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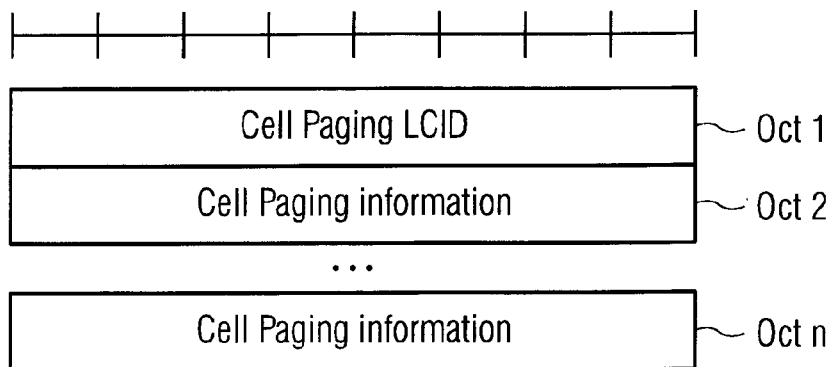
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FIG 7



(57) Abstract: There is provided a method comprising causing control information to be transmitted on a physical layer control channel during at least one transmission time interval of a time period in which a physical broadcast channel is combined across a plurality of physical broadcast channel occasions, wherein the control channel is capable of transmitting first level control information and second level control information, wherein the first level and second level are different.

DESCRIPTION

Title

5 METHOD, SYSTEM AND APPARATUS

Field

10 This disclosure relates to wireless communication and more particularly to wireless communication via antenna beams provided by access points and user equipment of a communication system.

Background

15 A communication system can be seen as a facility that enables communication sessions between two or more entities such as user terminals, base stations/access points and/or other nodes by providing carriers between the various entities involved in the communications path. A communication system can be provided for example by means of a communication network and one or more compatible communication devices. The
20 communication sessions may comprise, for example, communication of data for carrying communications such as voice, electronic mail (email), text message, multimedia and/or content data and so on. Non-limiting examples of services provided comprise two-way or multi-way calls, data communication or multimedia services and access to a data network system, such as the Internet.

25

In a wireless communication system at least a part of a communication session between at least two stations occurs over a wireless link.

A user can access the communication system by means of an appropriate communication
30 device or terminal. A communication device of a user is often referred to as user equipment (UE) or user device. A communication device is provided with an appropriate signal receiving and transmitting apparatus for enabling communications, for example enabling access to a communication network or communications directly with other users. The communication device may access a carrier provided by a station or access point, and
35 transmit and/or receive communications on the carrier.

The communication system and associated devices typically operate in accordance with a given standard or specification which sets out what the various entities associated with the system are permitted to do and how that should be achieved. Communication protocols and/or parameters which shall be used for the connection are also typically defined. One
5 example of a communications system is UTRAN (3G radio). An example of attempts to solve the problems associated with the increased demands for capacity is an architecture that is known as the long-term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) radio-access technology. Another example communication system is so called 5G radio access technology.

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Summary

In a first aspect, there is provided a method comprising causing control information to be transmitted on a physical layer control channel during at least one transmission time
15 interval of a time period in which a physical broadcast channel is combined across a plurality of physical broadcast channel occasions, wherein the control channel is capable of transmitting first level control information and second level control information, wherein the first level and second level are different.

20 The first level control information may be layer two level control information. The second level control information is layer three level control information.

The at least one transmission time interval may comprise a sweeping block.

25 The at least one transmission time interval may comprise a subframe.

The method may comprise causing first control information to be transmitted in at least one first transmission time interval of the time period and second control information to be transmitted in at least one second transmission time interval of the time period, wherein
30 the first control information is of a different type to the second control information.

The first control information may comprise paging related control information. The second control information may comprise system information.

35 The physical layer control channel may comprise a sweep control channel.

The method may comprise providing an indication of the information to be transmitted on the physical layer control channel of at least one subsequent transmission time interval of the time period in at least one transmission time interval of the time period.

- 5 The method may comprise providing the indication in at least one of a media access control control element and a media access control protocol data unit.

The method may comprise providing the indication in a header of the media access control control element.

10

The control information may comprise a plurality of types of control information multiplexed in the at least one transmission time interval.

- 15 In a second aspect, there is provided a method comprising receiving control information on a physical layer control channel during at least one time interval of a time period in which a physical broadcast channel is combined across a plurality of physical broadcast channel occasions, wherein the control channel is capable of transmitting first level control information and second level control information, wherein the first level and second level are different.

20

The first level control information may be layer two level control information. The second level control information may be layer three level control information.

- 25 The at least one transmission time interval may comprise a sweeping block.

25

The at least one transmission time interval may comprise a subframe.

- 30 The method may comprise receiving first control information in at least one first transmission time interval of the time period and second control information in at least one second transmission time interval of the time period, wherein the first control information is of a different type to the second control information.

- 35 The first control information may comprise paging related control information. The second control information may comprise system information.

35

The physical layer control channel may comprise a sweep control channel.

The method may comprise receiving an indication of the information to be transmitted on the physical layer control channel of at least one subsequent transmission time interval of the time period in at least one transmission time interval of the time period.

5

The method may comprise receiving the indication in at least one of a media access control control element and a media access control protocol data unit.

10 The method may comprise receiving the indication in a header of the media access control control element.

The control information may comprise a plurality of types of control information multiplexed in the at least one transmission time interval.

15 In a third aspect, there is provided an apparatus comprising means for causing control information to be transmitted on a physical layer control channel during at least one transmission time interval of a time period in which a physical broadcast channel is combined across a plurality of physical broadcast channel occasions, wherein the control channel is capable of transmitting first level control information and second level control
20 information, wherein the first level and second level are different.

The first level control information may be layer two level control information. The second level control information is layer three level control information.

25 The at least one transmission time interval may comprise a sweeping block.

The at least one transmission time interval may comprise a subframe.

30 The apparatus may comprise means for causing first control information to be transmitted in at least one first transmission time interval of the time period and second control information to be transmitted in at least one second transmission time interval of the time period, wherein the first control information is of a different type to the second control information.

35 The first control information may comprise paging related control information. The second control information may comprise system information.

The physical layer control channel may comprise a sweep control channel.

5 The apparatus may comprise means for providing an indication of the information to be transmitted on the physical layer control channel of at least one subsequent transmission time interval of the time period in at least one transmission time interval of the time period.

10 The apparatus may comprise means for providing the indication in at least one of a media access control control element and a media access control protocol data unit.

The apparatus may comprise means for providing the indication in a header of the media access control control element.

15 The control information may comprise a plurality of types of control information multiplexed in the at least one transmission time interval.

20 In a fourth aspect, there is provided an apparatus, said apparatus comprising means for receiving control information on a physical layer control channel during at least one transmission time interval of a time period in which a physical broadcast channel is combined across a plurality of physical broadcast channel occasions, wherein the control channel is capable of transmitting first level control information and second level control information, wherein the first level and second level are different.

25 The first level control information may be layer two level control information. The second level control information may be layer three level control information.

The at least one transmission time interval may comprise a sweeping block.

30 The at least one transmission time interval may comprise a subframe.

The apparatus may comprise means for receiving first control information in at least one first transmission time interval of the time period and second control information in at least one second transmission time interval of the time period, wherein the first control information is of a different type to the second control information.

35

The first control information may comprise paging related control information. The second control information may comprise system information.

The physical layer control channel may comprise a sweep control channel.

5

The apparatus may comprise means for receiving an indication of the information to be transmitted on the physical layer control channel of at least one subsequent transmission time interval of the time period in at least one transmission time interval of the time period.

10 The apparatus may comprise means for receiving the indication in at least one of a media access control control element and a media access control protocol data unit.

The apparatus may comprise means for receiving the indication in a header of the media access control control element.

15

The control information may comprise a plurality of types of control information multiplexed in the at least one transmission time interval.

20 In a fifth aspect, there is provided an apparatus comprising at least one processor and at least one memory including a computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to cause control information to be transmitted on a physical layer control channel during at least one transmission time interval of a time period in which a physical broadcast channel is combined across a plurality of physical broadcast channel
25 occasions, wherein the control channel is capable of transmitting first level control information and second level control information, wherein the first level and second level are different.

30 The first level control information may be layer two level control information. The second level control information is layer three level control information.

The at least one transmission time interval may comprise a sweeping block.

The at least one transmission time interval may comprise a subframe.

35

The apparatus may be configured to cause first control information to be transmitted in at least one first transmission time interval of the time period and second control information to be transmitted in at least one second transmission time interval of the time period, wherein the first control information is of a different type to the second control information.

5

The first control information may comprise paging related control information. The second control information may comprise system information.

The physical layer control channel may comprise a sweep control channel.

10

The apparatus may be configured to provide an indication of the information to be transmitted on the physical layer control channel of at least one subsequent transmission time interval of the time period in at least one transmission time interval of the time period.

15 The apparatus may be configured to provide the indication in at least one of a media access control control element and a media access control protocol data unit.

The apparatus may be configured to provide the indication in a header of the media access control control element.

20

The control information may comprise a plurality of types of control information multiplexed in the at least one transmission time interval.

In a sixth aspect, there is provided an apparatus comprising at least one processor and at least one memory including a computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to receive control information on a physical layer control channel during at least one transmission time interval of a time period in which a physical broadcast channel is combined across a plurality of physical broadcast channel occasions, wherein the control channel is capable of transmitting first level control information and second level control information, wherein the first level and second level are different.

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The first level control information may be layer two level control information. The second level control information may be layer three level control information.

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The at least one transmission time interval may comprise a sweeping block.

The at least one transmission time interval may comprise a subframe.

5 The apparatus may be configured to receive first control information in at least one first transmission time interval of the time period and second control information in at least one second transmission time interval of the time period, wherein the first control information is of a different type to the second control information.

10 The first control information may comprise paging related control information. The second control information may comprise system information.

The physical layer control channel may comprise a sweep control channel.

15 The apparatus may be configured to receive an indication of the information to be transmitted on the physical layer control channel of at least one subsequent transmission time interval of the time period in at least one transmission time interval of the time period.

20 The apparatus may be configured to receive the indication in at least one of a media access control control element and a media access control protocol data unit.

The apparatus may be configured to receive the indication in a header of the media access control control element.

25 The control information may comprise a plurality of types of control information multiplexed in the at least one transmission time interval.

30 In a seventh aspect there is provided a computer program embodied on a non-transitory computer-readable storage medium, the computer program comprising program code for controlling a process to execute a process, the process comprising causing control information to be transmitted on a physical layer control channel during at least one transmission time interval of a time period in which a physical broadcast channel is combined across a plurality of physical broadcast channel occasions, wherein the control channel is capable of transmitting first level control information and second level control information, wherein the first level and second level are different.

35

The first level control information may be layer two level control information. The second level control information is layer three level control information.

The at least one transmission time interval may comprise a sweeping block.

5

The at least one transmission time interval may comprise a subframe.

The process may comprise causing first control information to be transmitted in at least one first transmission time interval of the time period and second control information to be transmitted in at least one second transmission time interval of the time period, wherein the first control information is of a different type to the second control information.

10

The first control information may comprise paging related control information. The second control information may comprise system information.

15

The physical layer control channel may comprise a sweep control channel.

The process may comprise providing an indication of the information to be transmitted on the physical layer control channel of at least one subsequent transmission time interval of the time period in at least one transmission time interval of the time period.

20

The process may comprise providing the indication in at least one of a media access control control element and a media access control protocol data unit.

The process may comprise providing the indication in a header of the media access control control element.

25

The control information may comprise a plurality of types of control information multiplexed in the at least one transmission time interval.

30

In an eighth aspect there is provided a computer program embodied on a non-transitory computer-readable storage medium, the computer program comprising program code for controlling a process to execute a process, the process comprising receiving control information on a physical layer control channel during at least one transmission time interval of a time period in which a physical broadcast channel is combined across a plurality of physical broadcast channel occasions, wherein the control channel is capable

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of transmitting first level control information and second level control information, wherein the first level and second level are different.

The first level control information may be layer two level control information. The second
5 level control information may be layer three level control information.

The at least one transmission time interval may comprise a sweeping block.

The at least one transmission time interval may comprise a subframe.
10

The process may comprise receiving first control information in at least one first transmission time interval of the time period and second control information in at least one second transmission time interval of the time period, wherein the first control information is of a different type to the second control information.

15 The first control information may comprise paging related control information. The second control information may comprise system information.

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The process may comprise receiving an indication of the information to be transmitted on the physical layer control channel of at least one subsequent transmission time interval of the time period in at least one transmission time interval of the time period.

25 The process may comprise receiving the indication in at least one of a media access control control element and a media access control protocol data unit.

The process may comprise receiving the indication in a header of the media access control control element.
30

The control information may comprise a plurality of types of control information multiplexed in the at least one transmission time interval.

In a ninth aspect there is provided a computer program product for a computer, comprising
35 software code portions for performing the steps the method of the first and second aspect when said product is run on the computer.

A device for a communication system may comprise the apparatus according to the above elements.

In the above, many different embodiments have been described. It should be appreciated
5 that further embodiments may be provided by the combination of any two or more of the
embodiments described above.

Description of Figures

10

Embodiments will now be described, by way of example only, with reference to the
accompanying Figures in which:

Figure 1 shows a schematic diagram of a control apparatus according to some
15 embodiments;

Figure 2 shows a schematic presentation of a possible communication device;

Figure 3 shows a schematic diagram of an access point with a plurality of beams and a
20 communication device;

Figure 4 schematically shows sweep blocks;

Figure 5 shows an example physical broadcast channel structure;
25

Figure 6 shows a flowchart of an example method according to some embodiments;

Figure 7 shows a schematic diagram of an example MAC control element;

30 Figure 8 shows a schematic diagram of an example MAC protocol data unit;

Detailed description

In the following certain exemplifying embodiments are explained with reference to mobile
35 communication devices capable of communication via a wireless cellular system and mobile
communication systems serving such mobile communication devices. Before explaining in

detail the exemplifying embodiments, certain general principles of a wireless communication system, access systems thereof, and mobile communication devices are briefly explained with reference to Figures 1 to 2 to assist in understanding the technology underlying the described examples.

5

A communication device 10 or terminal can be provided wireless access via base stations or similar wireless transmitter and/or receiver nodes providing access points of a radio access system.

10 Each of the access points may provide at least one antenna beam directed in the direction of the communication device 10. The antenna beam can be provided by appropriate elements of antenna arrays of the access points. For example, access links between the access points (AP) and a user equipment (UE) can be provided by active antenna arrays. Such arrays can dynamically form and steer narrow transmission/reception beams and thus
15 serve UEs and track their positions. This is known as UE-specific beamforming. The active antenna arrays can be used both at the AP and at the UE to further enhance the beamforming potential. More than one beam can be provided by each access point and/or antenna array.

20 Access points and hence communications there through are typically controlled by at least one appropriate controller apparatus so as to enable operation thereof and management of mobile communication devices in communication therewith. Figure 1 shows an example of a control apparatus for a node, for example to be integrated with, coupled to and/or otherwise for controlling any of the access points. The control apparatus 30 can be arranged
25 to provide control on communications via antenna beams by the access points and on operations such as handovers between the access points. For this purpose the control apparatus comprises at least one memory 31, at least one data processing unit 32, 33 and an input/output interface 34. Via the interface the control apparatus can be coupled to relevant other components of the access point. The control apparatus can be configured to
30 execute an appropriate software code to provide the control functions. It shall be appreciated that similar components can be provided in a control apparatus provided elsewhere in the network system, for example in a core network entity. The control apparatus can be interconnected with other control entities. The control apparatus and functions may be distributed between several control units. In some embodiments, each
35 base station can comprise a control apparatus. In alternative embodiments, two or more base stations may share a control apparatus.

Access points and associated controllers may communicate with each other via fixed line connection and/or air interface. The logical connection between the base station nodes can be provided for example by an X2 interface. This interface can be used for example for
5 coordination of operation of the stations.

The communication device or user equipment (UE) 10 may comprise any suitable device capable of at least receiving wireless communication of data. For example, the device can be handheld data processing device equipped with radio receiver, data processing and user
10 interface apparatus. Non-limiting examples include a mobile station (MS) such as a mobile phone or what is known as a 'smart phone', a portable computer such as a laptop or a tablet computer provided with a wireless interface card or other wireless interface facility, personal data assistant (PDA) provided with wireless communication capabilities, or any combinations of these or the like. Further examples include wearable wireless devices such
15 as those integrated with watches or smart watches, eyewear, helmets, hats, clothing, ear pieces with wireless connectivity, jewellery and so on, universal serial bus (USB) sticks with wireless capabilities, modem data cards, machine type devices or any combinations of these or the like.

Figure 2 shows a schematic, partially sectioned view of a possible communication device. More particularly, a handheld or otherwise mobile communication device (or user equipment UE) 10 is shown. A mobile communication device is provided with wireless communication capabilities and appropriate electronic control apparatus for enabling operation thereof. Thus the mobile device 10 is shown being provided with at least one data processing entity
25 26, for example a central processing unit and/or a core processor, at least one memory 28 and other possible components such as additional processors 25 and memories 29 for use in software and hardware aided execution of tasks it is designed to perform. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board 27 and/or in chipsets. Data processing and memory functions provided by the
30 control apparatus of the mobile device are configured to cause control and signalling operations in accordance with certain embodiments of the present invention as described later in this description. A user may control the operation of the mobile device by means of a suitable user interface such as touch sensitive display screen or pad 24 and/or a key pad, one of more actuator buttons 22, voice commands, combinations of these or the like. A
35 speaker and a microphone are also typically provided. Furthermore, a mobile communication device may comprise appropriate connectors (either wired or wireless) to

other devices and/or for connecting external accessories, for example hands-free equipment, thereto.

The mobile device may communicate wirelessly via appropriate apparatus for receiving and transmitting signals. Figure 2 shows schematically a radio block 23 connected to the control apparatus of the device. The radio block can comprise a radio part and associated antenna arrangement. The antenna arrangement may be arranged internally or externally to the mobile device. The antenna arrangement may comprise elements capable of beamforming operations.

Some embodiments relate to mobile communication networks which beamforming techniques. For example the proposed 5G radio access technology and LTE-A (Long term evolution – advanced) evolution have proposed using beam forming techniques. It should be appreciated that other embodiments may be used with any other communication system which uses beamforming. For example some wireless area networks may use beamforming.

The so-called 5G system may use frequencies from 400MHz to 100GHz. Beamforming is considered to be desirable in enabling the use of the higher frequency bands due to coverage issues.

Some transceivers (e.g. a hybrid transceiver architecture) may use analogue beamforming, which may mean a limited number of concurrent beams as this is dependent on the number of antenna ports. It should be appreciated that other embodiments may be used with digital beamforming transceiver architecture or so-called hybrid transceiver architecture which use a hybrid of digital baseband processing (such as MIMO Multiple Input Multiple Output, and /or digital precoding) and analogue beamforming.

Reference is made to Figure 3 which shows an access point 1. The access point may be a base station. In some standards, such as 5G, the access point may be referred to an eNB (evolved Node B). The access point has a cell coverage area generally denoted by the reference numeral 3. The cell coverage area is covered by beams defined by the access node. In the example shown in Figure 3, four beams are shown. These are beam 1, beam 2, beam 3 and beam 4. It should be appreciated that in different embodiments, more or less than four beams may be provided. In some embodiments, the number of beams provided may vary over time.

To enable system access, periodical transmission of system information may be required per direction where one or more beams cover a specific area of a cell. The corresponding directions may need to be covered to provide resources for system access. When an access point covers a specific area with set of beams during a time interval (such as symbol duration or two symbol durations) it is called a sweep block. Figure 3 illustrates the concept of sweep blocks: For sweep block 1 the analogue beams 1 and 2 are active and for sweep block 2 the beams 3 and 4 are active. To schematically illustrate the sweep blocks, the four beams, for sweep block 1, show the first and second beams as active and the third and fourth beams as inactive with respect to the first sweep. The four beams are then shown for sweep block 2 with the first and second beams inactive and the third and fourth beams as inactive with respect to the second sweep. Each beam is shown twice, once for sweep block 1 and once for sweep block 2. It should be appreciated, that this is for illustrative purposes and in practice the position of the beams with respect to the access node is as represented for sweep block 1. Although Figure 3 illustrates that adjacent beams are active during sweep block it should be understood that the set of beams may be selected so that in sweep block 1 the beams 1 and 3 are active and for sweep block 2, the beams 2 and 4 are active.

Reference is made to Figure 4 which illustrates the sweep blocks in an example downlink subframe 4 (each block may take one or more symbols) and the corresponding uplink subframe. These sweep blocks are assumed to be periodical so that e.g. initial access resources may be mapped to UL sweep blocks. In the example shown in Figure 4, the downlink sub frame has a first field 4a for downlink control, a second field 4b for the sweep block 1, a third field 4c for the sweep block 2, n other fields and a final field 4d for uplink control. The uplink sub frame 5 has a first field 5a for downlink control, a second field 5b for the sweep block 1, a third field 5c for the sweep block 2, n other fields and a final field 5d for uplink control. Although the fields for downlink control 4d and uplink control 5d are illustrated, they are optional and may be excluded.

These sweep blocks are assumed to be periodical so that, for example, during DL sweep blocks an access point may transmit e.g. broadcast/cell information/initial access information (covering specific direction/directions on each sweep block), and there may be corresponding UL sweep blocks during UL subframe which cover the cell area on uplink direction. The UL sweep blocks may have e.g. resources for initial cell access (Random Access Channel) or other periodic signals such as SR (scheduling request).

There may be over 100 beams associated to one cell. Due to the limited number of simultaneous directions (beams) the NW can transmit simultaneously in one cell, providing the same information for the whole cell area may be problematic. For example, where there are 4 beams transmitted simultaneously and 100 beams associated to a cell, 25 time slots (100/4) would be required to transmit the same information to all the beams.

UEs may require some critical information to be able to access the cell (e.g., synchronization signals, beam structure, etc.). With analog beamforming, this may be achieved by means of sweeping subframes where synchronisation signals and/or other critical information is transmitted to all directions one by one. The sweeping may be designed such that the sweeping takes the minimum amount of time. For instance, 1 symbol duration sweep for each direction where synchronization signals are mapped along with physical broadcast channel (PBCH) (cf. LTE MIB) may be used to provide UEs with synchronization and information about the beam structure as well as other critical information such as, but not limited to, system frame number to be able to decode the rest of the system information, for instance. In the system shown in Figure 3, two beams can be transmitted simultaneously, so for a 100 beam system, 50 symbols would be required.

An illustration of a PBCH structure is shown in Figure 5. Each symbol forms a sweeping symbol for a beam direction. The secondary synchronisation signal (SSS), primary synchronisation signal (PSS) and extended synchronisation signal (ESS) are provided for each symbol.

The PBCH channel may have demanding decoding requirements. As a result, the PBCH resource may be scarce and the information on the PBCH should not change frequently. For example, it has been considered that the PBCH should be able to be combined in time across multiple PBCH occasions. The UE can combine the PBCH of the same beam but transmitted in another sweep in time (say after 5 ms). The period may be for instance 4 x PBCH combined so for a 5ms sweep periodicity, the combination period would be a 20 ms period. Since, the PBCH is blindly decoded in PHY layer, it should have information bits fixed such that receiver (e.g. UE) knows what each bit means. Thus, agreed information in the PBCH is fixed and may not be used to provide common control information that may be needed in addition to the synchronisation signals and PBCH content.

Additional common control information may comprise other system information from PBCH (cf. LTE SIBs) and IDLE mode paging information, or connected mode paging

information. UEs that are in connected mode and sending small amount of data infrequently may be configured for a so-called inactive state where UE context is stored in the RAN but the UE could be moving within a RAN tracking area without having to indicate this to the NW. For a proposed RRC-INACTIVE state, a mechanism may be required for
5 connected mode paging, where more information may be available in the NW and the UE compared to IDLE mode paging. For example, the UE location may be more precisely known by the RAN compared to IDLE mode and/or the UE may have been provided with shorter RAN level ID to be identified compared to IDLE mode ID.

10 Another requirement for the common control information may be to provide the recovery of the error scenarios generated by the analog beamforming based system, where UE and NW may fall out-of-synch in certain circumstances. To recover information about the current beam that should be used for the UE in DL, a cell-paging solution where UE location is known in cell level but not in beam level may be used. The cell-paging solution
15 may involve a NW paging the UE over the beams associated with the cell. Alternatively or additionally the cell paging may imply paging in multiple neighboring cells.

In contrast to the PBCH information, additional common control information such as the examples described above may not be as time critical, and the periodicity may be longer.
20

In legacy, e.g. LTE and UMTS systems, the common control information and its type may be identified by PHY layer means, e.g., by means of RNTI or the physical channel used for that information. The MAC layer is used to map the information in the corresponding logical channel above.

25 Analogue beamformed systems may not afford such arrangement to dedicatedly transmit each information by the physical layer. The common control information may include both L2, such as MAC layer, and L3, such as RRC and/or NAS layer, level control information while legacy common control information did not require differentiation since it includes
30 only L3 control information.

A sweep control channel (SWCC) may be introduced in a beam formed system. The PBCH may indicate the presence of the SWCC in the sweep. The PBCH content does not change over the combination period, i.e., the SWCC shall be transmitted in each
35 sweeping subframe over the PBCH combination period.

The resources used for SWCC may be, for instance, the additional resources available in the sweeping subframe frequency multiplexed with the synchronization signals and PBCH (see white portions of the Figure 5); time multiplexed with the corresponding sweep blocks with additional symbols; time multiplexed with the sweeping subframes with another
5 sweeping subframes defined for SWCC; or combination of these.

The UE may determine, as an example, from the used channel bandwidth whether the SWCC is frequency multiplexed in the sweeping symbol or time multiplexed with an additional symbol(s) following after the synchronisation and PBCH symbol or the
10 sweeping subframe or explicitly indicated by PBCH whether the resources are frequency or time multiplexed. Independent of where the resources are, they need to be known to the UE beforehand (i.e. by means of specification) or to have clear predefined mapping rules to be able to search for the SWCC when PBCH indicates its availability. SWCC has fixed characteristics in the PHY layer for the UE to be able decode it (similarly to PBCH)
15 without pre-scheduling (e.g., fixed MCS, location, etc.) or alternatively scheduled in in-resource manner within the resources of each SWCC. The SWCC may be transmitted more infrequently than PBCH.

Figure 6 shows a flowchart of an example method according to some embodiments. In a
20 first step, S1, the method comprises causing control information to be transmitted on a physical layer control channel during at least one transmission time interval of a time period in which a physical broadcast channel is combined across a plurality of physical broadcast channel occasions, wherein the control channel is capable of transmitting first level control information and second level control information.

25

The time period in which a physical broadcast channel is combined across a plurality of physical broadcast channel occasions may be referred to as the combination period as discussed above.

30 The at least one transmission time interval may comprise a sweeping block, also referred to as a SWCC occasion. The at least one transmission time interval may comprise at least one subframe. For example, a sweeping block may expand over a subframe or a plurality of subframes.

The first level control information may be L2, such as MAC layer, level control information. The second level control information may be L3, such as RRC and/or NAS layer, level control information.

- 5 The control information may comprise various additional control information as discussed above, e.g. paging related control information and/or system information. The control information may include, but is not limited to, system information; IDLE mode, CONNECTED mode, or Cell paging information.
- 10 The physical layer channel may be an SWCC in at least one sweeping subframe or transmission time interval. The physical layer channel may be a MAC layer channel.

A method as described with reference to Figure 6 may provide different common control information based on L2 based mechanisms in a common physical layer channel, taking
15 advantage of the PBCH combination period during which the PBCH content shall not change in the PHY layer. The method may provide means to be able to overcome the challenge generated by the common control provisioning in the analogically beamformed system and the requirement to support various types of common control information in the 5G system.

- 20 In one embodiment the SWCC carries different common control information in different sweeping subframes over the PBCH combination period. The method may comprise causing first control information to be sent in at least one first transmission time interval of the time period and second control information to be sent in at least one second
25 transmission time interval of the time period, wherein the first and second control information are different.

In one example embodiment, it may be defined, e.g. in a specification, in which transmission time interval, or sweeping block, during the PBCH combination period certain
30 control information is transmitted. For instance, paging related common control information may be carried in the first blocks, whereas system information may be carried in subsequent blocks. This arrangement may increase energy efficiency since UEs need to wake up listening to the paging, while system information may be valid for longer.

- 35 The method may comprise providing an indication of the contents of at least one subsequent transmission time interval in the time period in at least one transmission time

interval of the time period. The indication (or scheduling information) may be provided in a MAC CE (Control Element) or protocol data unit (PDU).

In an embodiment, the first occasion of SWCC (i.e. a first transmission interval) during the PBCH combination period may include scheduling information in a MAC CE to indicate what will follow in the forthcoming SWCCs in subsequent transmission time intervals. Since the SWCC content amount may be fixed and/or limited, it may be possible the NW needs to expand, e.g., the paging over multiple SWCCs if many UEs are to be paged. The UE may be then required to listen to multiple SWCCs during the PBCH combination period based on the scheduling.

The indication may apply only to the next SWCC occasion (in the next transmission time interval) or to certain control information that is expected in the next SWCC. As a result, the NW may have more flexibility during the PBCH combination period to change the control information it is going to place in each SWCC. In one embodiment the existence of the SWCC during the PBCH combination period after the first SWCC occasion may be indicated and/or scheduled in the MAC CE.

In one embodiment the parsing of the control information is made by the MAC layer in L2. The NW may multiplex various common control information in one transmission of the SWCC (such as system information; IDLE mode, CONNECTED mode, or Cell paging information; etc.). The method may comprise providing an indication of the type of control information. The indication may be provided in a MAC CE, specifically a MAC CE header. The indication of the common control information type may be specified by the MAC header, e.g., by at least one LCID (Logical Channel Identification) value reserved for each specific control type. An example illustration of the Cell paging MAC CE is given in Figure 7. The MAC CE header as shown in Figure 7 comprises an indication in the form of an LCID that the MAC CE comprises paging information.

The MAC layer may pass the L3 (e.g., RRC or NAS) related common control information directly to the corresponding logical channels (e.g., BCCH or PCCH) and process the L2 common control information itself.

Control information related to a first level may be carried in a payload, while control information related to another level may be carried in control elements. For example, the L3 related common control information may be carried in the MAC payload and L2

common control information in MAC Control Elements. An example illustration example of such an arrangement is shown in Figure 8. The benefit of this mechanism is to follow normal data MAC protocol data unit (PDU) processing principles which would allow reusing the same implementation for different use cases, for instance, receiving a data
5 PDU. Furthermore, if the UE is in CONNECTED mode, it may not need to proceed with processing the L3 level common control information at all but can ignore it. For instance, if the UE was to listen to the CONNECTED mode paging information (which could be provided in L2), it could ignore the L3 level IDLE mode paging information.

10 In one option an indication may be provided in a MAC CE that specifies whether the system information will be modified during a system information modification period. System information modification MAC CE may be placed in each SWCC or alternatively in the first SWCC over the PBCH combination period when the system information is about to change.

15 The UE may attempt to decode one SWCC during the system information modification period to check whether the system information will change. This may improve UE energy efficiency as the UE would not need to decode system information during the system information modification period if the UE cannot find a System information modification
20 MAC CE in a decoded SWCC.

In one option, the modified SIB index(es) may be provided in the MAC CE. This is usable in case not all the SIBs are required in IDLE mode compared to CONNECTED mode or vice versa, or certain SIB is reserved for certain feature that a UE does not support. Since
25 most of the SIBs are considered to be subject to request from the NW via dedicated signalling in analogue beam formed system, it would be pure overhead to request update for a SIB the UE would not need.

In one embodiment, a MAC CE may provide an indication which specifies which system
30 information blocks are included in the payload – MAC may be instructed by the higher layers to forward only payload that include certain SIBs. Alternatively, higher layers may inform MAC of the time instances when MAC should forward the system information payload to the L3. In this option, the system information periodicity and content is known to higher layers in advance.

35

In one option, certain information (like certain SIB or cell access related information) is always present in the SWCC or alternatively in certain occasion of the SWCC during the PBCH combination period.

- 5 In one option no additional headers are required for information which is always present in the SWCC, but the information has a fixed place in the SWCC MAC PDU, for instance, it may be the first MAC SDU of the payload part. A Length Indicator may still be needed if the information size is variable.
- 10 In one embodiment, the first occasion (the first transmission time interval) of SWCC during the PBCH combination period includes PHY layer scheduling information in a MAC CE for the forthcoming SWCCs in the same PBCH combination period. This may allow dynamic scheduling of the SWCC without requiring more blind decoding attempts by the UE as the first occasion of the SWCC would always have fixed characteristics for decoding.
- 15 The scheduling information could be the used modulation and coding scheme (MCS) or the amount of symbols used for SWCC after the synchronisation and PBCH symbol, i.e. sweep block. This option could be applied if no in-resource scheduling for the SWCC is specified for PHY layer.
- 20 In one embodiment the NW may configure additional occasions for the common control provisioning via SWCC for the CONNECTED mode UEs. This does not require NW to indicate the availability of the SWCC in the PBCH, thus, the channel does not need to exist over the PBCH combination period. Furthermore, this allows NW to use different
- 25 PHY layer scheduling parameters for the SWCC as UE does not need to blindly detect it. The NW could also direct these additional SWCC occasions to only certain beam directions, e.g., based on known location of certain UEs it wants to direct the common control provisioning.
- 30 In one embodiment the MAC PDU type field may be used to indicate what common control information is included in the PDU. Due to the limited space in the SWCC, this option may be used to minimize the header overhead with the cost of flexibility in the PDU formation (i.e., all the information should have fixed places in the PDU – only the Length Indicators might be defined).

Embodiments may provide efficient means to provide different common control information in a beamformed system where using the SCH (shared channel) for common control maybe undesirable. Takes advantage of the requirement the PBCH indication of SWCC availability is required over the PBCH combination period without requiring any
5 additional info to be provided by the PBCH / PHY layer.

The required data processing apparatus and functions of a network elements such as base station apparatus and other access points and controller elements, a communication device, a core network element and any other appropriate apparatus may be provided by
10 means of one or more data processors. The described functions at each end may be provided by separate processors or by an integrated processor. The data processors may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs), application specific integrated circuits (ASIC), gate level circuits and
15 processors based on multi core processor architecture, as non-limiting examples. The data processing may be distributed across several data processing modules. A data processor may be provided by means of, for example, at least one chip. Appropriate memory capacity can also be provided in the relevant devices. The memory or memories may be of any type suitable to the local technical environment and may be implemented using any suitable data
20 storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory.

In general, the various embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects of the invention may be
25 implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the invention is not limited thereto. While various aspects of the invention may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods
30 described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof. The software may be stored on such physical media as memory chips, or memory blocks implemented within the processor, magnetic media such as hard disk or floppy disks, and optical media such as for example
35 DVD and the data variants thereof, CD.

The foregoing description has provided by way of exemplary and non-limiting examples a full and informative description of the exemplary embodiment of this invention. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying
5 drawings and the appended claims. However, all such and similar modifications of the teachings of this invention will still fall within the spirit and scope of this invention as defined in the appended claims. Indeed there is a further embodiment comprising a combination of one or more of any of the other embodiments previously discussed.

Claims

1. A method comprising:
causing control information to be transmitted on a physical layer control channel
5 during at least one transmission time interval of a time period in which a physical
broadcast channel is combined across a plurality of physical broadcast channel
occasions, wherein the control channel is capable of transmitting first level control
information and second level control information, wherein the first level and second level
are different.
10
2. A method according to claim 1, wherein the first level control information is layer
two level control information and the second level control information is layer three level
control information.
- 15 3. A method according to any preceding claim, wherein the at least one transmission
time interval comprises a sweeping block.
4. A method according to any preceding claim, wherein the at least one transmission
time interval comprises a subframe.
20
5. A method according to any preceding claim, comprising causing first control
information to be transmitted in at least one first transmission time interval of the time
period and second control information to be transmitted in at least one second
transmission time interval of the time period, wherein the first control information is of a
25 different type to the second control information.
6. A method according to claim 5, wherein the first control information comprises
paging related control information and the second control information comprises system
information.
30
7. A method according to any preceding claim, wherein the physical layer control
channel is a sweep control channel.
8. A method according to any preceding claim, comprising providing an indication of
35 the information to be transmitted on the physical layer control channel of at least one

subsequent transmission time interval of the time period in at least one transmission time interval of the time period.

9. A method according to claim 8, comprising providing the indication in at least one
5 of a media access control control element and a media access control protocol data unit.

10. A method according to claim 9, comprising providing the indication in a header of the media access control control element.

10 11. A method according to any preceding claim, wherein the control information comprises a plurality of types of control information multiplexed in the at least one transmission time interval.

12. A method comprising:
15 receiving control information on a physical layer control channel during at least one transmission time interval of a time period in which a physical broadcast channel is combined across a plurality of physical broadcast channel occasions, wherein the control channel is capable of transmitting first level control information and second level control information, wherein the first level and second level are different.

20 13. A method according to claim 12, wherein the first level control information is layer two level control information and the second level control information is layer three level control information.

25 14. A method according to any one of claims 12 or 13, wherein the at least one transmission time interval comprises a sweeping block.

15. A method according to any one of claims 12 to 14, wherein the at least one transmission time interval comprises a subframe.

30 16. A method according to any one of claims 12 to 15, comprising receiving first control information in at least one first transmission time interval of the time period and second control information in at least one second transmission time interval of the time period, wherein the first control information is of a different type to the second control
35 information.

17. A method according to claim 16, wherein the first control information comprises paging related control information and the second control information comprises system information.
- 5 18. A method according to any one of claims 12 to 17, wherein the physical layer control channel is a sweep control channel.
19. A method according to any one of claims 12 to 18, comprising receiving an indication of the information to be transmitted on the physical layer control channel of at
10 least one subsequent transmission time interval of the time period in at least one transmission time interval of the time period.
20. A method according to claim 19, comprising receiving the indication in at least one of a media access control control element and a media access control protocol data unit.
15
21. A method according to claim 20, comprising receiving the indication in a header of the media access control control element.
22. A method according to any one of claims 12 to 21, wherein the control information
20 comprises a plurality of types of control information multiplexed in the at least one transmission time interval.
23. An apparatus comprising means for performing a method according to any one of claims 1 to 22.
25
24. A computer program product for a computer, comprising software code portions for performing the steps of any of claims 1 to 22 when the product is run on the computer.
25. An apparatus comprising:
30 at least one processor and at least one memory including a computer program code, the at least one memory and the computer program code configured to, with the at least one processor, cause the apparatus at least to:
cause control information to be transmitted on a physical layer control channel during at least one transmission time interval of a time period in which a physical
35 broadcast channel is combined across a plurality of physical broadcast channel occasions, wherein the control channel is capable of transmitting first level control

information and second level control information, wherein the first level and second level are different.

26. An apparatus comprising:

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

receive control information on a physical layer control channel during at
least one transmission time interval of a time period in which a physical broadcast channel
10 is combined across a plurality of physical broadcast channel occasions, wherein the control channel is capable of transmitting first level control information and second level control information, wherein the first level and second level are different.

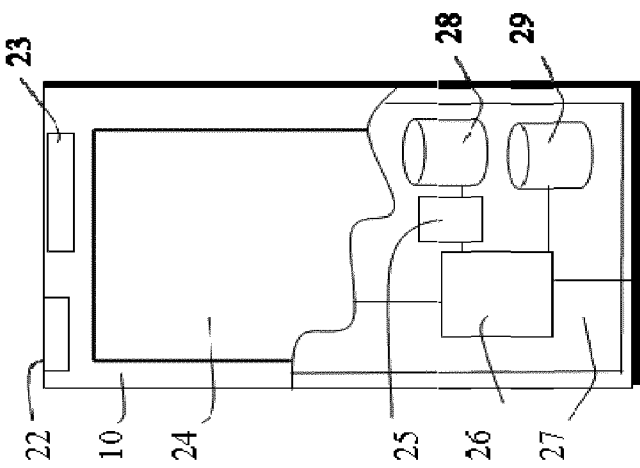


Fig. 2

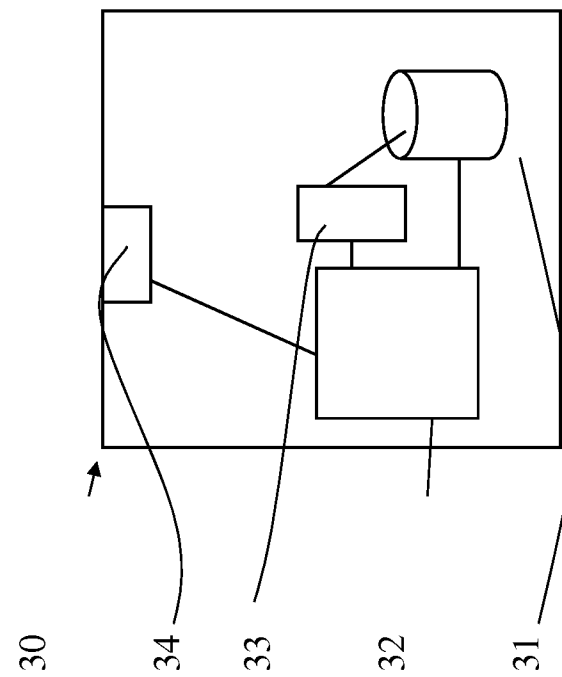


Fig. 1

Figure 3

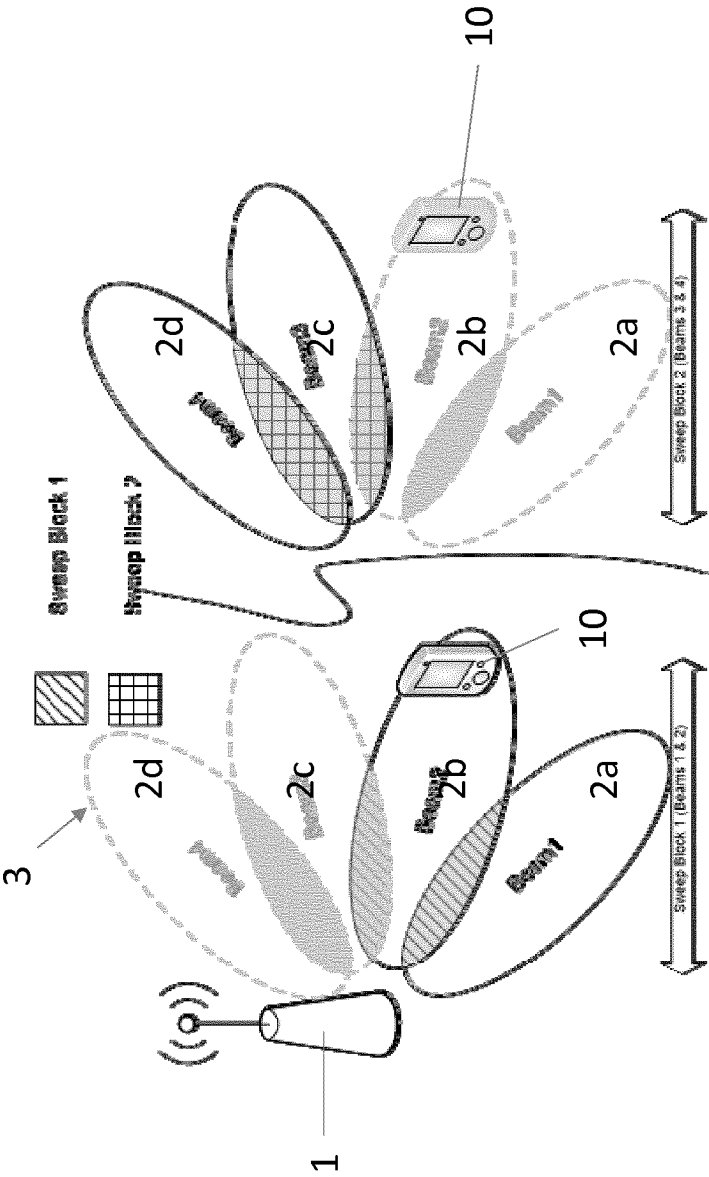
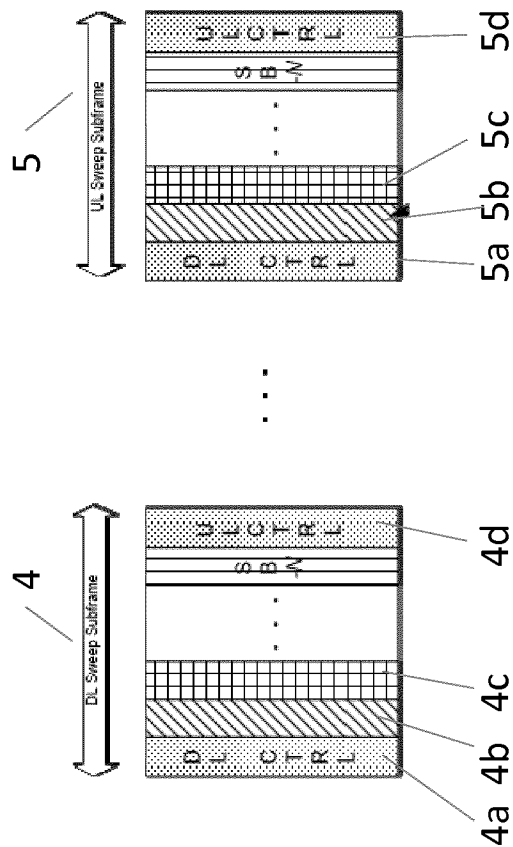


Figure 4



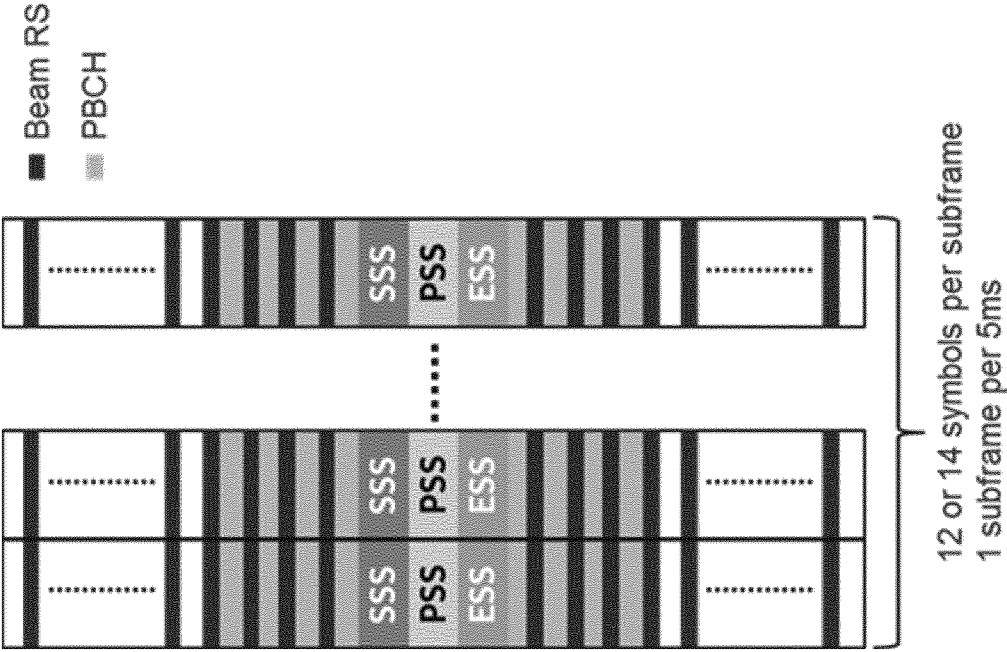


Figure 5

Figure 6

Causing control information to be transmitted on a physical layer control channel during at least one transmission time interval of a time period in which a physical broadcast channel is combined across a plurality of physical broadcast channel occasions, wherein the control channel is capable of transmitting first level control information and second level control information, wherein the first level and second level are different.

~ S1

Figure 7

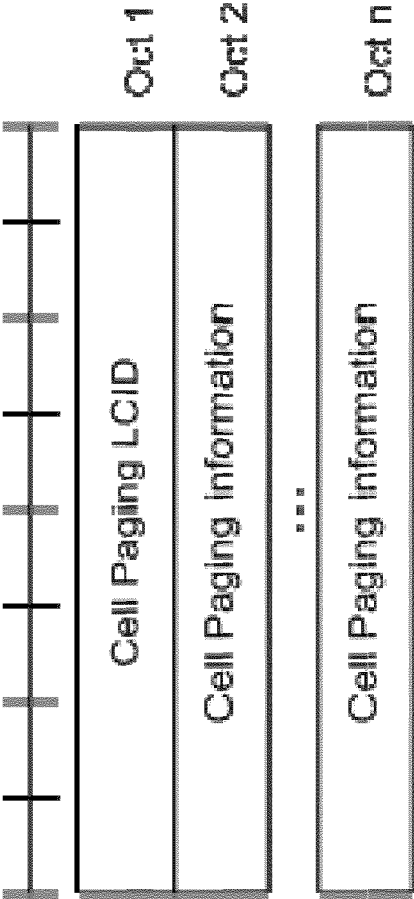
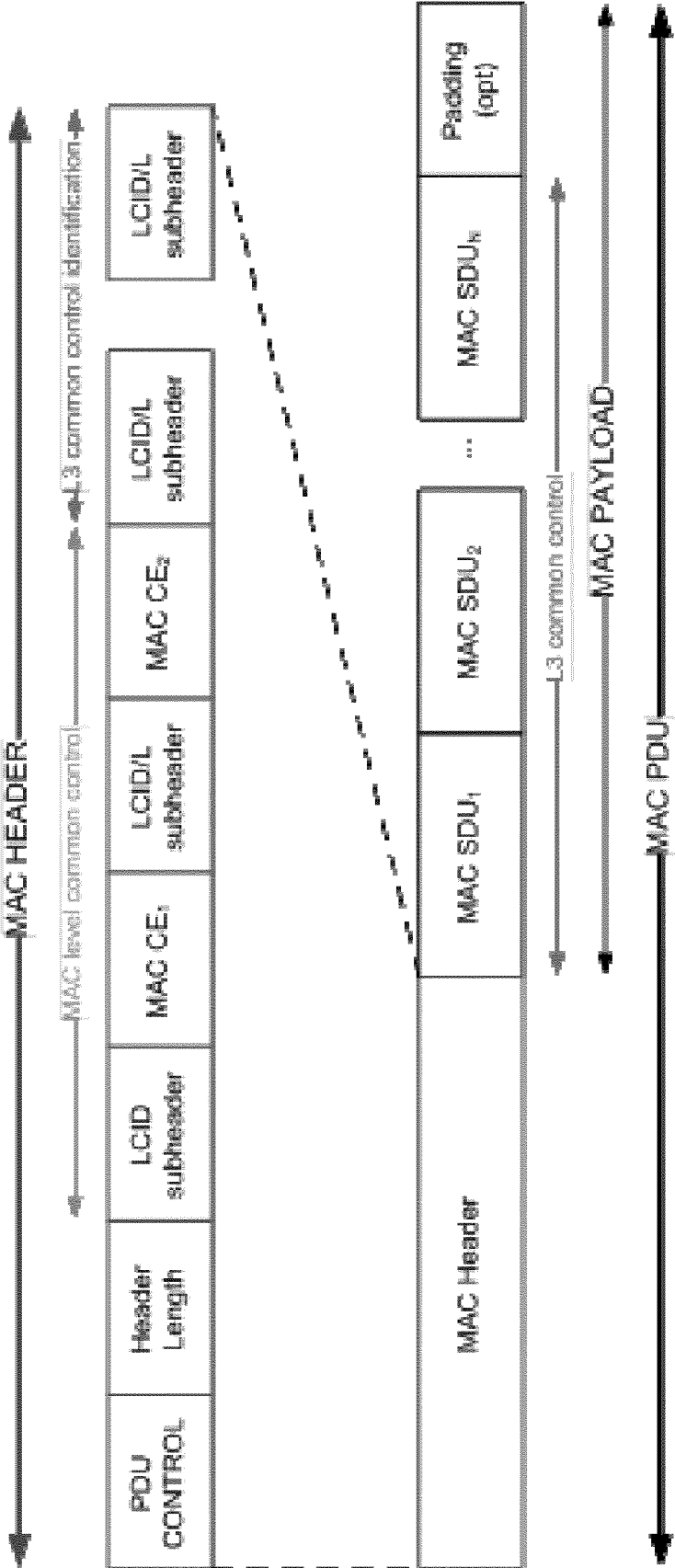


Figure 8



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FIG 1

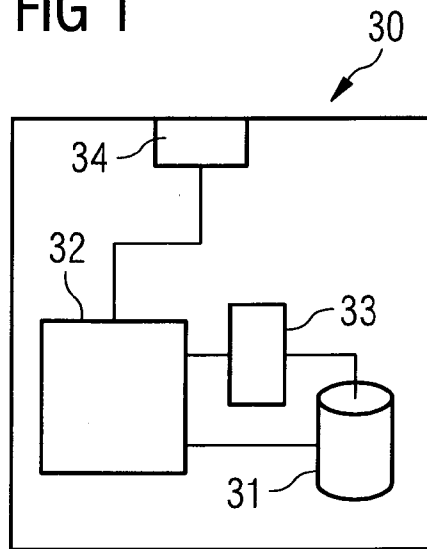


FIG 2

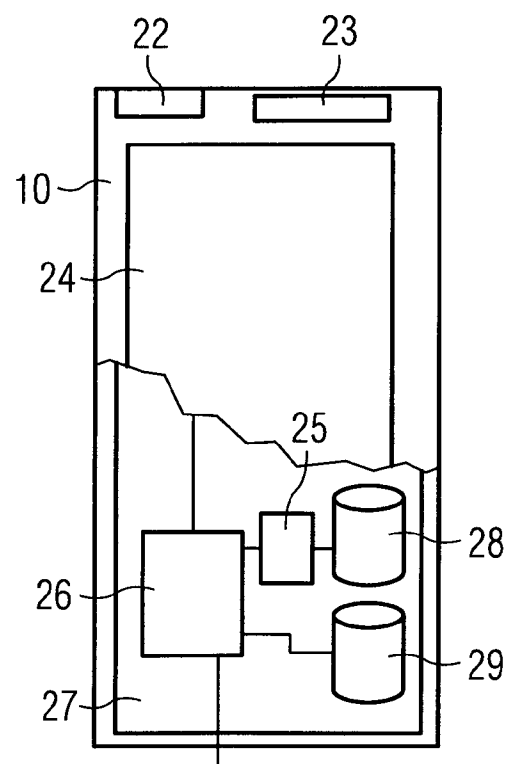


FIG 3

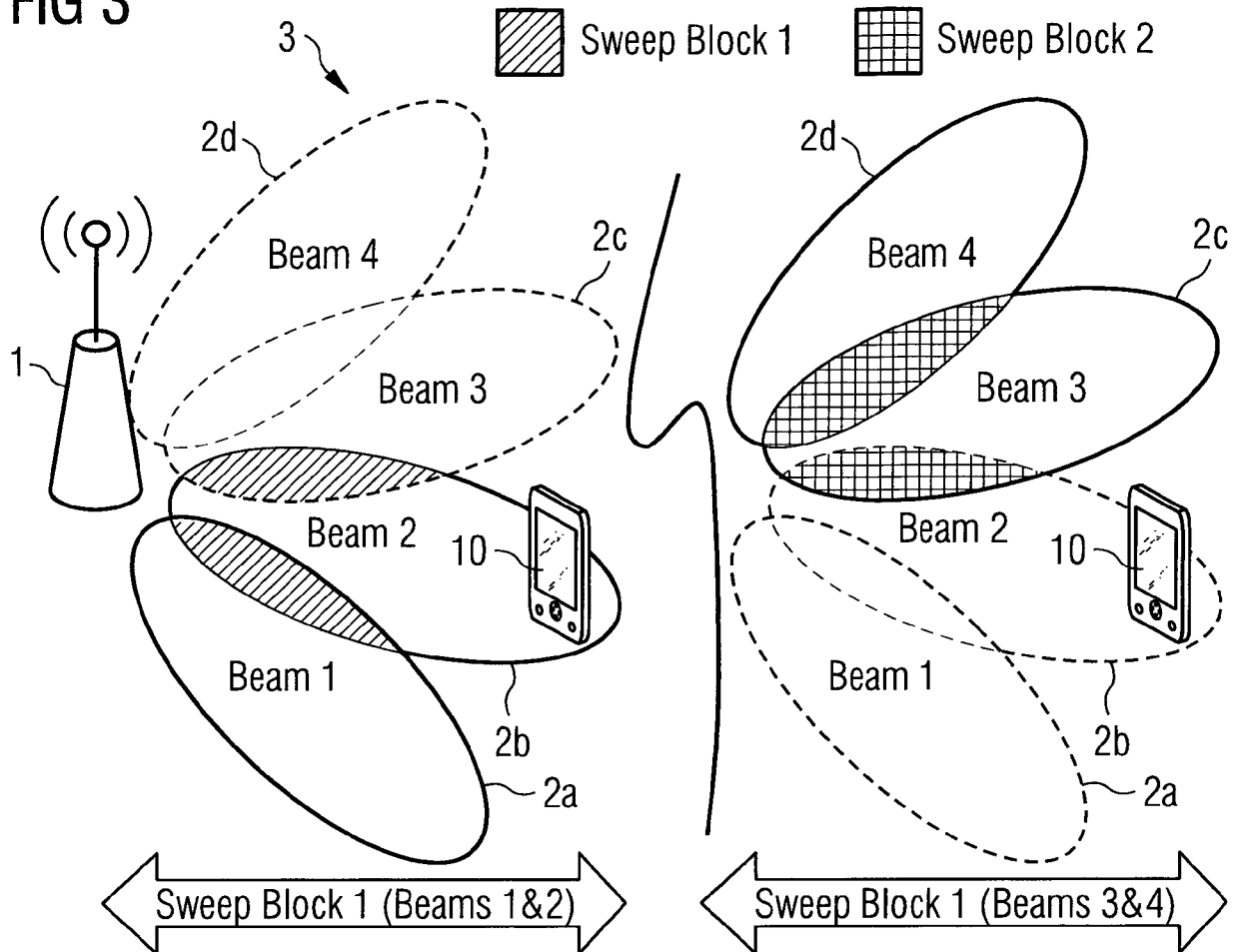
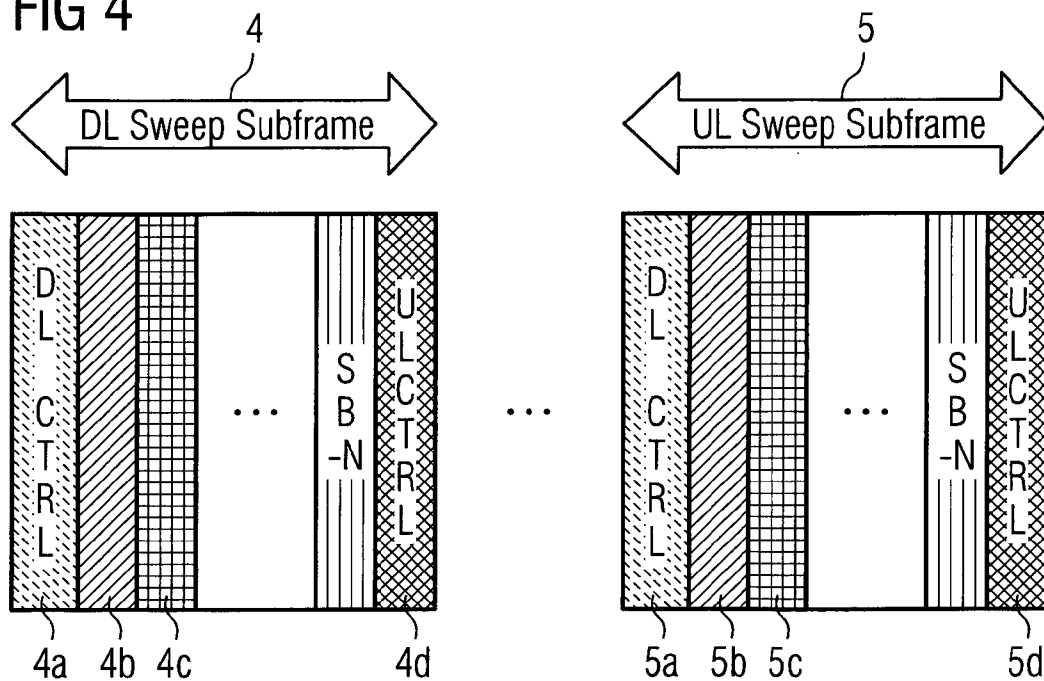


FIG 4



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FIG 5

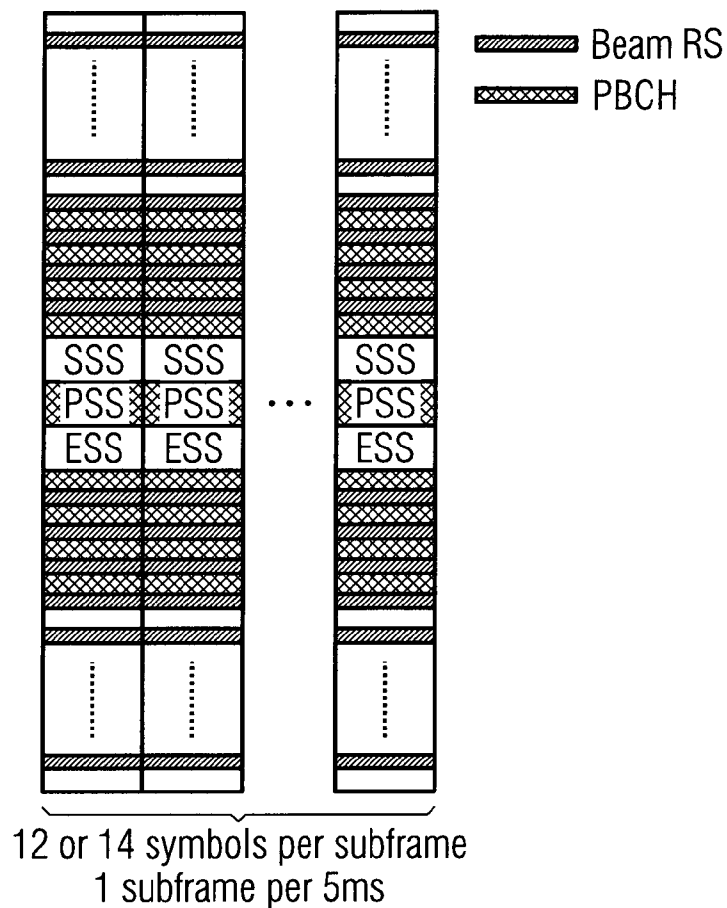


FIG 6

S1

Causing control information to be transmitted on a physical layer control channel during at least one transmission time interval of a time period in which a physical broadcast channel is combined across a plurality of physical broadcast channel occasions, wherein the control channel is capable of transmitting first level control information and second level control information, wherein the first level and second level are different.

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FIG 7

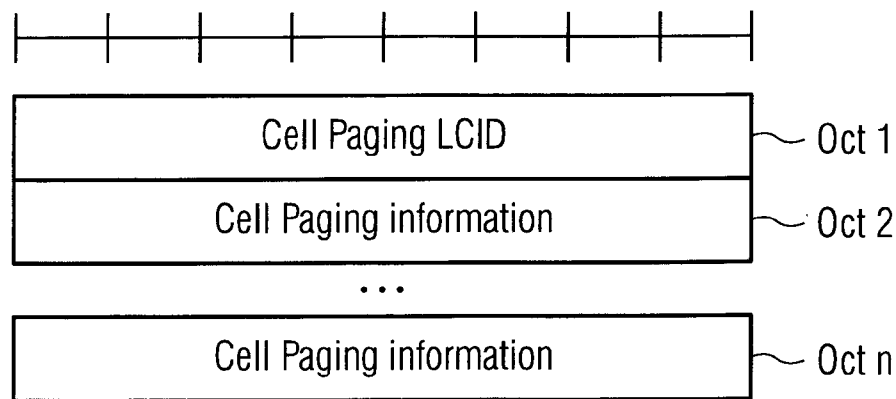
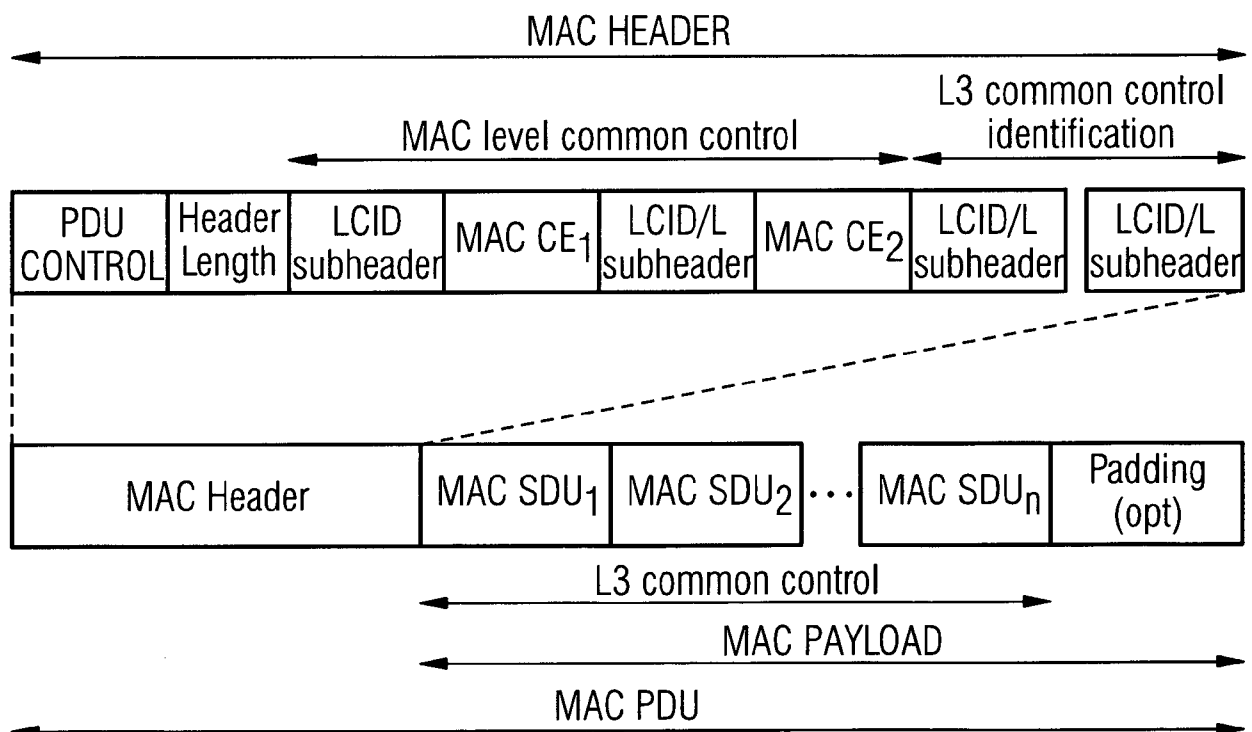


FIG 8



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/057515

A. CLASSIFICATION OF SUBJECT MATTER		
INV.	H04L5/00 H04W88/06	H04W16/08 H04W74/08 H04W84/12 H04W88/04
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) H04L H04W		
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, INSPEC		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NOKIA ET AL: "Support for Beam Based Common Control Plane in 5G New Radio", 3GPP DRAFT; R1-162895, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Busan, Korea; 20160411 - 20160415 1 April 2016 (2016-04-01), XP051079736, Retrieved from the Internet: URL: http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_84b/Docs/ [retrieved on 2016-04-01] section 2 and 3 figure 3 ----- -/-	1-5, 7-16, 18-26
☒ 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 25 November 2016		Date of mailing of the international search report 02/12/2016
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Anghel, Paul

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/057515

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NOKIA ET AL: "Basic frame structure principles for 5G new radio", 3GPP DRAFT; R1-162893, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Busan, Korea; 20160411 - 20160415 1 April 2016 (2016-04-01), XP051079734, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_84b/Docs/ [retrieved on 2016-04-01] subsection 3.2 figure 3	1-5, 7-16, 18-26
X A	----- WO 2016/041589 A1 (NOKIA SOLUTIONS & NETWORKS OY [FI]) 24 March 2016 (2016-03-24) figures 1,8 page 15, line 12 - line 24 page 7, line 5 - line 18 -----	1-5, 7-16, 18-26 6,17
X A	US 2016/044711 A1 (LOU HANQING [US] ET AL) 11 February 2016 (2016-02-11) paragraph [0087] paragraph [0065] paragraph [0030] -----	1-5, 7-16, 18-26 6,17
A	----- KEI SAKAGUCHI ET AL: "Millimeter-Wave Wireless LAN and Its Extension toward 5G Heterogeneous Networks", IEICE TRANSACTIONS ON COMMUNICATIONS., vol. E98.B, no. 10, 1 January 2015 (2015-01-01), pages 1932-1948, XP055322654, JP ISSN: 0916-8516, DOI: 10.1587/transcom.E98.B.1932 figures 3-5 page 4, column 2 -----	1-26

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/057515

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WO 2016041589	A1	24-03-2016	NONE

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			EP 2974494 A1 20-01-2016
			TW 201503735 A 16-01-2015
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