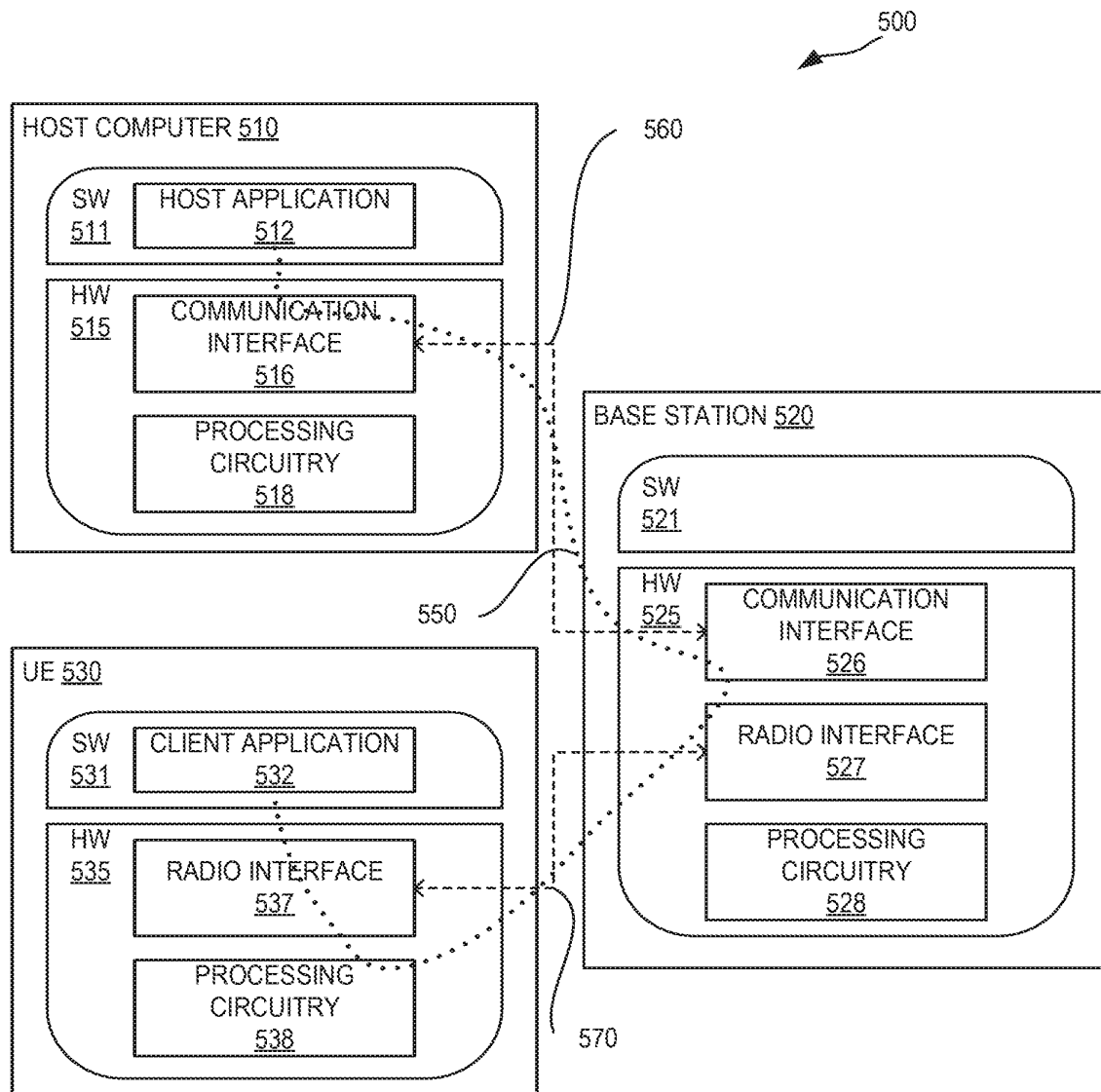
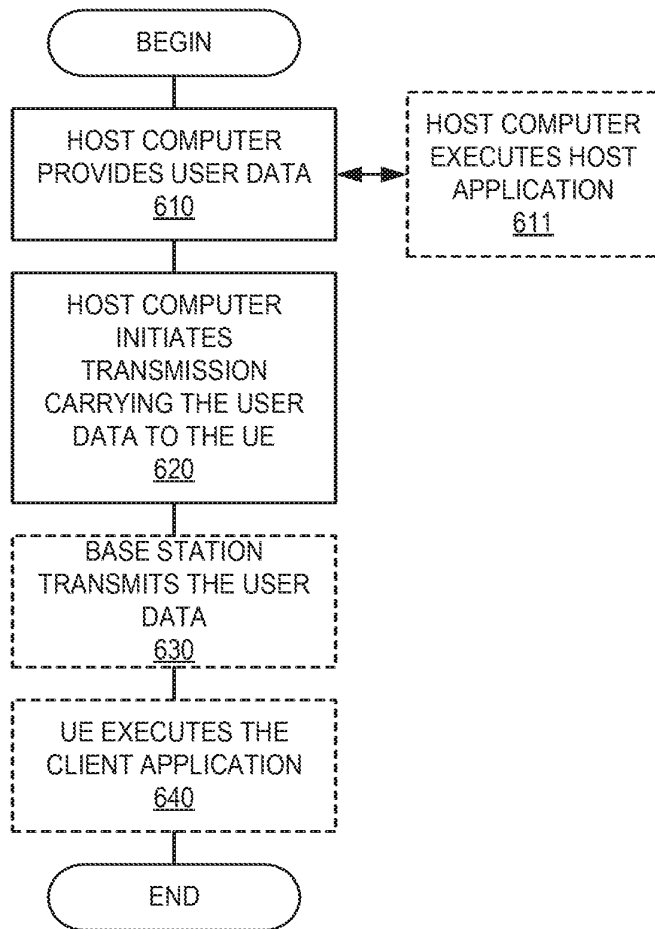
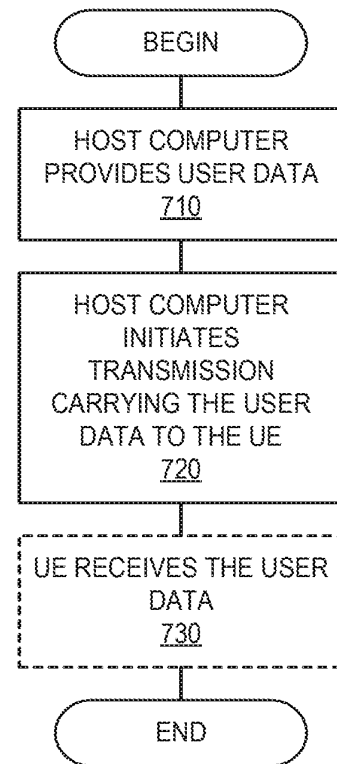
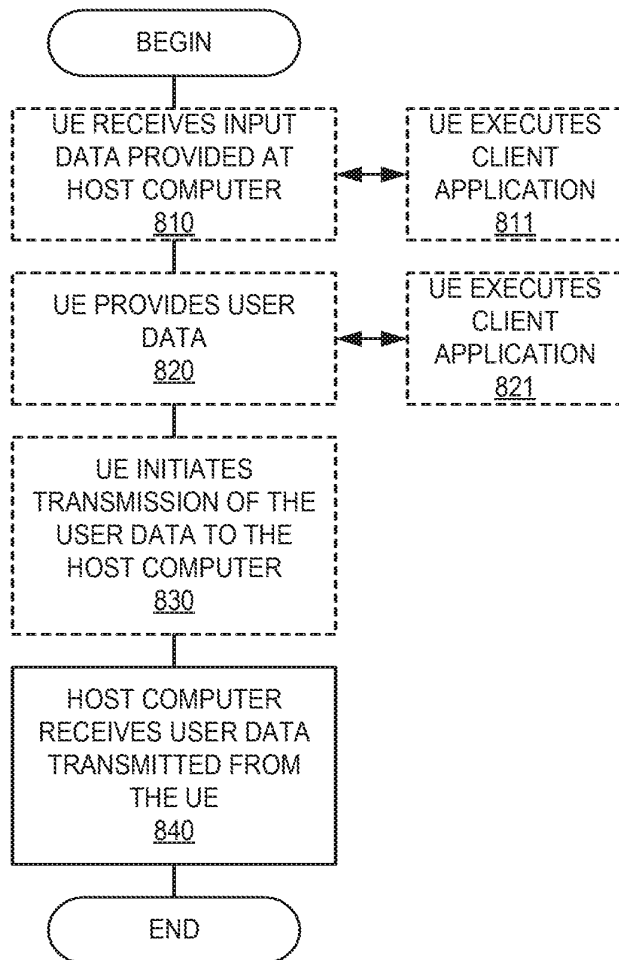
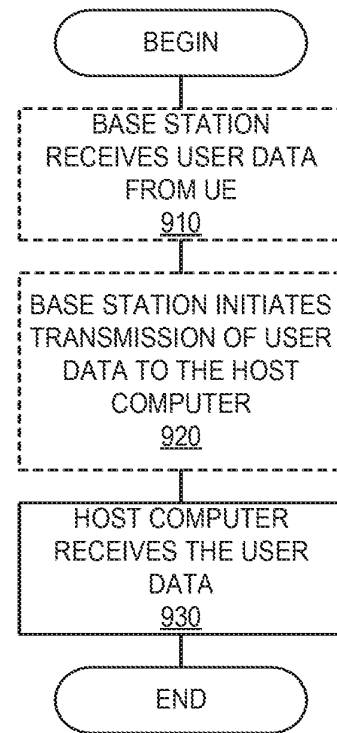
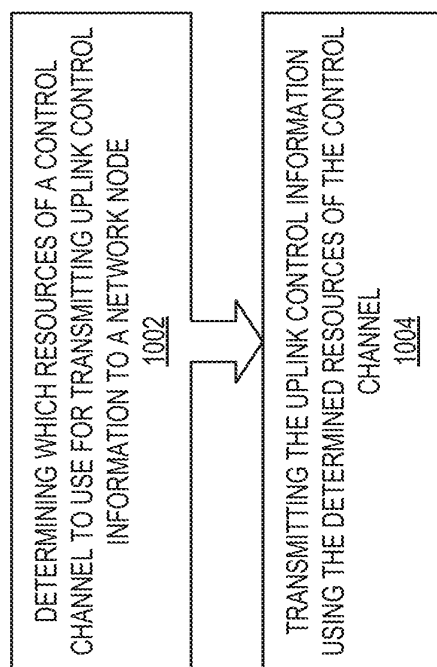


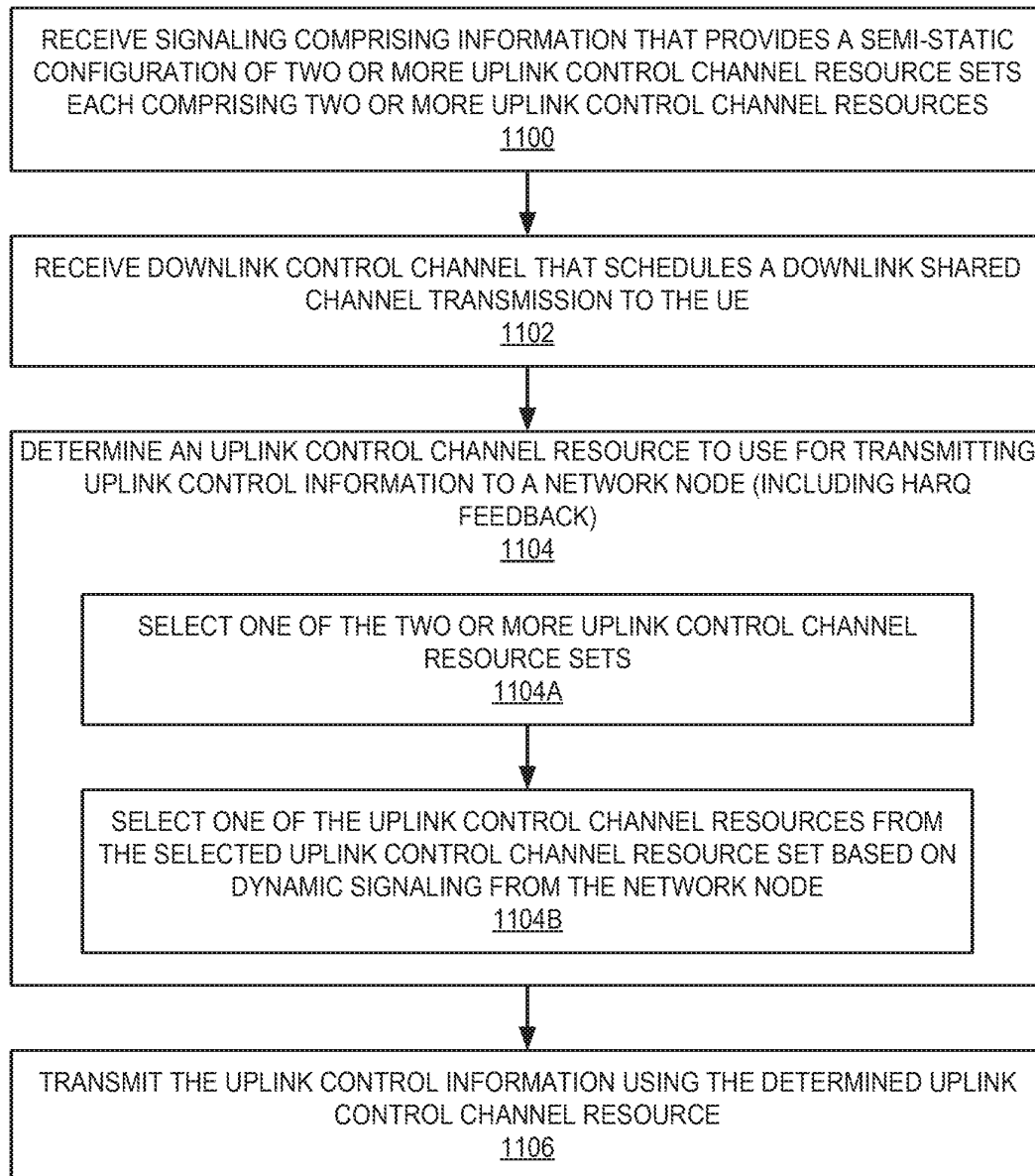
FIG. 3

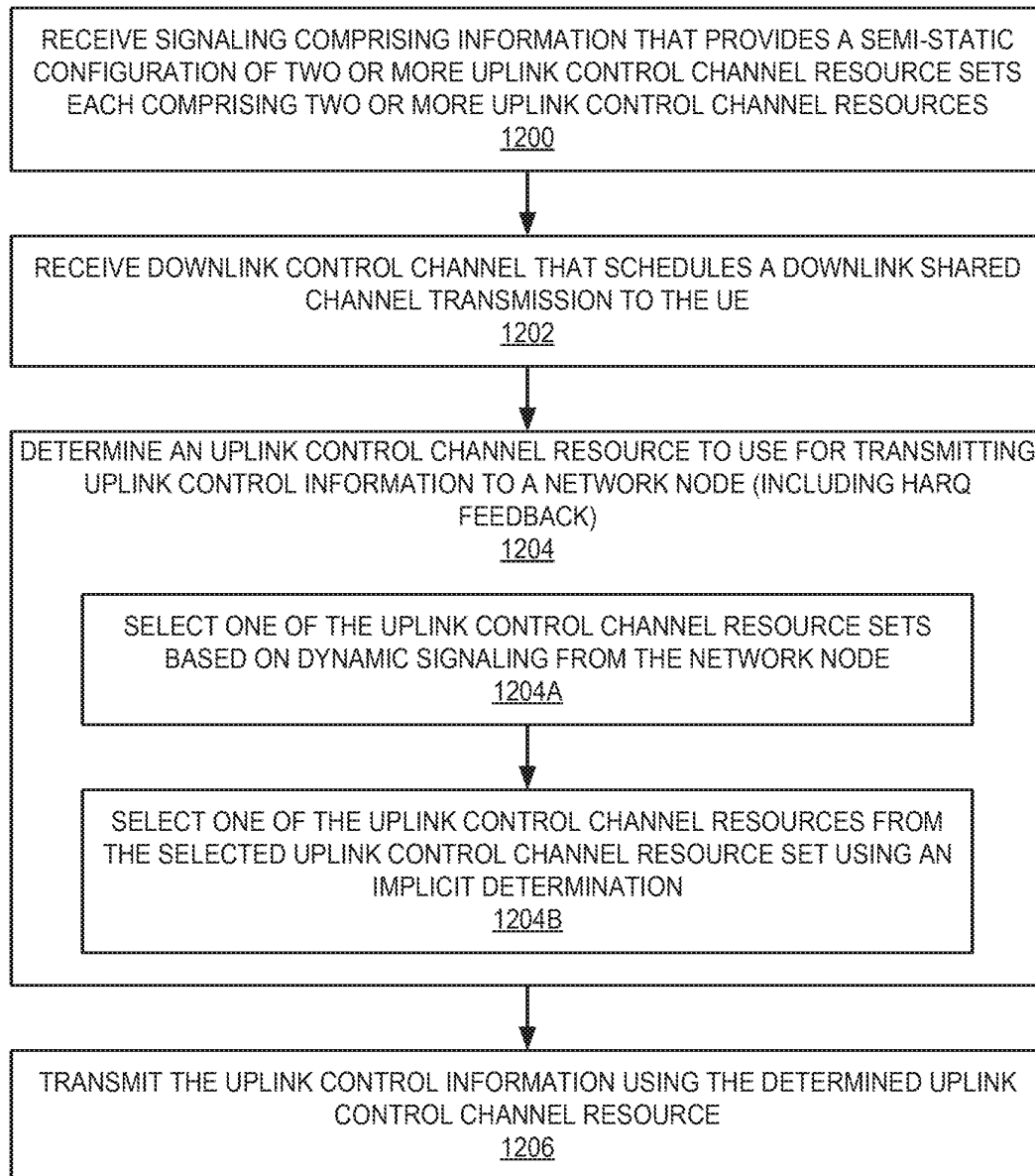
**FIG. 5**

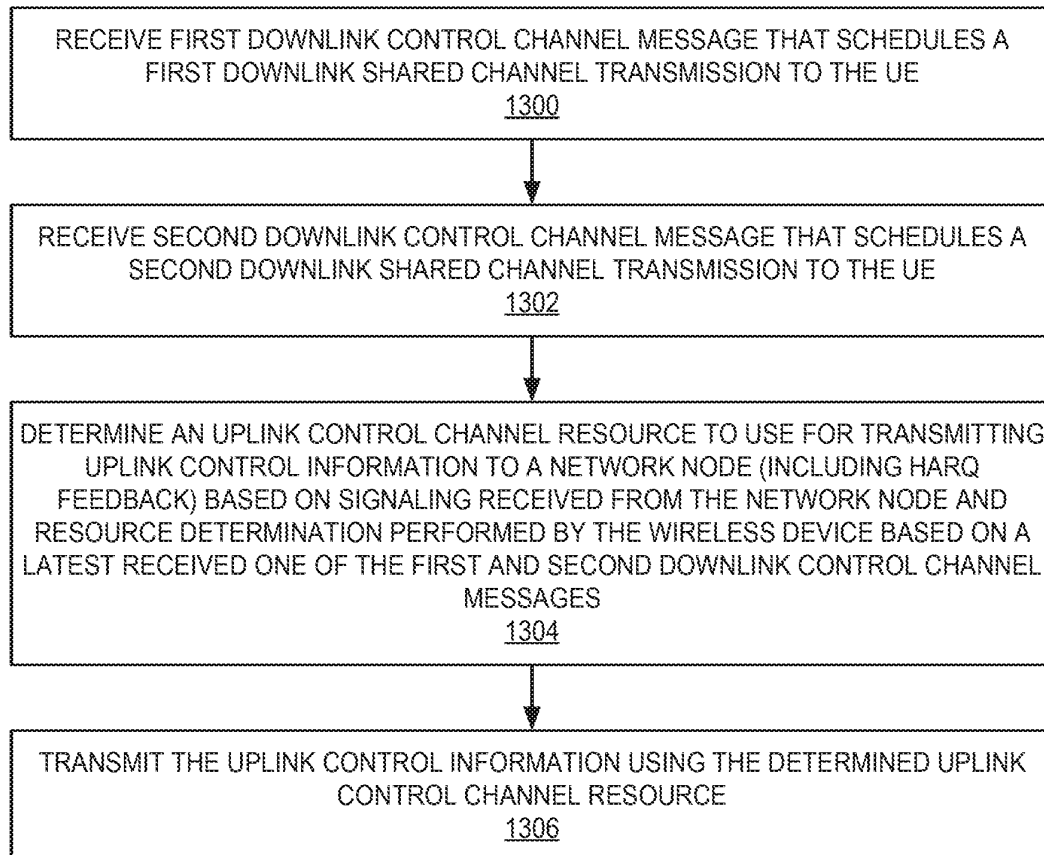
**FIG. 6****FIG. 7**

**FIG. 8****FIG. 9**

**FIG. 10**

**FIG. 11**

**FIG. 12**

**FIG. 13**

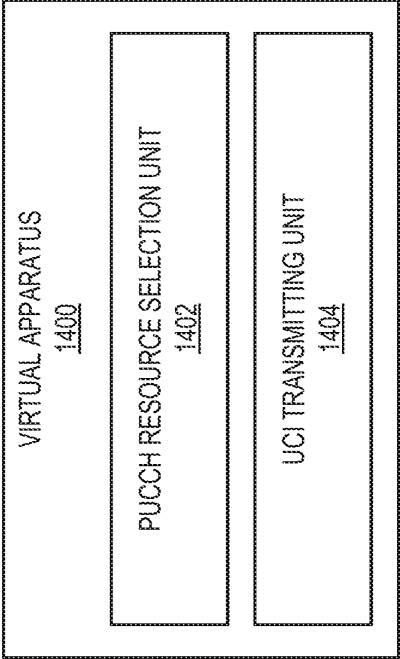


FIG. 14

Electronic Patent Application Fee Transmittal				
Application Number:				
Filing Date:				
Title of Invention:		PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION		
First Named Inventor/Applicant Name:		Havish Koorapaty		
Filer:		Roger Scott Burleigh/Akiko Cline		
Attorney Docket Number:		P73334-US2		
Filed as Large Entity				
Filing Fees for Track I Prioritized Examination - Nonprovisional Application under 35 USC 111(a)				
Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
UTILITY APPLICATION FILING	1011	1	300	300
UTILITY SEARCH FEE	1111	1	660	660
UTILITY EXAMINATION FEE	1311	1	760	760
REQUEST FOR PRIORITIZED EXAMINATION	1817	1	4000	4000
Pages:				
Claims:				
Miscellaneous-Filing:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
PROCESSING FEE, EXCEPT PROV. APPLS.	1830	1	140	140
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Miscellaneous:				
Total in USD (\$)				5860

Electronic Acknowledgement Receipt	
EFS ID:	34427853
Application Number:	16203391
International Application Number:	
Confirmation Number:	3937
Title of Invention:	PHYSICAL UPLINK CONTROL CHANNEL (PUCCH) RESOURCE ALLOCATION
First Named Inventor/Applicant Name:	Havish Koorapaty
Customer Number:	27045
Filer:	Roger Scott Burleigh/Akiko Cline
Filer Authorized By:	Roger Scott Burleigh
Attorney Docket Number:	P73334-US2
Receipt Date:	28-NOV-2018
Filing Date:	
Time Stamp:	19:07:05
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	\$ 5860
RAM confirmation Number	112918INTEFSW00018690501379
Deposit Account	
Authorized User	
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:	

File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	TrackOne Request	P73334_US2_2018-11-28_185403_TrackOne.pdf	120387	no	2
			99b59a0114639192ab18b23d61dc3b7443eee8e7		
Warnings:					
Information:					
2	First Action Interview - Enrollment Request	P73334_US2_2018-11-28_185403_Interview.pdf	621097	no	3
			f197fae1712ce2141598abdc09a3d8f104865756		
Warnings:					
Information:					
3	Application Data Sheet	P73334_US2_2018-11-28_185403_ADS.pdf	1823076	no	9
			e2bc4398f9bb069841a4cac5d8fd67ee83d878d8		
Warnings:					
Information:					
4		P73334_US2_2018-11-28_185403_Application.pdf	385415	yes	58
			506a6fba7c520d52d5a14a84b3c17740b104c67f		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Specification		1	51	
	Claims		52	57	
	Abstract		58	58	
Warnings:					
Information:					
5	Power of Attorney	P73334_US2_2018-11-28_185403_POA.pdf	519011	no	2
			d67e9deb220360c4005933ea191ebbbe6843cc3f		

Warnings:					
Information:					
6	Oath or Declaration filed	P73334-WO1_signed-declaration.pdf	2061073 41d6e2fe682afo135e6950692cc2a88c6d2755ae	no	4
Warnings:					
The page size in the PDF is too large. The pages should be 8.5 x 11 or A4. If this PDF is submitted, the pages will be resized upon entry into the Image File Wrapper and may affect subsequent processing					
Information:					
7	Drawings-only black and white line drawings	P73334_US2_2018-11-28_185403_Drawings.pdf	2109907 d4dd85af3543bf6de76df63ddabae10a6b870d7a	no	12
Warnings:					
Information:					
8	Fee Worksheet (SB06)	fee-info.pdf	40423 4aa719b1c7f6a6b2b3fe37bb4df8e5f965c41fdb	no	2
Warnings:					
Information:					
Total Files Size (in bytes):			7680389		
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