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Procedure and Radio Communication System to Allocate the
Radio Resources of a Radio Interface

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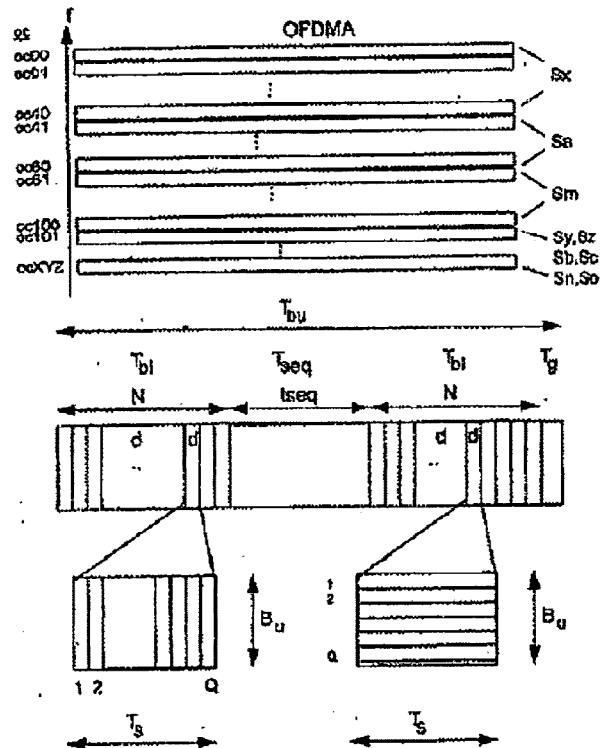
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Description

The invention involves a procedure to allocate the radio resources of a radio interface of a radio communications system as well as a corresponding radio communication system.



As is known radio communication systems manifest a radio interface across which data symbols can be transmitted between a fixed base station and usually several mobile station in a radio coverage area - e.g. a radio cell. In the process multiplex access procedures are

used, in order to be able to effectively use the radio resources of the radio interface. A classic multiple access procedure is the time multiplex (TDMA, Time Division Multiple Access) in which the data symbols are contained in bursts in a time slot. Another multiplex access procedure is the code multiplex (CDMA, Code Division Multiple Access) in which each data symbol is splayed with several code symbols on a certain bandwidth.

In addition, there is the OFDMA multi-carrier procedure (Orthogonal Frequency Division Multiple Access) which uses the OFDM principle to transmit the data symbols according to Chapter 15.3.2 of "Information Transmission", K. D. Kammeyer, Teubner Publishers, Stuttgart, 2nd Edition, 1996. Almost rectangular-shaped, transmission and reception filter impulse, responses enable a FFT (Fast Fourier Transformation) or an IFFT (Inverse Fast Fourier Transformation) based signal processing in the transmitter and receiver which allows for high data rates with relatively low complexity. It is also advantageous, that narrow band sub-carriers (OFDMA carriers) which, for example, can only be separated from each other by a few kilohertz enable a fine granularity of the data rates depending on the actual application. Thus a number of sub-carriers and also a segment of a frequency spectrum can be

allocated for the communication link between the base station and the mobile station.

From German Patent DE 4441323A1 a procedure is known to transmit OFDM signals in a mobile communication system in which for high transmission rates dynamically reduced OFDM signals can be amplified by a transmission amplifier within a basically linear amplification range.

The invention has the goal of providing an improved procedure and radio communication system for allocating radio resources, when using a OFDMA multi-carrier procedure.

This goal is achieved in the invention by the procedure with the characteristics of Patent Claim 1 and by a radio communication system with the characteristics of Patent Claim 12. Further variations of the inventions can be taken from the sub-claims.

1x The procedure of the invention begins with the OFDMA multi-carrier procedure and the use of a number of sub-carriers which are assigned for the communication link between the base station and the mobile stations and includes the following steps:

- Measure the quality of various segments of the frequency spectrum through each mobile station,

- Determine at least one suitable segment preferred for its own communication link through each mobile station and the transmission of appropriate information to the base station,

5 - Evaluate the information received from the mobile stations through the base station and allocate a/2 segment for the respective communication link to each mobile station depending on the evaluation,

- Transmit information across the allocated segment to each mobile station through the base station.

11 The radio communication system of the invention also begins with the OFDMA multi-carrier procedure and the use of a number of sub-carriers which are allocated for the communication link between the base station and the mobile station and includes the following means:

16 - Control means in each mobile station to measure the quality of various segments of the frequency spectrum and to determine at least a suitable segment preferred for its own communication link,

21 - Control means in each mobile station to transmit appropriate information to the base station,

- Control means in each base station to evaluate the information received from the mobile stations and to

allocate a segment for the respective communication link to each mobile station depending on the evaluation, as well as

- Transmission means in each base station to transmit information across the assigned segment to each mobile station.

By means of the allocation system described the advantages of the OFDMA multi-carrier procedure can be used and possibly optimal frequency resources can be provided for all communication links operated by a base station with the help of a flexible allocation of several sub-carriers and a thereby defined segment of a frequency spectrum. In the process, the quality of the actual communication link plays a decisive role with respect to the frequency situation which according to the procedure of the invention can be individually changed after the determination of the best suitable segments in each mobile station overseen by a base station and can thereby be improved.

allocati

19 Another important advantage consists of the fact, that by means of the invention the interferences, especially the critical inter-cell interference in the radio communication systems and the inter-symbol interferences, are considered and compensated for.

*Inter-cell
Interference*

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By means of the procedure of the invention and the radio communication system a cost effective and more effective - primarily for higher frequencies in the MHz range - allocation of frequency resources is obtained using the OFDMA multi-carrier procedure, as compared to a wideband communication. The improved OFDMA multi-carrier procedure can be combined with other multiplex access procedures which transmit data symbols of a finite duration in time slot into a more effective radio system. Thus the improved OFDMA multi-carrier procedure according to an especially preferred variant can be integrated into a TDMS/CDMA radio system which for applications with less power requirements - e.g., micro-cell systems - or for TDD applications (Time Division Duplex) or for applications with higher data rates - e.g., for indoor systems, wireless systems or for applications with low movement speeds acts in an especially advantageous manner.

The flexibility of the procedure of the invention can be especially used in an advantageous manner, if segments of the frequency spectrum are allocated to the mobile /3 stations by the base station whose bandwidths vary or a /2 different number of time slots for the transmission of data symbols are assigned to the allocated segments. Thus the best suited segments for communication can be determined at

any time for individual communications links which differ from each other and they can be changed as needed.

According to another version of the invention a priority list is sent from the mobile station to the base station which contains information about the segment best suited for its communication link as well as other suitable segments preferred for its own communication link. As a result, the base station receives knowledge from the incoming lists of the desires of the mobile station with respect to the best suited segment for it and can make appropriate new assignments of the segments of the frequency spectrum for all mobile stations which are better adapted to their transmitted needs.

It has proven useful, that the number of assigned sub-carriers in a time slot be set variably by the base station for each mobile station, in order to not only change the segments when needed but to also be able to change their bandwidth.

Another advantageous model of the invention to measure the quality of segments of the frequency spectrum envisions, that the mobile station receives all sub-carriers in the time slot allocated to it, checks for each sub-carrier, whether an amplitude modulation of the data symbols transmitted in the time slot is present, and forms

an average value from the results of the test for all sub-carriers belonging to the respective segment. The advantage lies in the two-step procedure in which initially the quality is determined for the individual sub-carriers and then the quality of the sub-carriers can be ascertained to determine the quality of the segment that was examined in particular.

An especially simple method to measure quality consists of so determining the relative deviations of the amplitudes of the data symbols, that the absolute amplitude difference from data symbol to data symbol is added up and the addition result is normalized with the average amplitude of all data symbols transmitted on a given sub-carrier.

According to another variant of the invention the radio communication system manifests a mobile station with a control means to measure the quality of various segments of the frequency spectrum and to determine at least one suitable segment preferred for its communication link, as well as a transmission means to transmit suitable appropriate information to the base station.

In another variation of the invention the radio communication device manifests a device which in alternative configurations is characterized as a part of

the base station or the base station control with a control means to evaluate the information received by the mobile stations and to allocate to each mobile station a segment for the communication link depending on the evaluation, as well as a transmission means to transmit information across the allocated segment to each mobile station.

In the following section the device of the invention will be described using execution models and references to the drawings.

Shown thereby

Figure 1 is a block diagram of a mobile radio system with several mobile stations overseen by a base station, /4

Figure 2 is a schematic depiction of a structure of a radio block with data symbols in a time slot as well as the OFDMA sub-carrier to form the segments of a frequency spectrum,

Figure 3 is an information flow to allocate frequency resources to the mobile stations,

Figure 4 is a schematic depiction of the amplitude modulation of the transmitted data symbols on a OFDMA sub-carrier to measure the quality of the segments,

Figure 5 is a block diagram of a mobile station, and

Figure 6 is a block diagram of a base station / base station control.

The radio communication system shown in Figure 1 corresponds in its structure to a known mobile radio system; the network devices of a mobile radio net, like e.g., the mobile relay positions, MSC, which are networked to each other provide the access to a fixed network, PSTN, and manifest base stations, BS, connected to a base station control, BSC, and the base station controls, BSC, connected with the mobile relay positions, MSC. Such a base station, BS, is a fixed radio station which establishes and maintains communication links to the mobile stations, MS, via a radio interface. Shown in Figure 1, for example, are three radio connections between the mobile stations, MS, and a base station, BS. An Operation and Maintenance Center, OMC, performs control and maintenance functions for the mobile radio system or for parts of it. The Operation and Maintenance Center, OMC, and the base station control, BSC, usually perform the functions of regulating and adapting the allocation of radio resources within the radio cells of the base station, BS. The functionality of the radio communication system can also be conveyed to another radio communication system, if necessary, even with a fixed

mobile station, MS. The procedure of the invention can even be used in such a radio communication system.

The communication links between the base station, BS, and the mobile stations, MS, are subject to a multiple path expansion which can also be caused by reflections, for example, off buildings or vegetation, in addition to a direct expansion path. If one assumes a movement of the mobile stations, MS, then the multiple path expansion together with other interference results in the signal components of the various expansion paths of a participant's signal being overlaid in time at the

12 receiving base station, BS. It will also be assumed, that a OFDMA multi-carrier procedure is used to transmit data symbols in time slots which assigns the mobile stations a number of sub-carriers and thus a segment of a frequency spectrum for the communication link between the base station, BS, and a mobile station, MS.

17 According to the device of the invention every mobile station, MS, measures the quality of various segments of the frequency spectrum, whereby it receives all sub-carriers in the time slot assigned to it, checks the quality of each individual sub-carrier and then determines the quality of the sub-carriers. Then each mobile station determines at least a suitable segment preferred for its

own communication link and transmits appropriate information to the base station, BS. In this example the first mobile station determines a segment, Sx, with sub-carriers oc00 ... 0c40 as the best suitable segment for it. In addition, it determines the segments, Sy, Sz as additional suitable segments preferred for its own communication link. Information about segments Sx, Sy, Sz

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is entered on a priority list, PL1, numbered according /3 to their suitability for the communication link and sent to the base station, BS.

In a similar manner, the second mobile station determines a segment, Sa, with sub-carriers oc41 ... oc60 as the suitable segment best for it. In addition, it determines segments, Sb, Sc, as additional suitable segments preferred for its own communication link. Information about segments Sa, Sb, Sc is entered on a priority list, PL2, numbered according to their suitability for the communication link and likewise is sent to the base station, BS.

Also the third mobile station, MS, overseen by the base station, BS, determines a segment, Sm, with sub-carriers, cc61 ... cc100 and the best suitable segment for its communication link. In addition, it provides in a

priority list, PL3, segments, S_n , S_o , as additional suitable segments preferred for its own communications link. The information about these three segments, S_m , S_n , S_o , which are numbered in the priority list, PL3, according to their suitability for the communication link, are also then sent to the base station, BS. It can be seen from the examples, that the number of sub-carriers $co \dots$ and thus the bandwidth of segments $S \dots$ can be variably selected.

The base station, BS, evaluates all information received from the mobile stations, MS, and assigns each mobile station a segment for the respective communication link depending on the evaluation. The base station sends the mobile station information about the assigned segment. It is assumed in this example, that each mobile station, MS, can be assigned the best suitable segment desired by it. That also depends on the transmission conditions and/or the capacity utilization of the radio cell overseen by the base station, BS, according to presets of the Operation and Maintenance Center, OMC, or the base station control, BSC, for radio resource management. Thus the first mobile station, MS, receives segment S_x , the second mobile station, MS, the segment S_a , and the third mobile station, MS, the segment S_m , accordingly with the appropriate OFDMA sub-carriers, $co \dots$, assigned by the base station, BS. A

different number of time slots to transmit data symbols in the allocated segments can also be assigned to the individual mobile stations, MS.

The flexibility of the procedure of the invention is used in an especially advantageous manner, when segments of the frequency spectrum are allocated to the mobile stations, MS, by the base station, BS, whose bandwidths are different or there are different numbers of time slots for the transmission of data symbols in the assigned segments. Thus the best suited segments for communications are determined at any time for individual communications links which differ from each other and can be changed, if needed.

Shown schematically in Figure 2 is the structure of a radio block with data symbols in a time slot, as well as the OFDMA sub-carriers to form the segments according to the examples in Figure 1. There are thus available, for example, several hundred sub-carriers, oc , - with a separation of several kilohertz between two adjacent carriers - in the radio cell of Figure 1 with three mobile stations, MS, linked to the base station, BS. Sub-carriers $oc00 \dots oc40$ define segment S_x , sub-carriers $oc41 \dots oc60$ define segment S_a , and sub-carriers $oc61 \dots oc100$ define segment S_m , appropriately distributed by the base station to the mobile stations. Other sub-carriers $oc101 \dots ocXYZ/6$

are available in the entire frequency band usable for the net operator which also contains the segments S_y , S_z and S_b , S_c , and S_n , S_o with a number of sub-carriers also categorized as suitable by the mobile stations. According to Figure 2 an identical bandwidth is assumed for segments S_x , S_m . That, however, is no prerequisite for a radio communication system in the sense of the invention.

The radio block shown as an example in Figure 2 is transmitted in a time slot of a TDMA frame structure. Provided in each frame is at least one time slot for one or more participant signals. A preset number of sub-carriers is used by the base station in each time slot on which a preset number of data symbols is transmitted. In addition, for each mobile station the number of assigned sub-carriers in a time slot can be variably adjusted by the base station.

The duration of the radio block is designated with T_{bu} . The radio block includes two blocks each with N data symbols, d , whereby each block has a length of T_{bl} . Both blocks are separated by a training sequence, t_{seq} , with a duration of T_{seq} . The end of the radio block forms a protective time, T_g , which is supposed to compensate for the running time variations because of the different distances of the mobile stations, MS , from the base station, BS . Also

shown in Figure 2 is how an individual data symbol, d , can be transmitted in a pure CDMA procedure - shown on left - or in a pure multi-carrier procedure - shown on the right. In the CDMA procedure each data symbol, d , is splayed with Q code symbols on the broadband, B_u . In the multi-carrier procedure each data symbol, d , is modulated on the Q carrier, whereby the total of the broadbands of the carrier gives the broadband, B_u . In both cases the duration the transmission of the data symbol provides the symbol duration, T_s . Thus the radio communication system is constructed as a TDMA/CDMA mobile radio system in which the data symbols, d , of several communication links can be transmitted in the frequency channels formed by the time slots, whereby the information from various links can be differentiated according to a fine structure individual for each link, for example by splaying the data symbols.

In a combination of the TDMA/CDMA mobile radio system with the OFDMA multi-carrier procedure, optimal frequency resources for all communication links overseen by a base station can be allocated according to the invention with the help of a flexible referral of several sub-carriers or a segment of the frequency spectrum defined thereby. That is especially advantageous for applications with low power requirements - e.g., micro-cell systems - or for TDD

applications (Time Division Duplex) or for applications with higher data rates - e.g., for indoor systems, wireless systems or for applications with low movement speeds. By means of the improved frequency resource referral procedure (smart frequency hopping approach) according to the invention, interferences, especially the critical inter-cell interference and the inter-symbol interferences, are considered and at least reduced or compensated for. That is therefore of significance, since for almost all radio communication systems it is a typical characteristic, that they are limited in power downlink which is even reinforced by interference.

Figure 3 shows the information flow across the radio interface for the allocation of the frequency resources to

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the mobile stations, MS, by the base station. Instead of /4 a base station, BS, a base station control, BSC, can control the allocation but the base station, BS, always communicates through the air with the mobile stations, MS. In an initial step (1) the mobile stations, MS, receive in a parallel manner all sub-carriers, oc , in the time slot, ts , assigned to them. For each sub-carrier, oc , the mobile station checks as a second step (2), whether an amplitude modulation is present in the data symbols transmitted in

the time slot, ts , and thus has a measurement result about the quality of the respective sub-carrier, oc . It forms an average value from the results of the check for all sub-carriers belonging to a selected segment which results in a quality value for the entire segment. It can perform that for several segments - preferably in a parallel manner. Each mobile station, MS , determines in another step (3) according to the knowledge of the quality of the various segments at least one suitable, preferred segment, for example segment Sx or Sa or Sm .

11 In another step (4) the mobile station, MS , sends via the radio interface to the base station, BS , its priority lists, $PL1 \dots PL3$, with the information about several preferred, suitable segments, i.e., about segments Sx , Sy , Sz or Sa , Sb , Sc or Sm , Sn , So for which a sequence of suitability is determined by the mobile station, MS .

16 In the next step (5) the base station, BS , evaluates the incoming priority lists, $PL1 \dots PL3$, with the information about the desired segments and decides - if necessary in a return conversation with the base station control, BSC - which segment was allocated to the respective mobile station, MS . In the example cited, the base station, BS , assigns the segments, Sx , Sa and Sm which were selected as the most suitable segments by the mobile

station to the three mobile stations, MS. For the case where the desired segment can not be allocated, one of the other segments is selected which were alternatively chosen by the mobile station, Ms. In a step (6) information about the allocated segments, S_x , S_a , and S_m is sent via the radio interface to the mobile stations, MS, which then use the received new frequency resources in the frequency spectrum for their individual communication links. To monitor as wide a frequency spectrum as possible the mobile stations, MS, each have a broadband receiver which is the case when using the OFDMA multi-carrier procedure. The point in time and thus the speed of the change of the allocation of radio resources and frequency resources can depend on the transmission conditions and/or the capacity utilization of a radio cell. It is basically possible per second in a relative frequency corresponding to the number of transmitted TDMA frames. In a mobile radio system based on a GSM standard, approximately 217 frames, for example, are transmitted per second.

Figure 4 shows a schematic depiction of the amplitude modulation of the transmitted data symbols on a OFDMA sub-carrier to measure the quality of the segments through each mobile station. By converting possibly appearing interferences or noises into an amplitude modulation from

data symbol to data symbol, the quality of the individual sub-carriers and thus the entire segment can be measured across all associated sub-carriers in a simple but effective manner. For every transmitted data symbol in a time slot an FFT signal processing is performed and the signal processing is continued in a carrier-selective

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manner for the sub-carriers of the segment. There thus arises a resulting signal, r_s , from a wanted signal, s_s , by means of an interference signal or a noise signal, i_s , with a definite amplitude which lies between a maximum amplitude, A_{max} , and a minimum amplitude, A_{min} . If interference or noise is present, the amplitudes of the individual data symbols on a certain sub-carrier vary from data symbol to data symbol. If there is no interference or noise, the amplitudes of all data symbols manifest the same value. Relative deviations of the amplitudes of the data symbols can thereby be most easily determined, so that the absolute amplitude difference from data symbol to data symbol can be added up and the addition result can be normalized with the average amplitude of all data symbols transmitted to a predetermined sub-carrier. In this example the quality results of all 40 sub-carriers of the segment, S_x , are determined and an appropriate quality value is

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determined for the segment, S_x . This is also done for a variety of other segments and a number of segments of the best quality for a communication link is determined.

A mobile station, MS, to support the procedure of the invention and the radio communication system is shown in Figure 5, while Figure 6 shows a corresponding base station, BS, or base station control, BSC. Only depicted are the means and devices essential for the object of the invention.

The mobile station, MS, manifests a control means, MSE, with a storage device, MSP, and an FFT device, FFT, a means of modulation, MOD, or a means of demodulation, DEM, and a transmitter/receiver, MHF.

Data symbols, d , of the participating signals are transmitted in both a down-link and up-link direction. For the transmission in an up-link direction they are processed by a control means, MSE, and are sent to the modulation means, MOD, for transmission. On the other hand, in the down-link direction data symbols, d , are received by the transmitter/receiver, MHF, are processed by the means of demodulation, DEM, and are sent on to the control means, MSE. Data modulation, error protection, packaging, etc. are performed in a part of the means of modulation, MOD. In addition, the data symbols, d , of a radio block are splayed

in a portion of the modulation means, MOD, corresponding to a combination of a TDMA and a CDMA procedure to achieve the fine structure specific to the individual link for the differentiation of the participating signals in a time slot. After an analog/digital conversion the radio blocks are amplified in the transmitter/receiver, MHF, and sent via the radio interface to the base station.

In the down-link direction the transmitter/receiver means, MHF, receives all sub-carriers, oc, from the air in the time slot allocated to the mobile station, MS, - see step (1) in Figure 3. The control means, MSE, is informed by the sub-carriers, oc, and conducts a measurement of the quality of various segments corresponding to the above variations. The control means, MSE, determines the suitable segments, S ..., preferred for its own communication link, enters them in the priority list, and schedules the transmitter/receiver to transmit appropriate information through the air to the base station - see step (4) in Figure 3.

The transmitter/receiver, MHF, also receives the information in the down-link direction via the individual segment, S ..., allocated by the base station - but at a later point in time after an evaluation of the transmitted

segments of all mobile station by the base station - see step (6) in Figure 3. In keeping with the allocated /9 frequency resources the control means, MSE, makes a /5 change of the radio parameters in the radio cell for the mobile station, MS.

At the same time because of the improved allocation procedure corresponding to the needs of the individual mobile stations, MS, the special transmission conditions (no CDMA or a multi-carrier procedure only within a certain bandwidth) and special data rates can be requested.

The device according to Figure 6 - designed as a base station, BS, or a base station control, BSC - manifests a control means, BSE, with a memory means, BSP, and an FFT device, FFT, a modulation means, MOD, or a demodulation means, DEM, and a transmitter/receiver, BHF. The transmitter/receiver, BHF, is scheduled by the control means, BSE, to transmit through the air the sub-carriers, ω_c , in the down-link direction to the mobile stations. In the opposite direction the transmitter/receiver, BHF, receives information via the segments, $S \dots$, determined by the mobile stations and sends it to the control means, BSE. Based on the evaluation of the totality of the incoming information, the control means, BSE, assigns a segment, $S \dots$, to each of its mobile stations and schedules the

transmitter/receiver, BHF, to transmit appropriate information through the air to the respective mobile station.

The change of the segments of the frequency spectrum also considers the transmission conditions (strong impediments and interference) and the utilization capacity of the radio resources (time slots, frequencies, splay code) in the radio cell. These conditions are signaled to the control means, BSE, by the base station controller, BSC, or the Operation and Maintenance Center, OMC. Then the control means, BSE, selects the sub-carriers for the definition of the segment according to the quality characteristics for each communication link.

The signal processing when using the OFDMA multi-carrier procedure by the FFT device as well as the modulation means, MOD, or the demodulation means, DEM, operates in the base station, BS, in the same manner as in the mobile station, MS, so that the above variants apply according to Figure 5. Stored in the memory device, BSP, are, among other things, the priority lists with the preferred suitable segments coming from the mobile stations.

To achieve as simple as possible a synchronization in relation to time and frequency, an initial synchronization

step is performed in which symbols with half transmission rates are sent, so that the transmitted symbols can be securely received in a time window, even with completely unsynchronized conditions. With the use of micro-cells only, a synchronization of the mobile stations to the base station is required.

A base station code can be formed to identify the base station, whereby the phases of the data symbols transmitted between at least two adjacent sub-carriers at a first position in the radio block are used. Preferably these are two sub-carriers which lie in the center of a data stream with several sub-carriers. Thus the phase 0 degrees is assigned to the first data symbol on the sub-carrier with the lower frequency. The phase of the first data symbol of the adjacent sub-carrier with the higher frequency forms the base station code, i.e., with the values 0 degrees, 90 degrees, 180 degrees and 270 degrees. The phases of the first symbols of both adjacent sub-carriers can also be used as a phase reference to detect information on all sub-carriers.

From the above remarks it can be seen, that the

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procedure of the invention is especially suitable for use in future radio communications systems, like the UMTS

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(Universal Mobile Communication System) or the FPLMTS
(Future Public Land Mobile Telecommunication System).

Patent Claims

1. Procedure to allocate the radio resources of a radio
interface of a radio communications system, whereby

- data symbols (d) are transmitted in time slots (ts)
across a radio interface between a base station (BS)
and several mobile stations (MS) overseen by the base
station (BS), and ✓
- an OFDMA multi-carrier procedure is used to transmit
the data symbols (d) which allocates to the mobile
stations (MS) a number of sub-carriers (oc) and thus a
segment (S ...) of a frequency spectrum for the
communication link between the base station (BS) and
the mobile station (MS),

with the following procedural steps: 66

- measurement of the quality of various segments (S ...)
the frequency spectrum by each mobile station (MS),
- determination by each mobile station (MS) of at
least one suitable segment (Sx ... Sa ... Sm...) preferred
for its own communication link and transmission of
appropriate information to the base station (BS),
- evaluation of the information received from the 23
mobile stations (MS) by the base station (BS) and

assignment of a segment (Sx, Sa, Sm) for the respective communication link to each mobile station (MS) depending on the evaluation, as well as

- transmission of information about the assigned segment (Sx, Sa, Sm) to each mobile station (MS) by the base station (BS).

assigned

2. Procedure according to Claim 1 in which at least two mobile station (MS) are assigned segments (Sx, Sa) of the frequency spectrum by the base station whose bandwidths differ from each other.

3. Procedure according to Claim 1 or 2 in which the mobile station (MS) is assigned a different number of time slots (ts) by the base station (BS) for the transmission of data symbols (d) in the assigned segments.

4. Procedure according to one of the previous claims in which a priority list (PL1, PL2, PL3) is sent from the mobile station (MS) to the base station (BS) which contains information about a best suited segment (Sx, Sa, Sm) for its own communication link, as well as other suitable segments (Sy, Sz; Sb, Sc; Sn, So) preferred for its own communication link.

priority list

5. Procedure according to one of the previous claims in which a predetermined number of sub-carriers (oc) is used

by the base station (BS) in each time slot on which a predetermined number of data symbols (d) is transmitted.

6. Procedure according to one of the previous claims in which the number of allocated sub-carriers (oc) in a time slot (ts) for each mobile station (MS) can be variably adjusted by the base station.

7. Procedure according to one of the previous claims in

which in order to measure the quality of the segments /6

(S ...) of the frequency spectrum by the mobile station

- all sub-carriers (oc) are received in the time slot allocated to it,
- a check is made for each sub-carrier (oc), whether an amplitude modulation of the data symbols (d) transmitted in the time slot is present and an average value is formed from the results of the test for all sub-carriers (oc) belonging to the respective segment (S ...).

8. Procedure according to Claim 7 in which relative deviations of the amplitudes of the data symbols (d) are so determined, that the absolute amplitude difference from data symbol to data symbol is added up and the addition result is normalized with the average amplitude of all data symbols transmitted on a predetermined sub-carrier (oc).

9. Procedure according to Claim 7 or 8 in which several segments (e.g., S_x , S_y , S_z) of the best quality are determined by the mobile station (MS) and are numbered in a priority list (e.g., PL1) corresponding to increasing amplitude modulation.

10. Procedure according to one of Claims 7 to 9 in which an amplitude modulation is then determined, when the amplitudes of the data symbols (d) transmitted on a certain sub-carrier (oc) differ from data symbol to data symbol because of interferences or noises.

11. Procedure according to one of the previous claims in which the radio communication system is designed as a TDMA/CDMA mobile radio system in which data symbols (d) of several communication links can be simultaneously transmitted in frequency channels formed by time slots, whereby the information of various communication links can differ according to the fine structure of individual links.

12. Radio communication system to allocate radio resources of a radio interface, whereby

- data symbols (d) are transmitted in time slots (ts) across a radio interface between a base station (BS) and several mobile stations (MS) overseen by the base station,

- an OFDMA multi-carrier procedure is used to transmit the data symbols (d) which allocates to the mobile stations (MS) a number of sub-carriers (oc) and thus a segment (S ...) of a frequency spectrum for the communication link between the base station (BS) and the mobile station (MS),

with

- a control means (MSE) in each mobile station (MS) to measure the quality of various segments (S ...) of the frequency spectrum and to determine at least one suitable segment (Sx ... Sa ... Sm...) preferred for its own communication link,

- a transmitter (MHF) in each mobile station (MS) to transmit appropriate information to the base station (BS),

- a control means (BSE) in each base station (BS) to evaluate the information received from the mobile stations (MS) and to allocate a segment (Sx, Sa, Sm) for the respective communication link to each mobile

station (MS) depending on the evaluation, as well as

- a transmitter (HF) in each base station to transmit information about the allocated segments (Sx, Sa, Sm) to each base station.

13. Radio communication system according to Claim 12 with a mobile station which manifests

- a control means (MSE) to measure the quality of various segments (S ...) of the frequency spectrum and to determine at least one suitable segment (Sx, Sa, Sm) preferred for its own communication link, and
- a transmitter (MHF) to transmit appropriate information to the base station (BS).

14. Radio communication system according to Claim 12 or 13 with a device which manifests

- a control means (MSE) to evaluate the information received from the mobile stations (MS) and to allocate a segment (Sx, Sa, Sm) for the communication link to each mobile station (MS) depending on the evaluation, as well as
- a transmitter (BHF) to transmit information about the allocated segments (Sx, Sa, Sm) to each mobile station (MS).

15. Radio communication system according to Claim 14 in which the control means (BSE) performs the evaluation of the information received from the mobile stations and the allocation of the segments (Sx, Sa, Sm) for the respective communication links to the mobile stations (MS) corresponding to the transmission conditions and/or the

utilization capacity of a radio cell according to input data from a device (BSC, OMC) for radio resource management.

16. Radio communication system according to Claim 14 or 15 in which the device is constructed as a part of the base station (BS).

17. Radio communication system according to Claim 14 or 15 in which the device is constructed as a part of the base station control (BSC).

FIG 1

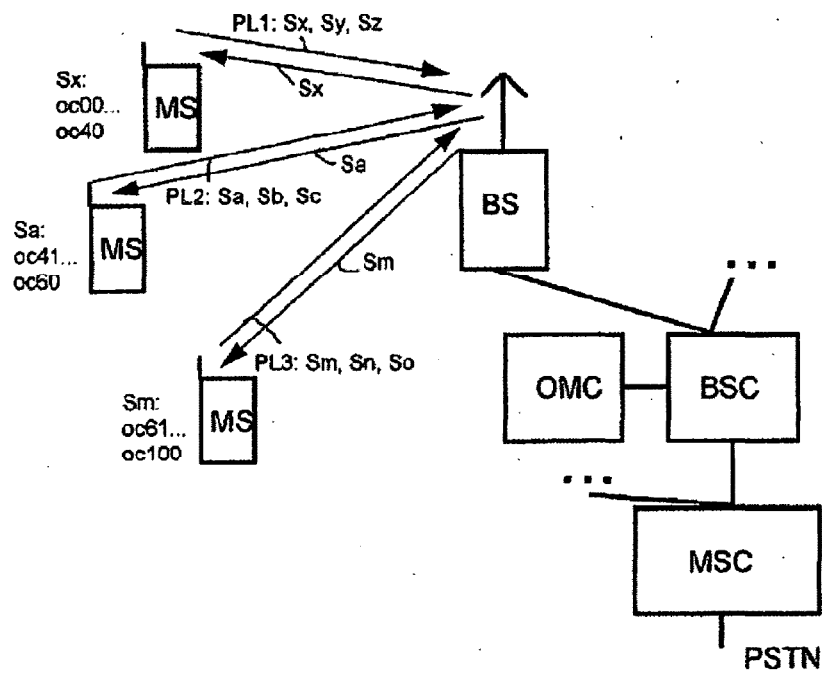


FIG 4

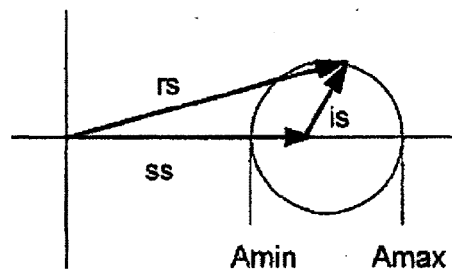
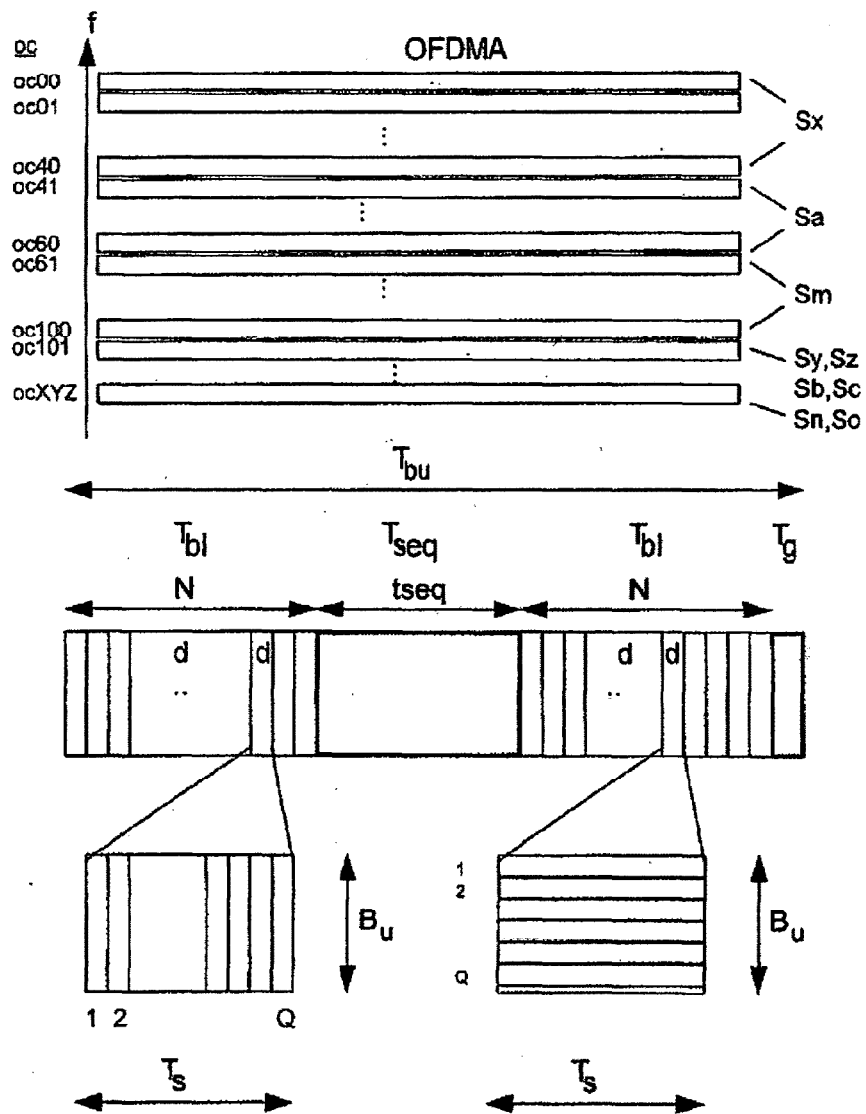


FIG 2



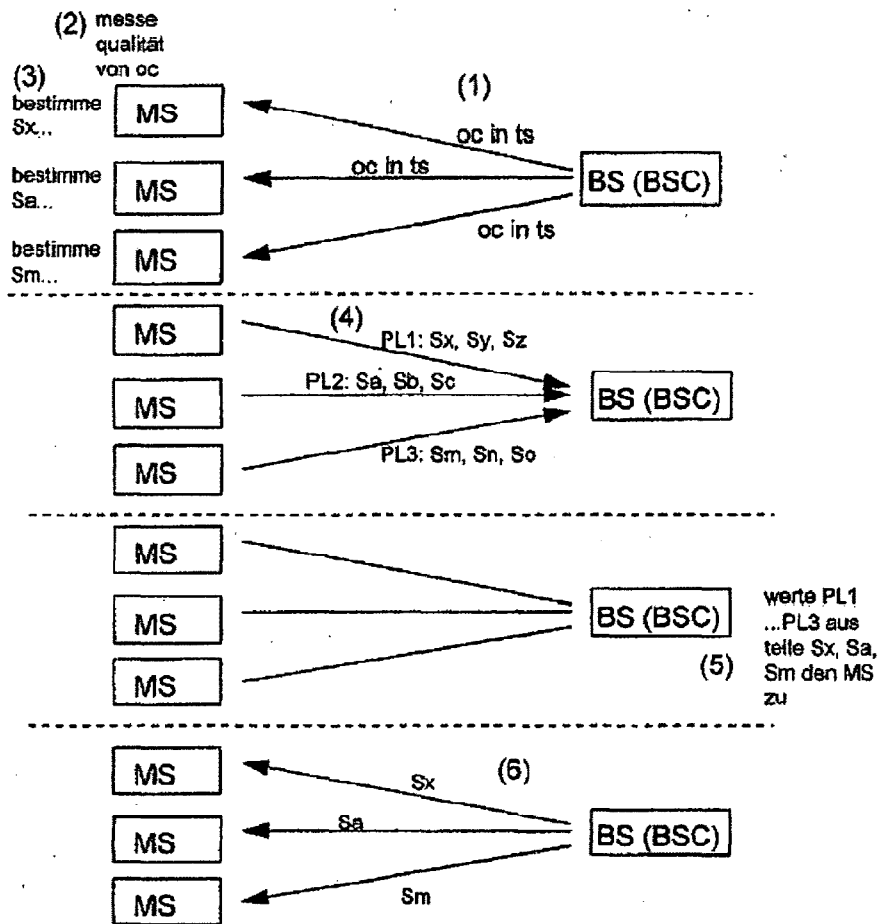


FIG 3

FIG 5

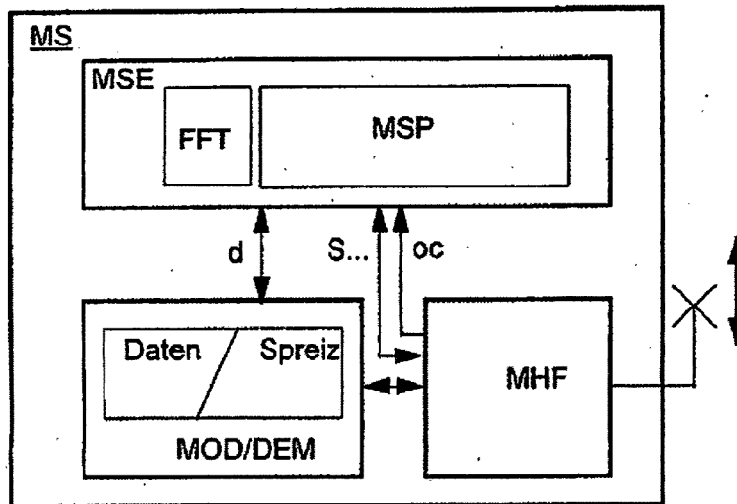
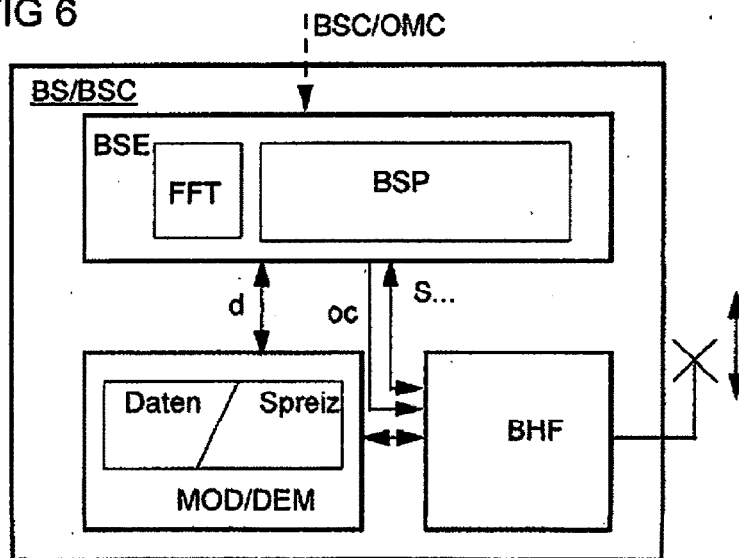


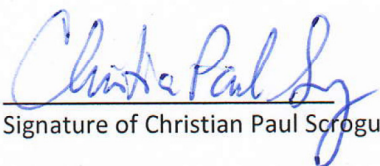
FIG 6





Date: March 10, 2015

I, Christian Paul Scrogum, declare under penalty of perjury that the foregoing is a true and accurate translation, to the best of my knowledge and belief, of German Patent Publication DE19800953C1, entitled "Verfahren und Funk-Kommunikationssystem zur Zuteilung von Funkressourcen einer Funkschnittstelle", except that a translation of the abstract is not included. I further declare that these statements in the translation were made with the knowledge that willful false statements and the like so made are punishable by fine, imprisonment, or both under Section 1001 of Title 18 of the United States Code.



Signature of Christian Paul Scrogum