(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
14 April 2011 (14.04.2011)

PCT

(10) International Publication Number
**WO 2011/042045 A1**

(51) **International Patent Classification**:
***H04B 7/04*** (2006.01) ***H04L 5/00*** (2006.01)

(21) **International Application Number**:
PCT/EP2009/062923

(22) **International Filing Date**:
6 October 2009 (06.10.2009)

(25) **Filing Language**: English

(26) **Publication Language**: English

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(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, 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, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

**Published**:
— *with international search report (Art. 21(3))*

(54) **Title**: RESERVATION OF COMMON CONTROL CHANNEL ELEMENTS FOR DEDICATED SIGNALLING

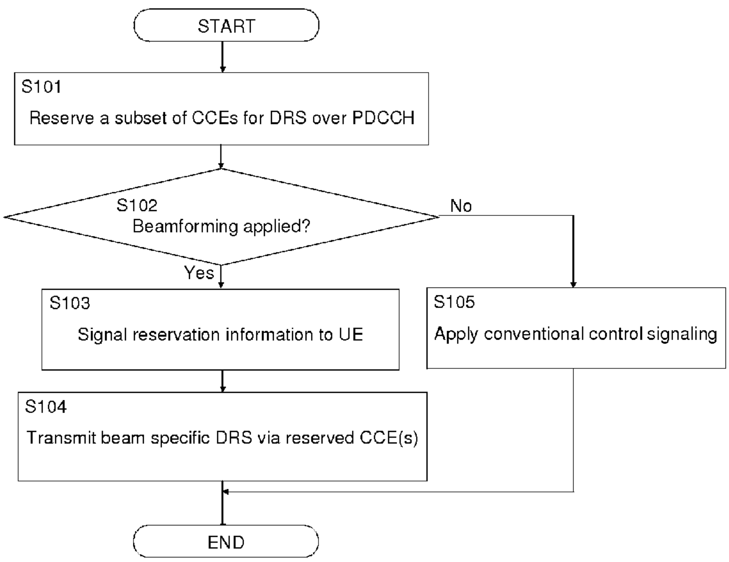


**Fig. 5**

**(57) Abstract**: The present invention relates to a method, system, apparatus, and computer program product for creating physical resources for dedicated reference information in a transmission structure wherein a subset of physical resources of a communication channel is reserved for at least one control channel and wherein the subset of physical resources is divided into control channel elements each consisting of a block of resource element groups. A predefined subset of the resource element groups is used for transmitting common reference information for channel estimation at a receiver of said communication channel and at least one of the control channel elements are reserved for transmitting beam-specific reference information in case beamforming is applied. Information which indicates the at least one reserved control channel element of the control channel elements is provided to the receiver, so that beam-specific reference information can be obtained via the at least one reserved control channel element.

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DESCRIPTION

TITLE

# Reservation of common control channel elements for dedicated signalling

## FIELD OF THE INVENTION

The present invention relates to a method, system, apparatus, and computer program products for creating physical resources for dedicated reference information in a transmission system, such as multiple-input multiple-output (MIMO) system.

## BACKGROUND OF THE INVENTION

Wireless communication systems are widely deployed to provide various communication content such as voice, video, packet data, messaging, broadcast, etc. These wireless systems may be multiple-access systems capable of supporting multiple users by sharing the available system resources. Examples of such multiple-access systems include Code Division Multiple Access (CDMA) systems, Time Division Multiple Access (TDMA) systems, Frequency Division Multiple Access (FDMA) systems, Orthogonal FDMA (OFDMA) systems, and Single-Carrier FDMA (SC-FDMA) systems.

In a wireless communication system, an access device (a base station or Node B) may send traffic data and/or control information on the downlink (DL) to a terminal device (e.g. a user equipment (UE)). The UE may also send traffic data and/or control information on the uplink to the Node B. The control information sent on each link may be useful but represents overhead. It is therefore desirable to efficiently and reliably send control information in order to achieve good performance.

Beamforming is a process used to create a radiation pattern of the antenna array by adding constructively the phases of the signals in the direction of desired targets or mobile devices, and/or nulling the pattern of target or mobile devices that are undesired or interfering. Beamforming takes advantage of interference to change the directionality of the array. When transmitting, a beamformer controls the phase and relative amplitude of the signal at each transmitter, in order to create a pattern of constructive and destructive interference in the wavefront.
In MIMO systems antenna arrays are used to enhance bandwidth efficiency. MIMO systems provide multiple inputs and multiple outputs for a single channel and are thus able to exploit spatial diversity and spatial multiplexing. Further information about MIMO systems can be gathered from the IEEE specifications 802.11n, 802.16-2004 and 802.16e, as well as 802.20 and 802.22 which relate to other standards. Specifically, MIMO systems have been introduced to radio systems like e.g. WiMAX (Worldwide Interoperability for Microwave Access) and are currently standardized in 3rd Generation Partnership Project (3GPP) for WCDMA (Wideband Code Division Multiple Access) as well as 3GPP E-UTRAN (Enhanced Universal Mobile Telecommunications System (UMTS) Terrestrial Radio Access Network), such as LTE (Long Term Evolution) or 3.9G.

However, to provide a reliable beamforming mechanism, beam-specific or dedicated control signalling has to be exchanged between terminal devices and access devices.

As an example, the control channel structure of 3GPP LTE is constructed such that a number of control channels are multiplexed in the time and frequency domain. These are the Physical Control Format Indicator Channel (PCFICH) which is a control channel for indicating the number of OFDM symbols for control, the Physical HARQ (Hybrid Automatic Repeat Request) Indicator Channel (PHICH) which is a control channel for the uplink (UL) HARQ, and Physical Downlink Control Channel (PDCCH) which is a control channel for the indication of UL and DL data allocations. On top of these channels, a subset of the physical resources are reserved for so-called reference symbols (or pilot symbols), which are used to create a common reference such that it is possible for a terminal device to do channel estimation when receiving the control and/or data channels. These reference symbols are common to all UEs, and are typically being denoted common reference symbols (CRS).

When multiple transmit antennas are used in the base station device, it is possible to introduce MIMO techniques, e.g. beamforming, which can be applied at the transmitting end without any requirements for the terminal receiver setup besides the fact that the terminal device should be able to do demodulation based on dedicated reference symbols (which may be present within the scheduled resources). That is, it is possible to use the techniques no matter whether the terminal device has 1 or more reception antennas.

The PDCCH (and the control channels for LTE in general) are constructed from some building blocks, which are denoted resource element groups (REG). These REGs may consist of four neighbouring resource elements, wherein one resource element may be a subcarrier symbol for the duration of one OFDM symbol. The elements within a REG might be divided, if there is a reference symbol in between, since these have higher priority than the grouping of the elements in the REGs.

Fig. 3 shows an example structure of the creation and allocation of REGs, as suggested for example in proposal R1-074080 for 3GPP TSG RAN Meeting #50bis, Shanghai, China, October 8-12, 2007. Here, it is seen that each REG is constructed of four neighbouring resource elements (upper part), and for the shown case there are three OFDM symbols allocated for control channel information. The REGs are interleaved and combined in blocks of nine REGs to create a control channel element (CCE). Such a CCE is the minimum entity which can be used for transmitting the resource allocation for a UL or DL scheduling for a single terminal device.

In case the terminal device is in poor channel conditions, it is possible to aggregate these CCEs to provide more radio resources (and thereby achieve better coverage).

In the conventional setup of control channels and data channels, it is such that there is support for implementing beamforming. This beamforming can be supported by introducing dedicated reference symbols (DRS) into the physical downlink shared channel (PDSCH), but there is currently no support for DRS in the control channel part. A problem is that DRS is defined to be terminal specific, so that conventional implementation would create a chicken/egg problem in that the terminal device will need to decode the control channel correctly (e.g. identify its radio network temporary identity (RNTI)) to know that it has been scheduled. However, to achieve this, it needs to know the DRS, which it will only be able to identify when it is being scheduled.

To solve this problem, it has been proposed to implement beam-specific DRS, so that the DRS is not addressed directly to the terminal device, but dedicated to a beam formed by the base station device towards a specific direction. However, such solutions require modification of the structure of the CRS to allow for beam specific DRS at the same positions, and would therefore impact the "backwards compatibility" of the system, which is not a preferred way in terms of traditional evolution of the system. As an example, it may be difficult to ensure that DRS is transmitted in the full bandwidth and this may introduce constraints on the scheduling. It may for example be difficult to schedule terminal devices of different evolutionary levels of a standard (e.g. 3GPP Release 8 and 3GPP Release 10 UEs) in the same sub frame, as the earlier standard might support transmission of proper DRS in its allocated bandwidth only.

Furthermore, in Wideband CDMA (WCDMA), beamforming based Spatial Division Multiple Access (SDMA) is supported by adding a secondary common synchronization channel. Using this, SDMA can be applied to both dedicated control and data channels. However, this approach is not directly applicable in LTE, as the multiple access scheme is OFDMA and the reference or pilot signals are designed in a quite different way.

## SUMMARY

According to various embodiments, two interrelated methods are provided.

First, a method is provided, which comprises:

- reserving a subset of physical resources of a communication channel for at least one control channel;
- dividing said subset of physical resources into control channel elements each consisting of a block of resource element groups;
- using a predefined subset of said resource element groups for transmitting common reference information for channel estimation at a receiver of said communication channel; and
- reserving at least one of said control channel elements for transmitting beam-specific reference information in case beamforming is applied.

Second, a method is provided, which comprises:

- reserving a subset of physical resources of a communication channel for at least one control channel;

- dividing said subset of physical resources into control channel elements each consisting of a block of resource element groups;

- using a predefined subset of said resource element groups for receiving common reference information for channel estimation;

- determining a reservation information which indicates at least one reserved control channel element of said control channel elements; and

- receiving beam-specific reference information via said at least one reserved control channel element.

Additionally, according to various embodiments, two interrelated apparatuses are provided.

First, an apparatus is provided, which comprises:

- a controller for reserving a subset of physical resources of a communication channel for at least one control channel and for dividing said subset of physical resources into control channel elements each consisting of a block of resource element groups; and

- a transmitter for using a predefined subset of said resource element groups for transmitting common reference information for channel estimation at a receiver of said communication channel;

- wherein said controller is adapted to reserve at least one of said control channel elements for transmitting beam-specific reference information in case beamforming is applied.

Second, an apparatus is provided, which comprises:

- a controller for reserving a subset of physical resources of a communication channel for at least one control channel, and for dividing said subset of physical resources into control channel elements each consisting of a block of resource element groups;

- a receiver adapted to use a predefined subset of said resource element groups for receiving common reference information for channel estimation; and

- a detector for detecting a reservation information which indicates at least one reserved control channel element of said control channel elements;

- wherein said controller is adapted to control said receiver to receive beam-specific reference information via said at least one reserved control channel element.

Further, a system is provided, which comprises at least one of both apparatuses defined above.

In addition, a respective computer program product can be provided comprising code means for producing the steps of the above methods when run on a computer device.

Accordingly, a concept of reserving a set of CCEs is proposed, such that they are not used for conventional control channel signalling, but might be used for transmitting beam-specific DRS (or other types of reference or pilot signals). Hence, the conventional control channel structure is not influenced by the proposed reservation, but might choose to sacrifice control channel capacity (in terms of number of CCEs available) for the feature of beam-specific control signalling. Whenever beam-forming is used on top of the control channel it might be possible to schedule two or more UEs at the same time on the same physical resources at a time (i.e.

spatial multiplexing), and for a high penetration of UEs supporting this feature, the gain from spatial multiplexing can easily be higher than the loss from reserving a few CCEs for the DRS.

According to a non-limiting example, the beam-specific reference information may comprise at least one dedicated terminal-specific reference or pilot symbol for supporting beamforming.

According to another non-limiting example, the at least one control channel may comprises a physical downlink control channel for indicating uplink and downlink data allocation.

The reservation information for informing the receiver side about the reserved control channel element(s) may be transmitted via a radio resource control signalling for example.

According to a further non-limiting example for an OFDM-based implementation, each of the resource element groups may consist of subcarrier symbols for the duration of one OFDM symbol. Optionally, the reserved control channel elements may be selected as neighboring control channel elements.

The claimed apparatus may be represented by a semiconductor chip, a chipset, or a (hardware) module comprising such chip or chipset; this, however, does not exclude the possibility that a functionality of an apparatus or module, instead of being hardware implemented, be implemented as software in a (software) module such as a computer program or a computer program product comprising executable software code portions for execution/being run on a processor.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described on the basis of an embodiment with reference to the accompanying drawings in which:

Fig. 1 shows a schematic block diagram of a communication system in which the present invention can be implemented;

Fig. 2 shows a schematic diagram of a multi antenna Node B device with an apparatus according to a first embodiment;

Fig. 3 shows an illustration of a conventional approach for creating a set of control channel elements and a corresponding numbering scheme;

Fig. 4 shows a schematic block diagram of a UE device with an apparatus according to a second embodiment.

Fig. 5 shows a schematic flow diagram of a network-sided CCE reservation procedure according to a third embodiment;

Fig. 6 shows a schematic flow diagram of a terminal-sided CCE reservation procedure according to a fourth embodiment;

Fig. 7 shows a schematic diagram indicating average frequency distance between REGs used for DRS;

Fig. 8 shows a schematic diagram indicating maximum frequency distance between REGs used for DRS; and

Fig. 9 shows a schematic block diagram of a computer-based implementation according to a fifth embodiment.

## DESCRIPTION OF THE EMBODIMENT

Exemplary embodiments of the present invention will now be described. Indeed, the invention may be embodied in many different forms and should not be constructed as limited to the embodiments set forth herein. Although the specification may refer to “an”, “one”, or “some” embodiment(s) in several locations, this does not necessarily mean that each such reference is to the same embodiment(s), or that the feature only applies to a single embodiment. Single features of different embodiments may also be combined to provide other embodiments. Like reference numerals refer to like elements throughout.

The present invention is applicable to any base station device, access device, server device, corresponding component, and/or to any communication system or any combination of different communication systems that support beamforming. The protocols used, the specifications of communication systems, servers and user terminals, especially in wireless communication, develop rapidly. Such development may require extra changes to an embodiment. Therefore, all words and expressions should be interpreted broadly and they are intended to illustrate, not to restrict, the embodiment.

In the following, different embodiments will be described using, as an example of a system architecture whereto the embodiments may be applied, an architecture based on an LTE-Advanced network without restricting the embodiment to such architecture, however.

A general architecture of a communication system providing an example of an environment where the present solution may be used, is illustrated in Fig. 1 which shows a simplified system architecture. It is apparent to a person skilled in the art that the communication system may also comprise other functions and structures. It should be appreciated that functions, structures, elements and protocols used in or for group communication, may be irrelevant to the actual invention. Therefore, those need not to be discussed in more detail here.

Referring to Fig. 1, a communication system 100 comprises a user equipment (UE) 20 which may be e.g. a mobile or wireless user terminal, such as a mobile phone (mobile station), a personal digital assistant (PDA), a game console, a smart phone, a personal computer (PC), a laptop, a desktop computer or the like, capable of receiving/transmitting control and user data. The communication system 100 further comprises an access network (such as an evolved UMTS terrestrial radio access network of an enhanced cellular network (E-UTRAN)) which can be accessed via a network node or a component, such as a base station (enhanced Node B (eNB), E-UTRAN node B, eNodeB) 10, capable of transmitting/receiving component carrier signalling. Here it is assumed that the user equipment (UE) 20 is capable of communicating with the base station 10 by utilizing an air interface (also referred to as a radio interface). Respective arrows are depicted to indicate uplink (UL) and downlink (DL) directions. Transmission may be based on orthogonal frequency division multiplexing (OFDM) as a modulation scheme to communicate data between a signal source, such as the base station 10, and a subscriber station, such as the UE 20. OFDM enables communication of a large amount of data over a limited bandwidth by allocating the data among multiple smaller sub-signals, and then simultaneously transmitting the sub-signals using different sub-carriers.

Although discussed as a primary example herein, the present solution is not limited to E-UTRAN, LTE, and/or 3GPP systems. Thus, the present solution may also be applicable to other communications systems such as WiMAX (worldwide interoperability for microwave access) and/or WLAN (wireless local area network) and/or other multi-carrier systems.

The embodiment which will now be described is configured for a wireless multi-antenna transmission system or smart antenna system, such as - but not limited to - a MIMO system for an exemplary case of four antenna elements at a transceiver unit e.g. of a base station device, such as a Node B. However, it will be apparent from the following description and is therefore explicitly stressed that the present invention can be applied to any other multi-antenna transmission system for different radio access technologies involving multi-antenna transceiver devices (e.g. base station devices, access points or other access devices).

Fig. 2 shows a Node B device (e.g. the Node B 10 of Fig. 1) with an exemplary multi-antenna system in which the present invention could be implemented, wherein an antenna array or smart antenna 60 comprising four antenna elements is provided. A beamformer 65 may be implemented e.g. as part of a signal processing element. The multi-antenna system may be provided at a base station device or access device of a wireless or cellular network. As initially mentioned, the beamformer 65 is configured to adjust at least one of phases and amplitudes of respective signal components supplied to said smart antenna 60 in order to generate an antenna pattern with a predetermined directivity, e.g. beam or nulling direction. It is noted that Fig. 2 only shows those elements involved in or related to the proposed control signalling procedures or mechanisms. Other components have been omitted for reasons of clarity and brevity.

The beamformer 65 is controlled by a beamforming control signal or information 70 which is generated by a control processor 80. The control processor 80 and beamformer 65 are part of or integrated into the general signal generation/reception module 5. Blocks 5, 80, and 65 of Fig. 1 may be implemented as a digital processor, computer device, or analog processing circuit. The control processor 80 generates respective control signals (e.g. dedicated reference or pilot symbols, such as DRS) for each of four transmission (Tx) chains 22, 24, 26, and 28 and, respectively, receives control signals from each of four receiving (Rx) chains 32, 34, 36, and 38. These control signals may be used for channel estimation, calibration or the like. Each of the Tx chains 22, 24, 26, and 28 and Rx chains 32, 34, 36, and 38 is used for transmitting or respectively receiving a respective transmission signal component via a respective antenna element of the smart antenna 60. The Tx and Rx chains comprise a plurality of processing elements or stages (such as mixing stages, modulating or demodulating stages, filter stages, coding or decoding stages, amplifying stages, etc.) required for transmitting or receiving transmission signal components. Depending on an uplink or downlink beamforming control operation, respective switching elements (not shown), which may be electrical or mechanical switches are switched by a control function (not shown) to a predetermined switching position, so as to connect the Tx chains or RX chains to the smart antenna 60.

According to various embodiments, physical resources are created by reserving a set of CCEs in the respective control channel (e.g. PDCCH), such that they are not used for conventional common control channel signalling, but might be used for transmitting beam-specific DRS (or other types of reference signals). In the exemplary embodiments a concept of grid of fixed beams is applied, as it is intend for each beam to have its own unique identity (ID) and thereby a unique DRS. In this way, the current common control channel structure is no influenced or modified, but the control processor 80 might choose to sacrifice control channel capacity (in terms of number of CCEs available for common control) for the feature of beam-specific DRS. Whenever beam-forming is used on top of the control channel, the control processor 80 may decide to schedule two or more UEs at the same time on the same physical resources at the time (i.e. spatial multiplexing). If DRS is supported by many UEs, the capacity loss from reserving a few CCEs for the DRS may be outweighed by the gain achieved by spatial multiplexing.

Additionally, a control signalling may be provided for controlling which UEs are configured to use these DRS reserved CCEs, such that the eNB can choose which approach to use. A base configuration could be that the DRS control signaling is disabled at the UEs. When the need for beam forming on the PDCCH rises (and UEs support this), the eNB may indicate to the UEs (e.g. through radio resource control (RRC) signalling) which CCEs are reserved for DRS. This means that in case there is high frequency selectivity, the control processor 80 at the eNB can choose to reserve a predetermined number of CCEs (and potentially specific CCEs) for DRS transmission, and thereby balance the gain versus the potential control channel capacity loss.

As alternatives or in addition, the reserved DRS specific CCEs may be default CCEs preset by the network operator or may be settable or controllable at the UEs directly.

Additionally, the control processor 80 of Fig. 2 may be adapted to exercise control to the effect that all beam-specific (i.e. SDMA) PDCCHs and DRS transmitted to users in the same beam are precoded identically. This type of precoding is also called “grid of beams”. The DRS sequence could be arranged so that a receiving UE can derive the beam specific sequence in the full band. Also, the DRS sequences could be randomised or even orthogonalized in between different beams to ensure proper channel estimation performance.

The CCE can be reused for reference signals because the mapping to physical resources maximises diversity and thus even for a few CCEs there will be DRS in the full bandwidth.

Fig. 4 shows a schematic block diagram of a UE device (e.g. the UE 20 of Fig. 1) with an apparatus according to a second embodiment. It is noted that Fig. 4 only depicts those parts which are relevant for the description of the second embodiment.

The UE device comprises a radio frequency (RF) front end 22 adapted to transmit and receive user and control data. Additionally, a DRS determination (DET) functionality or unit 24 is connected to the RF front end 22 so as to detect a use of DRS specific CCEs and/or determine which CCEs have been reserved for DRS signaling. The detection and/or determination can be based on a reservation information received via an RRC signaling and/or based on a setting information provided at the UE device.

Based on the result of detection and/or determination, the determination unit 24 provides control information to a control processor 26 which comprises a beam-specific control (BSC) functionality or unit 262 for DRS control and a conventional control (CC) functionality or unit 264 for conventional common control. In response to the control information received from the determination unit 24, the control processor 26 activates one of the beam-specific control unit 262 and the common control unit 264.

Fig. 5 shows a schematic flow diagram of a network-sided CCE reservation procedure according to a third embodiment.

In step S101, a subset of CCEs is reserved for DRS over PDCCH. Then, it is checked or decided in step S102 whether beamforming is to be applied for a control signaling to a specific UE. If beamforming is to be applied, reservation information which indicates the reserved CCE(s) is signaled to the concerned UE ins step S103. Then, beam-specific DRS is transmitted to the concerned UE by using the reserved CCE(s). If it is determined in step S102 that beamforming is not applied, the procedure branches to step S105 and conventional common control without DRS is applied.

Fig. 6 shows a schematic flow diagram of a terminal-sided CCE reservation procedure according to a fourth embodiment.

In step S101, a check for reservation information which indicates the reserved CCE(s) is initiated. Then, it is determined in step S202 whether beam-specific control is applied by DRS over PDCCH. If beam-specific control is applied, reserved CCE(s) are determined in step S203 based on the reservation information. Then, beam-specific DRS is received via the reserved CCE(s). If it is determined in step S202 that beam-specific control is not applied, the procedure branches to step S205 and conventional common control without DRS is applied.

The reservation information may directly indicate the reserved CCE(s) or may just indicate use of beam-specific control while the reserved CCE(s) may be gathered from a default setting or an individual setting stored in the terminal and/or provided by the network.

To illustrate the performance of the proposed resource creation concept, information on the positions of the REGs in the frequency domain (which is needed to know the expected performance of the channel estimation) has been extracted. The tool for extracting this information simply places all the control channels in the resource element grid (time and frequency) and post processing scripts evaluate the distance between the resource element groups in the frequency domain.

Figs. 7 and 8 show schematic diagrams respectively indicating average and maximum frequency distance between REGs used for DRS. More specifically, the performance has been evaluated for neighbouring CCEs (to reduce fragmentation of the aggregated CCEs). In the evaluation, three cases have been considered: reservation of one CCE for DRS, two CCEs for DRS, and three CCEs for DRS. In all cases (for multiple CCEs) wrap-around has been used, meaning that in case CCE#43 is used, we also use CCE#1 and CCE#2 for DRS. The results are shown in Figs. 7 and 8. From these it can be gathered that it is possible to obtain an average frequency difference between the REGs of approximately 300 kHz when using three REGs for the DRS. It should be considered that at each REG, four resource elements are available for channel estimation (whichever way is used to provide channel estimation). Further, it is seen that by selecting the right set of neighbouring CCEs, it is possible to reduce the maximum separation between two REGs to approximately 500 kHz.

Fig. 9 shows a schematic block diagram of a software-based implementation of the proposed resource creation system. More specifically, the block diagram of Fig. 9 may correspond to the devices at both signalling ends, namely UE device and Node B device, respectively. Here, the respective control processors 26 and 80 are configured as a computer device 200 comprises a processing unit 210, which may be any processor or processing device with a control unit which performs control based on software routines of a control program stored in a memory 212. Program code instructions are fetched from the memory 212 and are loaded to the control unit of the processing unit 210 in order to perform the processing steps of the above functionalities described in connection with the respective Figs. 2, 4, 5 and 6. These processing steps may be performed on the basis of input data DI and may generate output data DO, wherein the input data DI may correspond to a beamforming trigger at the network side (e.g. Node B device) or to a detected reservation information at the terminal side (e.g. UE device). The output data DO may correspond to the reservation information at the network side or to a DRS specific control signalling at the terminal side.

At this point, it is noted that the functionalities of the control processor 80 of Fig. 2 and the control processor 26 of Fig. 4 can be implemented as discrete hardware or signal processing units, or alternatively as software routines or programs controlling a processor or computer device to perform the processing steps of the above functionalities.
To summarize, a method, system, apparatus, and computer program product for creating physical resources for dedicated reference information in a transmission structure have been described, wherein a subset of physical resources of a communication channel is reserved for at least one control channel and wherein the subset of physical resources is divided into control channel elements each consisting of a block of resource element groups. A predefined subset of the resource element groups is used for transmitting common reference information for channel estimation at a receiver of said commu-

nication channel and at least one of the control channel elements are reserved for transmitting beam-specific reference information in case beamforming is applied. Information which indicates the at least one reserved control channel element of the control channel elements is provided to the receiver, so that beam-specific reference information can be obtained via the at least one reserved control channel element.

It is to be noted that the present invention is not restricted to the embodiment described above, but can be implemented in any network environment involving multi-antenna systems with a beamforming functionality. Any kind of control element of a control signaling used for non-beam-specific common control could be reserved for the beam-specific control. The embodiment may thus vary within the scope of the attached claims.

## Claims

1. A method comprising:

reserving a subset of physical resources of a communication channel for at least one control channel;

dividing said subset of physical resources into control channel elements each consisting of a block of resource element groups;

using a predefined subset of said resource element groups for transmitting common reference information for channel estimation at a receiver of said communication channel; and

reserving at least one of said control channel elements for transmitting beam-specific reference information in case beamforming is applied.

2. A method comprising:

reserving a subset of physical resources of a communication channel for at least one control channel;

dividing said subset of physical resources into control channel elements each consisting of a block of resource element groups;

using a predefined subset of said resource element groups for receiving common reference information for channel estimation;

determining a reservation information which indicates at least one reserved control channel element of said control channel elements; and receiving beam-specific reference information via said at least one reserved control channel element.

3. The method according to claim 1 or 2, wherein said beam-specific reference information comprises at least one dedicated terminal-specific reference or pilot symbol for supporting said beamforming.

4. The method according to any one of the preceding claims, wherein said at least one control channel comprises a physical downlink control channel for indicating uplink and downlink data allocation.

5. The method according to claim 2, further comprising transmitting said reservation information via a radio resource control signalling.

6. The method according to any one of the preceding claims, wherein each of said resource element groups consists of subcarrier symbols for the duration of one orthogonal frequency division multiplexing symbol.

7. The method according to any one of the preceding claims, wherein said reserved control channel elements are neighboring control channel elements.

8. An apparatus comprising:

a controller for reserving a subset of physical resources of a communication channel for at least one control channel and for dividing said subset of physical resources into control channel elements each consisting of a block of resource element groups; and

a transmitter for using a predefined subset of said resource element groups for transmitting common reference information for channel estimation at a receiver of said communication channel;

wherein said controller is adapted to reserve at least one of said control channel elements for transmitting beam-specific reference information in case beamforming is applied.

9. An apparatus comprising:

a controller for reserving a subset of physical resources of a communication channel for at least one control channel, and for dividing said subset of physical resources into control channel elements each consisting of a block of resource element groups;

a receiver adapted to use a predefined subset of said resource element groups for receiving common reference information for channel estimation; and

a detector for detecting a reservation information which indicates at least one reserved control channel element of said control channel elements;

wherein said controller is adapted to control said receiver to receive beam-specific reference information via said at least one reserved control channel element.

10. The apparatus according to claim 8 or 9, wherein said beam-specific reference information comprises at least one dedicated terminal-specific reference or pilot symbol for supporting said beamforming.

11. The apparatus according to any one of claims 8 to 10, wherein said at least one control channel comprises a physical downlink control channel for indicating uplink and downlink data allocation.

12. The apparatus according to claim 11, wherein each of said resource element groups consists of subcarrier sym-

bols for the duration of one orthogonal frequency division multiplexing symbol.

13. The apparatus according to any one of claims 8 to 12, wherein said controller is adapted to reserve neighboring control channel elements for said beam-specific reference information.

14. The apparatus according to claim 8, wherein said apparatus is adapted to transmit a reservation information indicating said reserved at least one control channel element via a radio resource control signalling.

15. The apparatus according to claim 9, wherein said apparatus is adapted to receive said reservation information via a radio resource control signalling.

16. A transmission system comprising at least one apparatus according to claim 8 and at least one apparatus according to claim 9.

17. A computer program product comprising code means for producing the steps of method claim 1 or 2 when run on a computer device.

18. A base station device comprising an apparatus according to claim 8.

19. A terminal device comprising an apparatus according to claim 9.

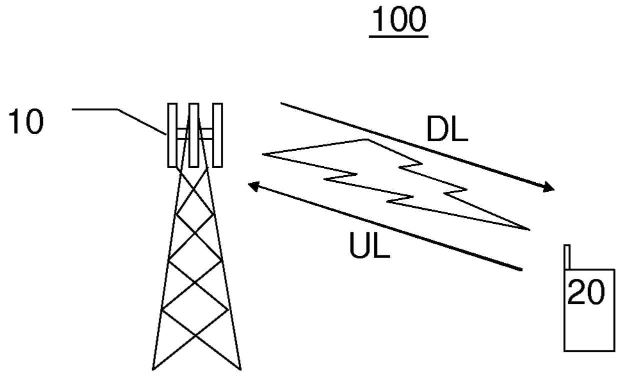
100
10
DL
UL
20

Fig. 1

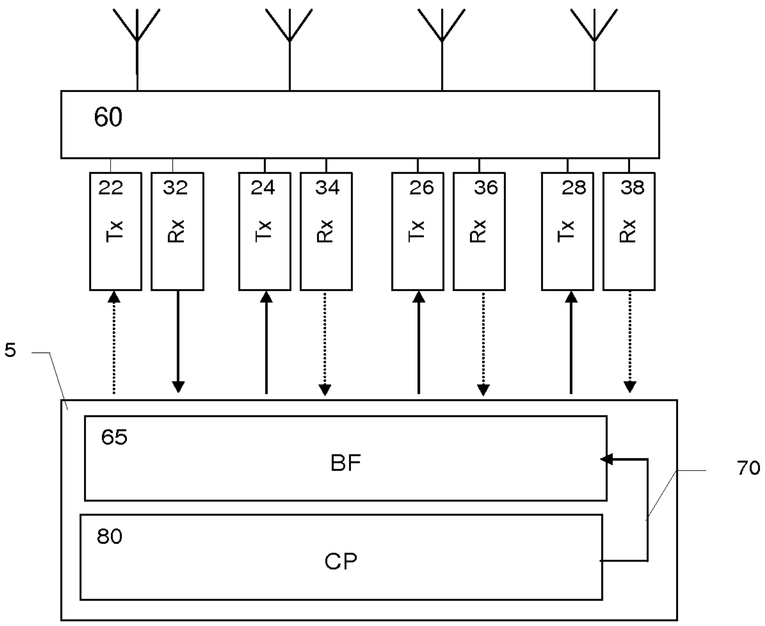
60
22
Tx
32
Rx
24
Tx
34
Rx
26
Tx
36
Rx
28
Tx
38
Rx
5
65
BF
70
80
CP

Fig. 2

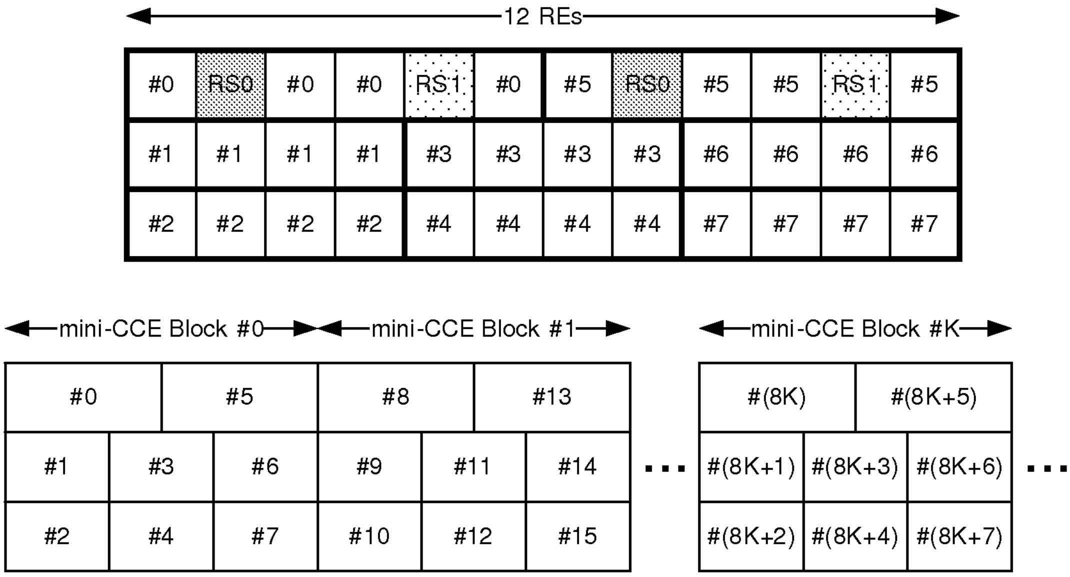
12 REs
#0
RS0
#0
#0
RS1
#0
#5
RS0
#5
#5
RS1
#5
#1
#3
#6
#2
#4
#7
mini-CCE Block #0
mini-CCE Block #1
mini-CCE Block #K
#0
#5
#8
#13
#9
#11
#14
#10
#12
#15
#(8K)
#(8K+5)
#(8K+1)
#(8K+3)
#(8K+6)
#(8K+2)
#(8K+4)
#(8K+7)

**Fig. 3**

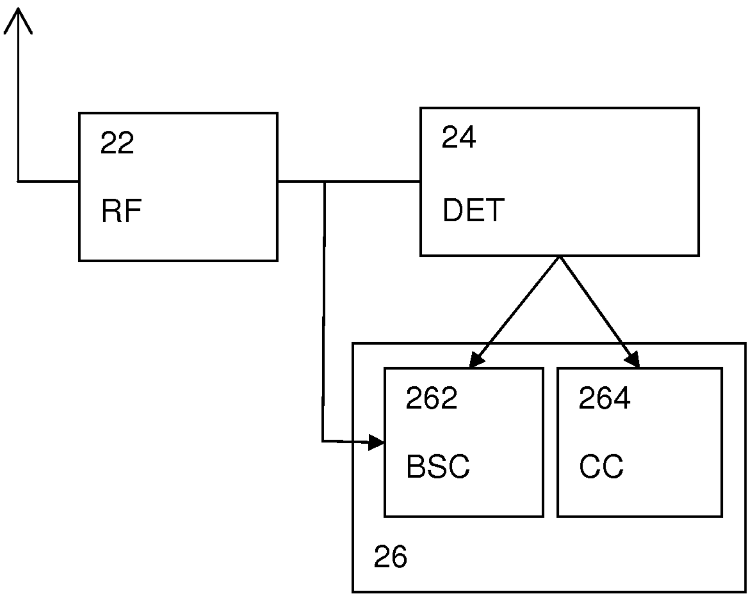
22
RF
24
DET
262
BSC
264
CC
26

**Fig. 4**

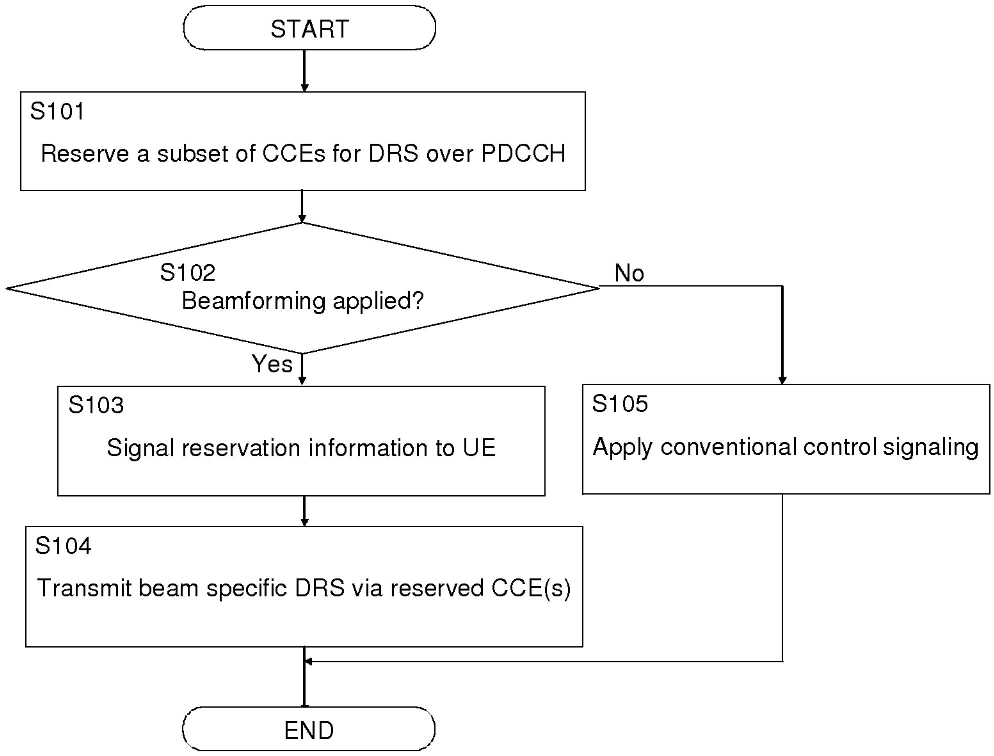
START
S101
Reserve a subset of CCEs for DRS over PDCCH
S102
Beamforming applied?
No
Yes
S103
Signal reservation information to UE
S105
Apply conventional control signaling
S104
Transmit beam specific DRS via reserved CCE(s)
END

**Fig. 5**

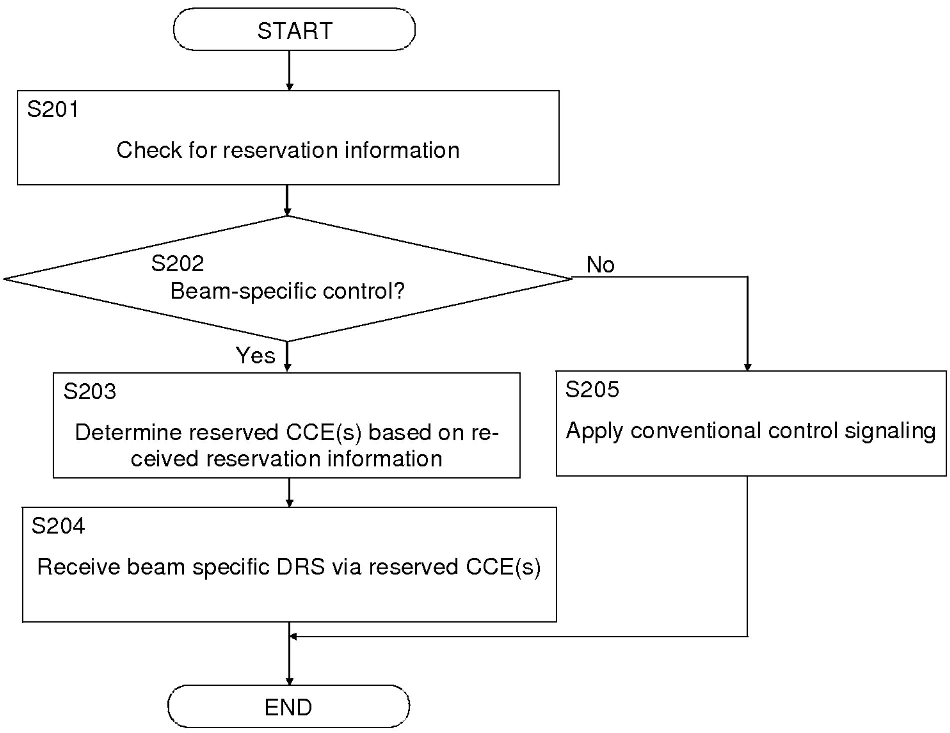
START
S201
Check for reservation information
S202
Beam-specific control?
No
Yes
S203
Determine reserved CCE(s) based on re-ceived reservation information
S205
Apply conventional control signaling
S204
Receive beam specific DRS via reserved CCE(s)
END

**Fig. 6**

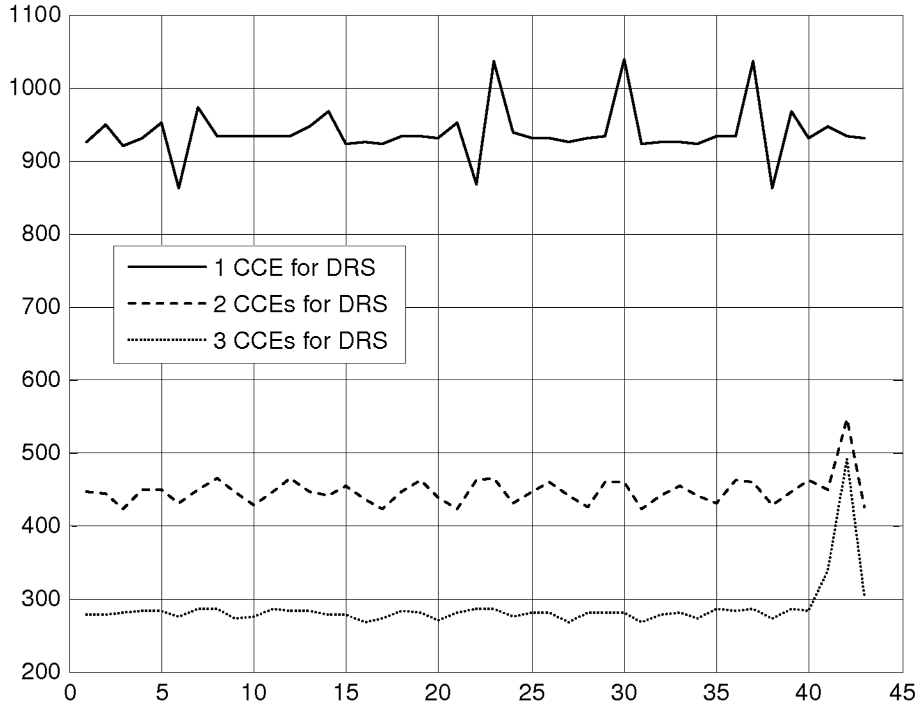
1100
1000
900
800
700
600
500
400
300
200
0
5
10
15
20
25
30
35
40
45
1 CCE for DRS
2 CCEs for DRS
3 CCEs for DRS

**Fig. 7**

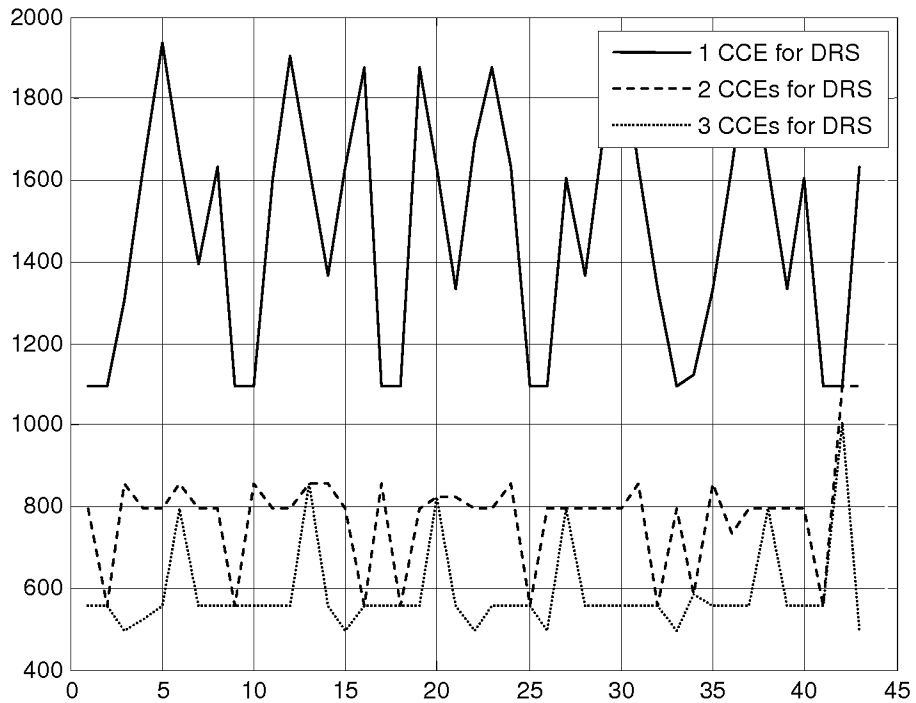
2000
1800
1600
1400
1200
1000
800
600
400
0
5
10
15
20
25
30
35
40
45
1 CCE for DRS
2 CCEs for DRS
3 CCEs for DRS

**Fig. 8**

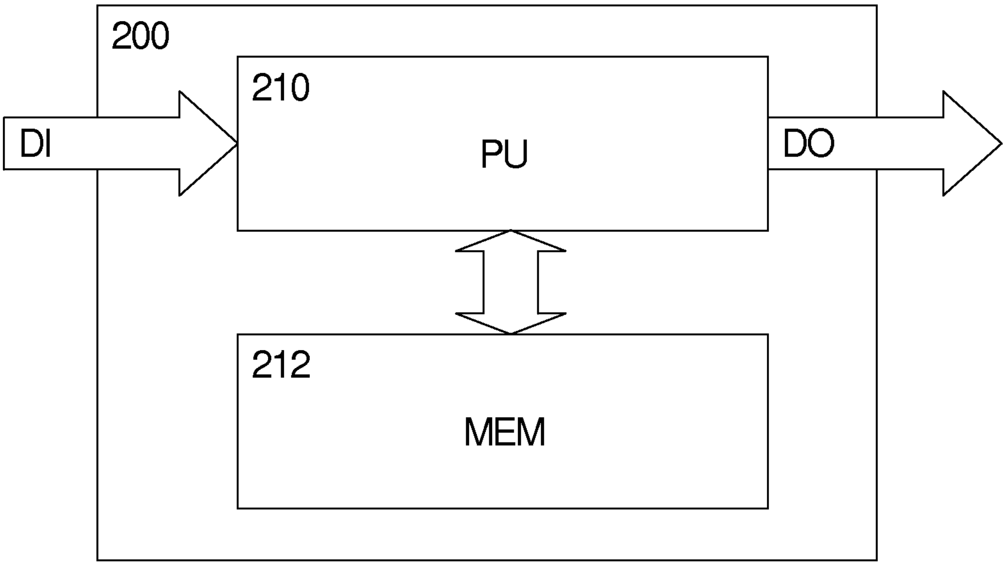


Fig. 9

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/062923

**A. CLASSIFICATION OF SUBJECT MATTER**
INV. H04B7/04 H04L5/00
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)
H04B H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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

EPO-Internal

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | NTT DOCOMO: "Support of DL Higher-Order MIMO Transmission in LTE-Advanced" 3GPP DRAFT; R1-084251 DL HIGHER-ORDER MIMO, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, no. Prague, Czech Republic; 20081104, 4 November 2008 (2008-11-04), XP050317536 [retrieved on 2008-11-04] pages 2-8 ----- | 1-19 |

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 5 July 2010 | 14/07/2010 |


| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL – 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Franz, Volker |

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/062923

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | SHARP: "Backward compatible design of downlink reference signals in LTE-Advanced" 3GPP DRAFT; R1-090023, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, no. Ljubljana; 20090107, 7 January 2009 (2009-01-07), XP050317971 [retrieved on 2009-01-07] page 3 ----- | 1-19 |
| X | EP 1 367 741 A2 (NOKIA CORP [FI]) 3 December 2003 (2003-12-03) paragraph [0047] - paragraph [0051]; figure 4 ----- | 1-19 |
| A | SAMSUNG: "PHICH/PDCCH to RE mapping" 3GPP DRAFT; R1-074080 PHICH PDCCH-TO RE MAPPING, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG1, no. Shanghai, China; 20071002, 2 October 2007 (2007-10-02), XP050107618 [retrieved on 2007-10-02] cited in the application page 1 ----- | 1-19 |

# INTERNATIONAL SEARCH REPORT

**Information on patent family members**

International application No
PCT/EP2009/062923

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| EP 1367741 A2 | 03-12-2003 | CN 1467942 A | 14-01-2004 |
| | | CN 101431359 A | 13-05-2009 |
| | | US 2004043736 A1 | 04-03-2004 |