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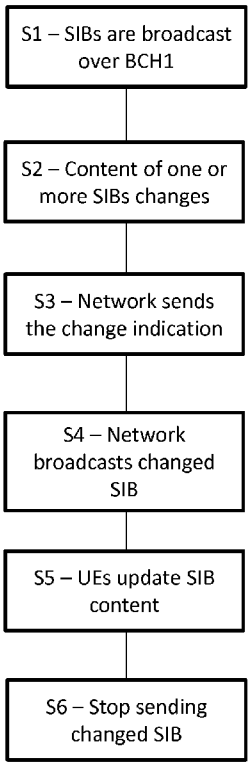
(54) Title: TRANSMISSION AND RECEPTION OF SYSTEM INFORMATION

Figure 4



(57) Abstract: A method comprises causing first system information to be transmitted; causing system information which has changed to be transmitted, the system information which has been changed being transmitted more frequently than the first information. A further method comprises receiving first system information on a first channel and subsequently receiving changed system information on a second channel, and retaining unchanged system information such that after said changed system information has been received, said unchanged system information is retained.

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TRANSMISSION AND RECEPTION OF SYSTEM INFORMATION

Some embodiments relate to a method, apparatus and computer program, and in particular but not exclusively to a method, apparatus and computer program associated with the providing of and receiving of system information.

A communication system can be seen as a facility that enables communication sessions between two or more entities such as fixed or mobile communication devices, base stations, servers and/or other communication nodes. A communication system and compatible communicating entities 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. For example, the standards, specifications and related protocols can define the manner how communication devices can access the communication system and how various aspects of communication shall be implemented between communicating devices. A communication can be carried on wired or wireless carriers. In a wireless communication system at least a part of the communication between at least two stations occurs over a wireless link.

Examples of wireless systems include public land mobile networks (PLMN) such as cellular networks, satellite based communication systems and different wireless local networks, for example wireless local area networks (WLAN). A wireless system can be divided into cells, and hence these are often referred to as cellular systems. A cell is provided by a base station. Cells can have different shapes and sizes. A cell can also be divided into sectors. Regardless of the shape and size of the cell providing access for a user equipment, and whether the access is provided via a sector of a cell or a cell, such area can be called radio service area or access area. Neighbouring radio service areas typically overlap, and thus a communication in an area can listen to more than one base station.

A user can access the communication system by means of an appropriate communication device. A communication device of a user is often referred to as user equipment (UE) or terminal. A communication device is provided with an appropriate signal receiving and transmitting arrangement for enabling communications with other parties. Typically a communication device is used for enabling receiving and transmission of communications such as speech and data. In wireless systems a communication device provides a transceiver station that can communicate with another communication device such as e.g. a base station of an access network and/or another user equipment. The communication device may

access a carrier provided by a station, for example a base station, and transmit and/or receive communications on the carrier.

Examples of communication systems attempting to satisfy the increased demands for capacity are architectures that are being standardized by the 3rd Generation Partnership Project (3GPP), such as the long-term evolution (LTE), or the Universal Mobile Telecommunications System (UMTS) radio-access technologies. The LTE aims to achieve various improvements, for example reduced latency, higher user data rates, improved system capacity and coverage, reduced cost for the operator and so on. A further development of the LTE is often referred to as LTE-Advanced. The various development stages of the 3GPP LTE specifications are referred to as releases.

In LTE-Advanced the network nodes can be wide area network nodes such as a macro eNodeB (eNB) which may, for example, provide coverage for an entire cell. Alternatively in LTE-Advanced, network nodes can be small area network nodes such as Home eNBs (HeNB) (femto cells) or pico eNodeBs (pico-eNB). Pico eNBs can, for example, be configured to extend the range of a cell. In some instances a combination of wide area network nodes and small area network nodes can be deployed using the same frequency carriers (e.g. co-channel deployment).

In UMTS multiple base stations (Node-Bs) may be controlled by one or more radio network controllers (RNCs).

In a Universal Mobile Telecommunications System (UMTS) (as well as LTE or any other wireless access technology) there is a need to broadcast cell specific system information and parameters that a UE needs to get access to a cell, and perform other interactions with the network without having to establish a dedicated connectivity channel. As the UMTS system has evolved, the amount of system information that the network can put and/or should provide to enable all the advanced features has increased.

According to an aspect, there is provided a method comprising: causing first system information to be transmitted; and causing system information which has changed to be transmitted, the system information which has been changed being transmitted more frequently than the first information.

The first system information may be transmitted on a first channel and said system information which has changed may be sent on a second different channel.

The first channel and said second channels may be broadcast channels.

The method may comprise causing information indicating that system information has changed to be transmitted.

The information indicating that system information has changed may comprise information indicating which system information has changed.

The method may comprise causing information indicating that said system information has been changed to be transmitted on a paging channel.

The causing information indicating that system information has changed may be transmitted for a period of time long enough for user equipment in a discontinuous reception mode to receive said information indicating that system information has changed.

The causing of information to be transmitted may comprise causing said information to be broadcast.

The method may comprise modifying said first system information to include said changed system information.

The method may comprise receiving said changed system information from a controller.

The method may comprise receiving period information with said changed system information for controlling a length of time for which information indicating that system information has changed is to be transmitted

The method may comprise receiving stop information from said controller to stop transmitting information indicating that system information has changed.

The method may comprise receiving system information from said controller for transmitting after said changed system information.

The method may be performed by an apparatus in a base station.

According to another aspect, there is provided a method comprising: receiving first system information; and receiving system information which has changed, wherein the system information which has been changed is transmitted with a higher frequency than the first information.

The first system information may be received on a first channel and said system information which has changed may be received on a second different channel.

The first channel and said second channel may be broadcast channels.

The method may comprise receiving said changed information on said second channel, and retaining system information not provided by said second channel.

The method may comprise receiving information indicating that system information has changed.

. The information indicating that system information has changed may comprise information indicating which system information has changed.

The method may comprise receiving information indicating that said system information has been changed on a paging channel.

The information indicating that said system information has changed causes a user equipment to go into an activated state.

After said user equipment has said changed system information, the method may comprise causing said user equipment to enter an inactive state.

The method may comprise acquiring system information and in response to receiving system information for a second time, stopping monitoring a respective channel.

The method may comprise receiving erasure information which causes erasing of at least some of said system information.

The method may be performed in an apparatus in a user equipment.

According to another aspect, there is provided a method comprising: receiving first system information on a first channel and subsequently receiving changed system information on a second channel, and retaining unchanged system information such that after said changed system information has been received, said unchanged system information is retained.

The method may be performed in an apparatus in a user equipment

According to another aspect, there is provided an apparatus, said apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured, with the at least one processor, to cause the apparatus at least to: cause: first system information to be transmitted; and cause system information which has changed to be transmitted, the system information which has been changed being transmitted more frequently than the first information.

The first system information may be transmitted on a first channel and said system information which has changed may be sent on a second different channel.

The first channel and said second channels may be broadcast channels.

The at least one memory and the computer code may be configured, with the at least one processor, to cause information indicating that system information has changed to be transmitted.

The information indicating that system information has changed may comprise information indicating which system information has changed.

The at least one memory and the computer code may be configured, with the at least one processor, to cause information indicating that said system information has been changed to be transmitted on a paging channel.

The causing information indicating that system information has changed may be transmitted for a period of time long enough for user equipment in a discontinuous reception mode to receive said information indicating that system information has changed.

The causing of information to be transmitted may comprise causing said information to be broadcast.

The at least one memory and the computer code may be configured, with the at least one processor, to modify said first system information to include said changed system information.

The at least one memory and the computer code may be configured, with the at least one processor, to receive said changed system information from a controller.

The at least one memory and the computer code may be configured, with the at least one processor, to receive period information with said changed system information for controlling a length of time for which information indicating that system information has changed is to be transmitted

The at least one memory and the computer code may be configured, with the at least one processor, to receive stop information from said controller to stop transmitting information indicating that system information has changed.

The at least one memory and the computer code may be configured, with the at least one processor, to receive system information from said controller for transmitting after said changed system information.

According to another aspect, there is provided an apparatus, said apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured, with the at least one processor, to cause the apparatus at least to: receive first system information; and receive system information which has changed, wherein the system information which has been changed is transmitted with a higher frequency than the first information.

The first system information may be received on a first channel and said system information which has changed may be received on a second different channel.

The first channel and said second channel may be broadcast channels.

The at least one memory and the computer code may be configured, with the at least one processor, to receive said changed information on said second channel, and retaining system information not provided by said second channel.

The at least one memory and the computer code may be configured, with the at least one processor, to receive information indicating that system information has changed.

The information indicating that system information has changed may comprise information indicating which system information has changed.

The at least one memory and the computer code may be configured, with the at least one processor, to receive information indicating that said system information has been changed on a paging channel.

The information indicating that said system information has changed causes a user equipment to go into an activated state.

After said user equipment has said changed system information, the at least one memory and the computer code may be configured, with the at least one processor, to cause said user equipment to enter an inactive state.

The at least one memory and the computer code may be configured, with the at least one processor, to acquire system information and in response to receiving system information for a second time, stopping monitoring a respective channel.

The at least one memory and the computer code may be configured, with the at least one processor, to receive erasure information which causes erasing of at least some of said system information.

The apparatus may be in user equipment.

According to another aspect, there is provided an apparatus, said apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured, with the at least one processor, to cause the apparatus at least to: receive first system information on a first channel and subsequently receiving changed system information on a second channel, and retaining unchanged system information such that after said changed system information has been received, said unchanged system information is retained.

The apparatus may be in a user equipment .

According to an aspect, there is provided an apparatus comprising: means for causing first system information to be transmitted; and for causing system information which has changed to be transmitted, the system information which has been changed being transmitted more frequently than the first information.

The first system information may be transmitted on a first channel and said system information which has changed may be sent on a second different channel.

The first channel and said second channels may be broadcast channels.

The causing means may be for causing information indicating that system information has changed to be transmitted.

The information indicating that system information has changed may comprise information indicating which system information has changed.

The causing means may be for causing information indicating that said system information has been changed to be transmitted on a paging channel.

The causing means may be for causing information indicating that system information has changed to be transmitted for a period of time long enough for user equipment in a discontinuous reception mode to receive said information indicating that system information has changed.

The causing means may be for causing said information to be broadcast.

The apparatus may comprise means for modifying said first system information to include said changed system information.

The apparatus may comprise means for receiving said changed system information from a controller.

The receiving means may be for receiving period information with said changed system information for controlling a length of time for which information indicating that system information has changed is to be transmitted

The receiving means may be for receiving stop information from said controller to stop transmitting of information indicating that system information has changed.

The receiving means may be for receiving system information from said controller for transmitting after said changed system information.

The apparatus may be provided in a base station.

According to another aspect, there is provided an apparatus comprising: means for receiving first system information; and for receiving system information which has changed, wherein the system information which has been changed is transmitted with a higher frequency than the first information.

The first system information may be received on a first channel and said system information which has changed may be received on a second different channel.

The first channel and said second channel may be broadcast channels.

The receiving means may be for receiving said changed information on said second channel, and means may be provided for retaining system information not provided by said second channel.

The receiving means may be for receiving information indicating that system information has changed.

. The information indicating that system information has changed may comprise information indicating which system information has changed.

The receiving means may be for receiving information indicating that said system information has been changed on a paging channel.

The information indicating that said system information has changed causes a user equipment to go into an activated state.

After said user equipment has said changed system information, the apparatus may comprise means for causing said user equipment to enter an inactive state.

The apparatus may comprise means for acquiring system information and in response to receiving system information for a second time, means for stopping monitoring a respective channel.

The receiving means may be for receiving erasure information which causes erasing of at least some of said system information.

The apparatus may be in a user equipment.

According to another aspect, there is provided an apparatus comprising: means for receiving first system information on a first channel and subsequently receiving changed system information on a second channel, and means for retaining unchanged system information such that after said changed system information has been received, said unchanged system information is retained.

The apparatus may be in a user equipment.

A computer program comprising program code means adapted to perform the method(s) may also be provided. The computer program may be stored and/or otherwise embodied by means of a carrier medium.

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

Various other aspects and further embodiments are also described in the following detailed description and in the attached claims.

Some embodiments will now be described by way of example only with reference to the following Figures in which:

Figure 1 shows a schematic diagram of a network according to some embodiments;

Figure 2 shows a schematic diagram of a communication device according to some embodiments;

Figure 3 shows a schematic diagram of a control apparatus according to some embodiments;

Figure 4 shows a method of an embodiment;

Figure 5 shows a current timing associated with a broadcast channel;

Figure 6 shows timing associated with two broadcast channels, in some embodiments; and

Figure 7 shows another timing associated with two broadcast channels in some embodiments.

In the following certain exemplifying embodiments are explained with reference to a wireless or mobile communication system serving communication devices. Before explaining in detail the exemplifying embodiments, certain general principles of a wireless communication system, access systems thereof, and communication devices are briefly explained with reference to Figures 1 to 3 to assist in understanding the technology underlying the described examples.

A communication device or user equipment 101, 102, 103, 104 is typically provided wireless access via at least one base station or similar wireless transmitter and/or receiver node of an access system. In Figure 1 three neighbouring and overlapping access systems or radio service areas 100, 110 and 120 are shown being provided by base stations 105, 106, and 108.

However, it is noted that instead of three access systems, any number of access systems can be provided in a communication system. An access system can be provided by a cell of a cellular system or another system enabling a communication device to access a communication system. A base station site 105, 106, 108 can provide one or more cells. A base station can also provide a plurality of sectors, for example three radio sectors, each sector providing a cell or a subarea of a cell. All sectors within a cell can be served by the same base station. A radio link within a sector can be identified by a single logical identification belonging to that sector. Thus a base station can provide one or more radio service areas. Each communication device 101, 102, 103, 104, and base station 105, 106, and 108 may have one or more radio channels open at the same time and may send signals to and/or receive signals from more than one source.

Base stations 105, 106, 108 are typically controlled by at least one appropriate controller apparatus 109, 107 so as to enable operation thereof and management of communication devices 101, 102, 103, 104 in communication with the base stations 105, 106, 108. The control apparatus 107, 109 can be interconnected with other control entities. The control apparatus 109 can typically be provided with memory capacity 301 and at least one data processor 302. The control apparatus 109 and functions may be distributed between a plurality of control units. Although not shown in Figure 1, in some embodiments each base station 105, 106 and 108 can comprise a control apparatus 109, 107.

The cell borders or edges are schematically shown for illustration purposes only in Figure 1. It shall be understood that the sizes and shapes of the cells or other radio service areas may vary considerably from the similarly sized omni-directional shapes of Figure 1.

In particular, Figure 1 depicts two wide area base stations 105, 106, which can be macro-eNBs 105, 106 in an LTE system. The macro-eNBs 105, 106 transmit and receive data over the entire coverage of the cells 100 and 110 respectively. Figure 1 also shows a smaller area base station or access point which in some embodiments can be a pico, a femto or Home eNB 108. The coverage of the smaller area base station 108 is generally smaller than the coverage of the wide area base stations 105, 106. The coverage provided by the smaller area node 108 overlaps with the coverage provided by the macro-eNBs 105, 106. Pico eNBs can be used to extend coverage of the macro-eNBs 105, 106 outside the original cell coverage 100, 110 of the macro-eNBs 105, 106. The pico eNB can also be

used to provide cell coverage in “gaps” or “shadows” where there is no coverage within the existing cells 100, 110 and/or may serve “hot spots”. In some embodiments, the smaller area node can be a femto or Home eNB which can provide coverage for a relatively small area such as the home. Some environments may have both pico and femto cells.

As shown, the radio service areas can overlap. Thus signals transmitted in an area can interfere with communications in another area (macro to macro, pico/femto to either one or both of the macro cells, and/or pico/femto to pico/femto).

The communication devices 101, 102, 103, 104 can access the communication system based on various access techniques, such as code division multiple access (CDMA), or wideband CDMA (WCDMA). Other examples include time division multiple access (TDMA), frequency division multiple access (FDMA) and various schemes thereof such as the interleaved frequency division multiple access (IFDMA), single carrier frequency division multiple access (SC-FDMA) and orthogonal frequency division multiple access (OFDMA), space division multiple access (SDMA) and so on.

Some non-limiting examples of the recent developments in communication systems are the long-term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) that is being standardized by the 3rd Generation Partnership Project (3GPP). As explained above, further development of the LTE is referred to as LTE-Advanced. Non-limiting examples of appropriate access nodes are a base station of a cellular system, for example what is known as NodeB (NB) in the vocabulary of the 3GPP specifications. The LTE employs a mobile architecture known as the Evolved Universal Terrestrial Radio Access Network (E-UTRAN). Base stations of such systems are known as evolved Node Bs (eNBs) and may provide E-UTRAN features such as user plane Radio Link Control/Medium Access Control/Physical layer protocol (RLC/MAC/PHY) and control plane Radio Resource Control (RRC) protocol terminations towards the user devices. Other examples of radio access systems include those provided by base stations of systems that are based on technologies such as wireless local area network (WLAN) and/or WiMax (Worldwide Interoperability for Microwave Access).

In Figure 1 the base stations 105, 106, 108 of the access systems can be connected to a wider communications network 113. A controller apparatus 107, 109 may be provided for coordinating the operation of the access systems. A gateway function 112 may also be provided to connect to another network via the network 113. The smaller area base station 108 can also be connected to the other network by a separate gateway function 111. The base stations 105, 106, 108 can be connected to each other by a communication link for sending and receiving data. The communication link can be any suitable means for sending

and receiving data between the base stations 105, 106 and 108 and in some embodiments the communication link is an X2 link.

The other network may be any appropriate network. A wider communication system may thus be provided by one or more interconnect networks and the elements thereof, and one or more gateways may be provided for interconnecting various networks.

It will be appreciated that embodiments may also be applicable to a UMTS network. In a UMTS network user equipment 101', 102', 103' and 104' may be in communication with NodeBs 105' and 106'. The Node Bs 105' and 106' may themselves be controlled by an RNC 112'.

The communication devices will now be described in more detail with reference to Figure 2. Figure 2 shows a schematic, partially sectioned view of a communication device 101 that a user can use for communication. Of course the other communication devices shown in Figure 1 may have the same or similar features. Such a communication device is often referred to as user equipment (UE) or terminal. An appropriate communication device may be provided by any device capable of sending and receiving radio signals. The communication device may be mobile or may be generally stationary. Non-limiting examples include a mobile station (MS) such as a mobile phone or what is known as a 'smart phone', a portable computer provided with a wireless interface card or other wireless interface facility, personal data assistant (PDA) provided with wireless communication capabilities, a computer or any combinations of these or the like.

A communication device may provide, for example, communication of data for carrying communications such as voice, electronic mail (email), text message, multimedia and so on. Users may thus be offered and provided numerous services via their communication devices. Non-limiting examples of these services include two-way or multi-way calls, data communication or multimedia services or simply an access to a data communications network system, such as the Internet. User may also be provided broadcast or multicast data. Non-limiting examples of the content include downloads, television and radio programs, videos, advertisements, various alerts and other information.

The device 101 may receive signals over an air interface 207 via appropriate apparatus for receiving and may transmit signals via appropriate apparatus for transmitting radio signals. In Figure 2 transceiver apparatus is designated schematically by block 206. The transceiver apparatus 206 may be provided for example by means of a radio part and associated antenna arrangement. The antenna arrangement may be arranged internally or externally to the communication device.

The communication device is also typically provided with at least one data processing entity 201, at least one memory 202 and other possible components 203 for use in soft-

ware and hardware aided execution of tasks it is designed to perform, including control of access to and communications with access systems and other communication devices. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board and/or in chipsets. This feature is denoted by reference 204.

The user may control the operation of the communication device by means of a suitable user interface such as key pad 205, voice commands, touch sensitive screen or pad, combinations thereof or the like. A display 208, a speaker and a microphone can be also provided. Furthermore, a 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.

Figure 3 shows an example of a control apparatus 109 for a communication system, for example to be coupled to and/or for controlling a station of an access system. In some embodiments the base stations 105, 106, and 108 comprise a control apparatus 109. In some embodiments, each base station will have a control apparatus. In other embodiments the control apparatus can be another network element. The control apparatus 109 can be arranged to provide control of communications by communication devices that are in the service area of the system. The control apparatus 109 can be configured to provide control functions in association with generation and communication of transmission patterns and other related information by means of the data processing facility in accordance with certain embodiments described below. For this purpose the control apparatus 109 comprises at least one memory 301, at least one data processing unit 302, 303 and an input/output interface 304. Via the interface the control apparatus can be coupled to a receiver and a transmitter of the base station. The control apparatus 109 can be configured to execute an appropriate software code to provide the control functions.

Currently, in a UMTS system information is already so loaded, that if new features are deployed, the network will have to either sacrifice other data, for instance neighbour cell lists, and/or increase the system information repetition cycle. This may have an undesirable effect on one or more other features such as cell reselection, voice call establishment, state transition or the like.

In some embodiments, the UMTS system will have two channels to carry system information. The two channels may be parallel channels. The channels may be BCH (broadcast channel) channels. A broadcast channel may be such that any UE within the cell's coverage can receive and decode that channel reliably.

Referring to a UTRAN system a UE, such as device 101, may be configured to receive system information blocks (SIBs). SIBs comprise system information that is transmitted from UTRAN (or E-UTRAN) to UE. The system information is required by the UE in order for

it to function correctly. Typically a SIB may be sent from the UTRAN (e.g. communications network 113) to the UE 101 using one or more of the following channels: BCCH (broadcast control channel - logical channel); BCH (broadcast channel - transport channel); PCCPCH (Primary Common Control Physical Channel); and SCCPCH (Secondary Common Control Physical Channel).

Different system information blocks may have different characteristics, for example regarding their repetition rate and the requirement(s) for UEs to update stored information. A master information block (MIB) may be used to specify which system information blocks are in use in a cell, and how they are scheduled. A system information block may also contain scheduling information for another system information block in a lower hierarchy.

The system information blocks are sent from the network 113 or RNC 112' to the UE 101, for example via a base station 105.

There may be one or more features in UMTS/HSPA (high speed packet access) system that depends on the system information, and in particular, that depend on how fast a UE can receive all the SIBs. All the system information is grouped logically into those blocks based on the functional or logical relevance, e.g., neighbour cell lists, cell access barring, control information for enhanced DL (downlink) and UL (uplink) in CELL_FACH (forward access channel), etc. Except for a few cases, a UE typically has to receive and correctly decode all the blocks before it can get an access to the cell and/or perform other actions such as call establishment.

Generally only UEs in the idle mode, or the CELL_PCH mode are woken up and transferred to CELL_FACH state and when in that state read the BCH, and will read the BCH only once. UEs in a CELL_DCH (connected mode) state may be provided with relevant system information in a unicast fashion by the RNC. Sometimes the contents of a SIB change. Then the RNC may send a notification that the SIB has changed. There following UEs will re-read the BCH broadcast channel. This process may take the whole of one BCH cycle.

It should be appreciated that one or more SIBs, for example, SIB7 may change frequently, and their change may not trigger a change notification. One or more of these SIBs may be updated by the NodeB in an autonomous fashion, without communication with the RNC. (SIB7 contains information on the UL interference level.). Some embodiments make use of an additional BCH to speed up the acquisition of the updated SIB for a UE. This may allow the UE to go immediately back to sleep.

In some embodiments, SIBs that are carried on a first BCH, BCH1 may also be carried on a second BCH, BCH2. The duplication may be based on a SIB change and may be

in parallel with a change notification. Some embodiments may increase the repetitions within a transmission cycle of a particular SIB for a specific amount of time.

In some embodiments, when the RNC sends a change indication, the RNC schedules the changed SIB information constantly on the second broadcast BCH2, instead of cycling through the content. The changed SIB may be broadcast non-stop for a period of a duration in which all idle UEs can be expected to have woken up.

In some current systems, the behaviour illustrated in Figure 5 is supported. When a SIB changes, the RNC sends new content to the NB, which starts broadcasting the new content. The first line of Figure 5 shows the SIB content of the BCH channel. The BCH cycle time is marked.

After the content has changed, a change notification is sent by the NB as shown by the second line of Figure 5. The change notification may or may not start with the BCH cycle. The change notification will start after the new content has been started to be broadcast. The change notification will be broadcast long enough that any UE in the DRX mode will have an active cycle when the notification is being broadcast.

One mechanism for sending the notification will be described. However, it should be appreciated that one or more alternative or additional method of sending the notification may be used. For UEs in CELL_PCH (paging channel) state, the process of sending the notification begins with a transmission on the PICH (paging indication channel). The PICH will be sent at the time that the RNC knows that the CELL_PCH UEs are supposed to listen. The PICH contains a bit pattern, and UEs will be configured to pay attention to certain bits within that pattern. If the certain bits are not set the UEs will go back to sleep. If the certain bits are set, the UEs continue to listen to the FACH (or HS-FACH) channel for information pertaining to them. The FACH will carry RRC messages. In this case the RNC will then send a broadcast RRC SYSTEM_CHANGE_INDICATION message on the FACH. For UEs in CELL_FACH the notification can be sent immediately, as all CELL_FACH UEs are continuously listening to the FACH channel. The change notification may be intended for those UEs that have already acquired the BCH (all SIBs of the BCH) previously and hence are no longer listening to the BCH and are not in a connected mode.

In Figure 5, the third and fifth lines respectively show the DRX (discontinuous reception) cycle of two UEs, UE 1 and UE 2. The lines show when the UE is awake and when the UE is not receiving. As can be seen from the fourth and sixth lines, the two UEs, UE1 and UE2 are respectively woken up when there is an active cycle in the DRX cycle and the NB is broadcasting the change notication.

The UEs then will start reading the BCH until they have acquired all SIBs again, including the changed SIB. The re-acquisition may respect the “value tag” which is contained

in the beginning of a SIB and acts as a content counter. If the counter has not been increased the content is the same and the UE does not need to read that SIB. However the UE has to wait for all SIBs to appear on the BCH to check whether their content has changed. The UEs have to acquire again all of the SIBs, because currently the notification of change does not contain information which SIB or SIBs has or have changed.

In some embodiments, the legacy behaviour can be maintained, in addition to the changes proposed by some embodiments. In some embodiments, the legacy behaviour may not be supported.

In some embodiments the change notification may be enhanced indicating not only that a change has occurred, but also which SIB has changed. For instance the paging channel PCCH (for CELL_PCH and IDLE UEs) and FACH channel (for CELL_FACH UEs) will send a message with system information change information indicating the index of the changed SIB. This means that the UE does not need to wait for the “value tag” of every SIB.

In some embodiments the change notification may indicate whether a change has occurred only on the BCH2, or only on the BCH1, or on BCH1 and BCH2. Fora PCCH system information change, this may be implemented by means of adding new IEs into the PAGING TYPE 1 message. With FACH UEs, a BCH2 specific H-RNTI (HS-DSCH (high speed downlink shared channel) radio network transaction identifier) may be provided or a new message type similar to the one already defined for a legacy channel may be used.

In some embodiments, the second broadcast channel will broadcast the changed SIB nonstop. The non-stop transmission of the changed SIB(s) may happen approximately as long as the change indication signal is being transmitted and the UEs have acquired the new SIB.

A method of some embodiments will now be described with reference to Figure 4 and with reference to Figure 6.

In step S1, the network broadcasts SIBs over the first broadcast channel BCH1. This is shown in the first line of Figure 6. The broadcast may be carried out by the base station. The broadcast may be controlled by the base station and/or the radio network controller. The first broadcast channel may broadcast some or all of the SIBs. In other embodiments, more recently introduced SIBs may be broadcast via the second broadcast channel.

In step S2, it is determined that the content of one or more of the SIBs has changed. This is referred to as SIBx in the Figures.

In step S3, the base station will send or broadcast the change indication. This may be controlled by the base station and/or the RNC. This is shown in line 2 of Figure 6.

In step S4, the base station will broadcast the SIB with the changed content SIBx over the second broadcast channel BCH2. This is shown in line 3 of Figure 6. The repeat

cycle of the second broadcast channel is shorter than that of the first broadcast channel. This may be controlled by the base station and/or the RNC.

In step S5, the UEs update the SIBx content from BCH2. The UE need only be awake or active long enough to get the SIBx. This is shown in lines 4 and 5 of Figure 6 which show two UEs. The change notification will trigger the UE to stay active long enough to get SIBx.

In step S6, the base station will stop sending SIBx over the second broadcast channel BCH2 in a cycled manner. This may be controlled by the base station and/or the RNC

It should be appreciated that in some embodiments, legacy UEs either (re-)read only first broadcast channel BCH1 or may stay in the dormant state if a change notification specific to the second broadcast channel BCH2 is used.

A UE can know which SIBs have changed, determine whether they have acquired all changed SIBs and can go back to sleep in one or more of the following ways:

The change notification contains an index or list of indices of which SIB(s) have changed, or an amount of changed SIBs, as described above described embodiment

In case the change notification does not contain the index of changed SIB(s), a UE will assume that all SIBs that are transmitted when it got a change indication are changed SIBs. As soon as the UE sees that a SIB which it already has re-acquired repeats, the UE will know that it has acquired all changed SIBs and can stop listening to the BCH. In this embodiment, if a SIB change happens while the previous change is still being broadcast, the RNC needs to complete the previous change broadcast before starting a new change cycle.

SIBx is changed on BCH1, and BCH1 is modified. The RNC starts to send the change notification, for CELL_PCH UEs at the times that the UEs are listening to the PICH. For CELL_FACH UEs the change notification is sent without using the PICH. The RNC broadcasts the change notification long enough for all UEs to wake up at least once. In legacy behaviour, once the UE has woken up, the UE will read the whole BCH cycle (dashed line for the first UE1 in line 4 of Figure 6). In embodiments, a UE, as soon as it wakes up, can read the SIBx on the BCH2, and then can go back to sleep (solid line for UE1 and UE2 in lines 4 and 5 of Figure 6).

The NodeB may be configured to send the SIBs in one or more of the following ways: The RNC sends a notification to the NodeB that a SIBx is changed and the change should be broadcast for a certain period. The notifcation in that case contains the two elements (SIBx, period). The period may be related to the time that it takes for all UEs to wake up at least once. As an alternative to informing the NodeB about the period, the RNC may also instruct the NodeB after the period to stop cycling the SIBx and return to “normal” operation. Alternatively, the RNC configures the NodeB with new broadcast information, in this case

only SIBx, and at the end of the period configures the NodeB again with the information that the NodeB was cycling on the BCH2 before it was transmitting only SIBx.

In some standards, the following behavior is specified for a UE reading BCH1: A SIB that does not appear in one cycle will be assumed to be non-existent, and will be erased. In some embodiments, the UE shall not erase SIBs that do not appear on BCH2. In another embodiment, an erasure of a SIB can be requested by an RRC message (for example for SIBs that appear only on BCH2 but shall be erased). The term erasure is intended to the SIB no longer being used by the UE. The SIB may be actually deleted or otherwise removed from the UE memory. Alternatively, the SIB is marked or otherwise has an indication that the SIB is no longer valid or to be used.

In alternative embodiments, the first broadcast channel may alternatively or additionally cycle SIBx at a higher frequency.

The second BCH2 may broadcast the changed SIB with a higher frequency as compared to other SIBs.

In some embodiments, only the one or more changed SIB may be broadcast on the second broadcast channel.

The changed SIBs may be interleaved or broadcast with other SIBs as shown in figure 7. Figure 7 shows a similar arrangement to that of Figure 6. However, on the second broadcast channel, during the period of higher frequency changed SIB cycling, there are two SIBs transmitted alternatively. The SIBs are SIBx and SIBu. SIBu may or may not be a changed SIB. It should be appreciated that in other embodiments, a different pattern may be used to transmit the SIBs. It should be appreciated that in some embodiments, more than two SIBs may be transmitted.

In some embodiments one or more SIBs may be allocated to the second broadcast channel. In the example shown in Figure 7, these are SIBU, SIBV and SIBW. These SIBs may be unchanged and are broadcast when the channel is not required for changed SIBs.

The second broadcast channel BCH2 may broadcast changed SIBs that are normally and still carried by the first broadcast channel BCH1.

It should be appreciated that some embodiments may be used when only one SIB has changed or where two or more SIBS have changed.

The BCH may be carried over any suitable physical channel. By way of example only, the physical channel may be HS-DPDCH (high speed dedicated physical data channel), P-CCPCH (primary common control physical channel), or S-CCPCH (secondary common control physical channel)

. Some embodiments may have an advantage of a faster acquisition of a changed SIB, and/or avoiding having to read the whole BCH cycle and thus being able to go back more quickly to a power saving mode.

In the embodiments shown there are disclosed two channels: a first channel and a second channel. In other embodiments there may be more than two channels. That is, the SIBs that are sent/received may be separated and/or shared between any number of a plurality of channels. It will of course be understood that the terms "first" and "second" are used to differentiate between channels, and does not necessarily constitute any temporal limitations. That is the "first" channel is not necessarily established before the "second" channel.

It is also noted herein that while the above describes exemplifying embodiments of the invention, there are several variations and modifications which may be made to the disclosed solution without departing from the scope of the present invention.

The required data processing apparatus and functions of a base station apparatus, a communication device and any other appropriate station may be provided by 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 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 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 implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the invention is not limited thereto. While various aspects of the invention may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

Some embodiments may be implemented by computer software executable by a data processor of the communication device, such as in the processor entity, or by hardware, or by a combination of software and hardware.

Further in this regard it should be noted that any blocks of the logic flow as in the Figures may represent program steps, or interconnected logic circuits, blocks and functions, or a combination of program steps and logic circuits, blocks and functions. 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 DVD and the data variants thereof, CD.

The memory may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor-based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory.

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 drawings and the appended claims. However, all such and similar modifications of the teachings of this invention will still fall within the scope of this invention 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 first system information to be transmitted;

causing system information which has changed to be transmitted, the system information which has been changed being transmitted more frequently than the first information.

2. A method as claimed in claim 1, wherein said first system information is transmitted on a first channel and said system information which has changed is sent on a second different channel.

3. A method as claimed in claim 2, wherein said first channel and said second channel are broadcast channels.

4. A method as claimed in any preceding claim, comprising causing information indicating that system information has changed to be transmitted.

5. A method as claimed in claim 4, wherein said information indicating that system information has changed comprises information indicating which system information has changed.

6. A method as claimed in claim 4 or 5, comprising causing information indicating that said system information has been changed to be transmitted on a paging channel.

7. A method as claimed in any preceding claim, wherein causing of information to be transmitted comprises causing said information to be broadcast.

8. A method as claimed in any preceding claim, comprising modifying said first system information to include said changed system information.

9. A method as claimed in any preceding claim, comprising receiving said changed system information from a controller.

10. A method as claimed in claim 9, comprising receiving period information with said changed system information for controlling a length of time for which information indicating that system information has changed is to be transmitted

11. A method as claimed in claim 9, comprising receiving stop information from said controller to stop transmitting information indicating that system information has changed.

12. A method as claimed in claim 9, comprising receiving system information from said controller for transmitting after said changed system information.

13. A method comprising:

receiving first system information; and

receiving system information which has changed, wherein the system information which has been changed is transmitted with a higher frequency than the first information.

14. A method as claimed in claim 13, wherein said first system information is received on a first channel and said system information which has changed is received on a second different channel.

15. A method as claimed in claim 14, comprising receiving said changed information on said second channel, and retaining system information not provided by said second channel.

16. A method as claimed in any of any of claims 13 to 15, comprising receiving information indicating that system information has changed.

17. A method as claimed in claim 16 wherein said information indicating that said system information has change causes a user equipment to go into an activated state.

18. A method as claimed in any of claims 13 to 17, comprising acquiring system information and in response to receiving system information for a second time, stopping monitoring a respective channel.

19. A method comprising:

receiving first system information on a first channel and subsequently receiving changed system information on a second channel, and

retaining unchanged system information such that after said changed system information has been received, said unchanged system information is retained.

20. A computer program comprising computer executable instructions which when run perform the method of any preceding claim.

21. An apparatus, said apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured, with the at least one processor, to cause the apparatus at least to:

cause first system information to be transmitted; and

cause system information which has changed to be transmitted, the system information which has been changed being transmitted more frequently than the first information.

22. An apparatus, said apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured, with the at least one processor, to cause the apparatus at least to:

receive first system information; and receive system information which has changed, wherein the system information which has been changed is transmitted with a higher frequency than the first information.

23. An apparatus, said apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured, with the at least one processor, to cause the apparatus at least to:

receive first system information on a first channel and subsequently receiving changed system information on a second channel, and

retaining unchanged system information such that after said changed system information has been received, said unchanged system information is retained.

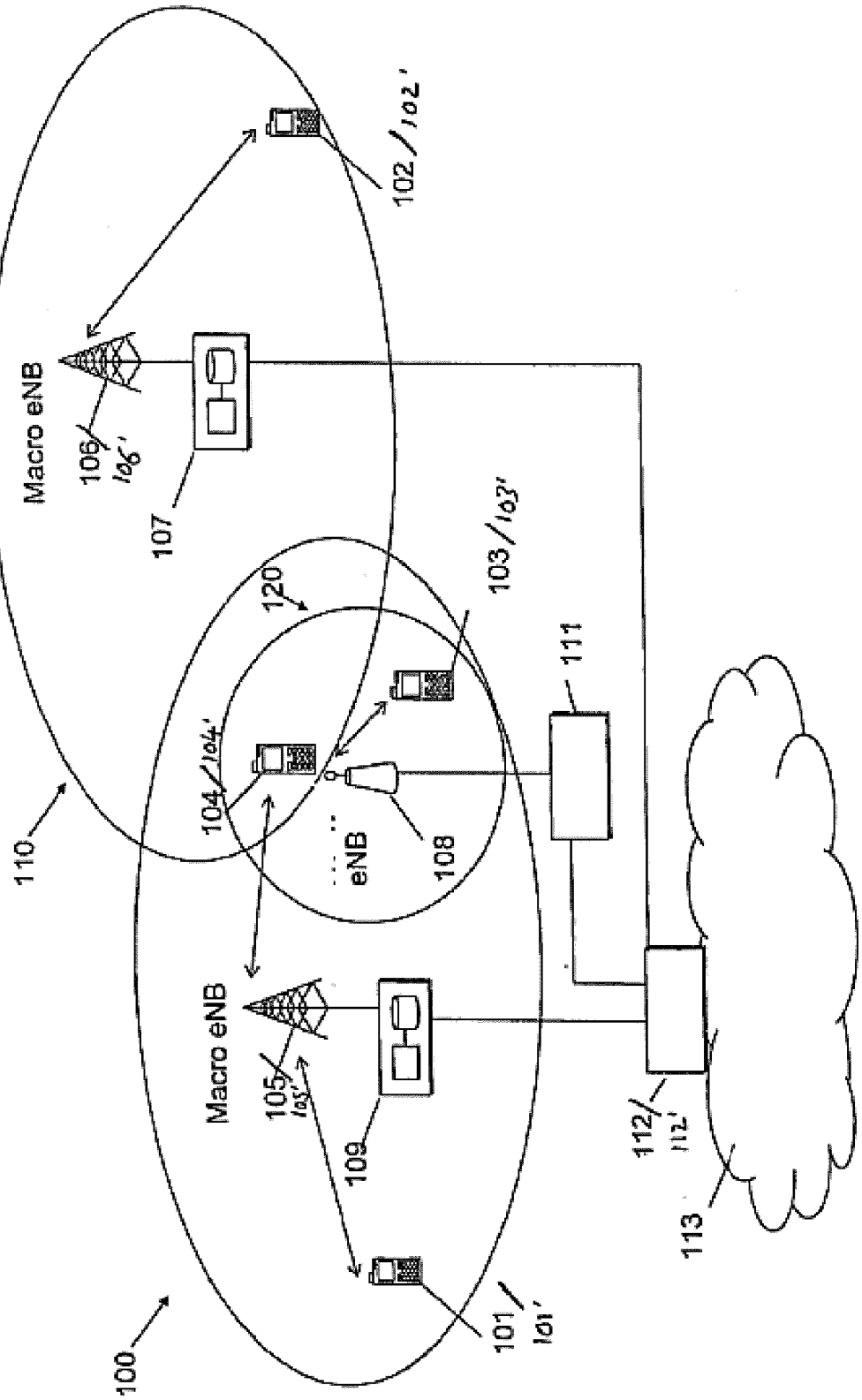
Macro eNB
106
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Figure 1

Figure 3

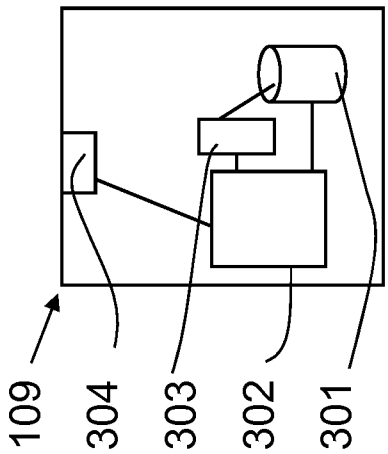
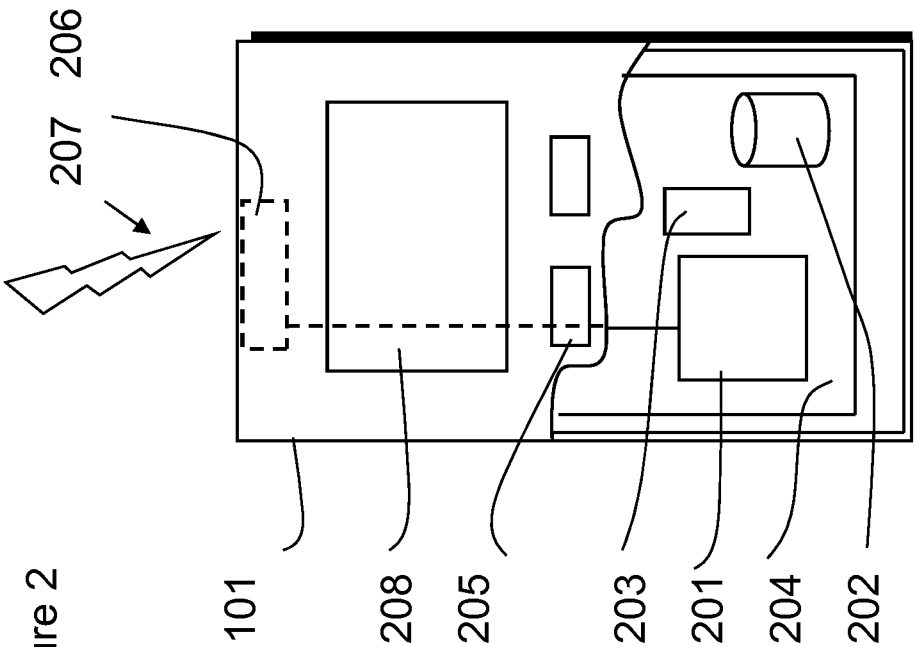


Figure 2



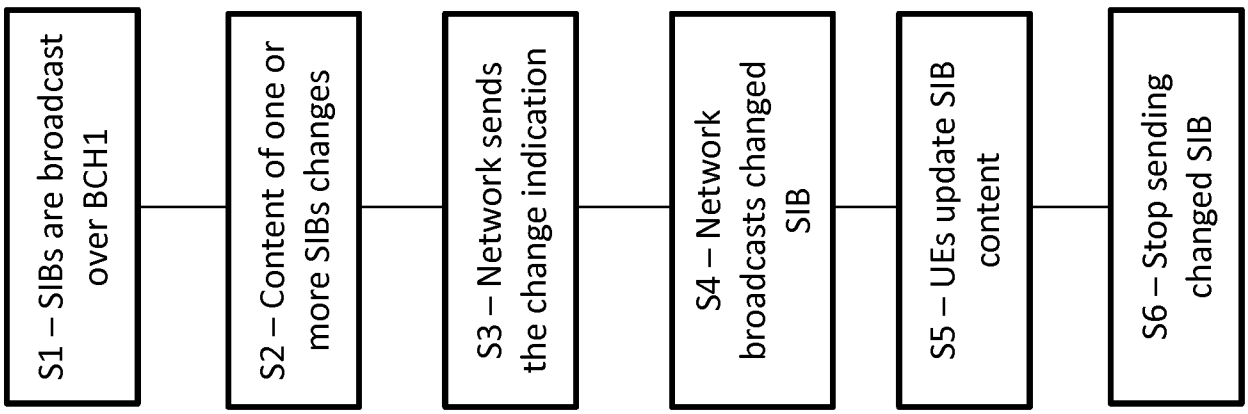

S1 – SIBs are broadcast over BCH1
S2 – Content of one or more SIBs changes
S3 – Network sends the change indication
S4 – Network broadcasts changed SIB
S5 – UEs update SIB content
S6 – Stop sending changed SIB

Figure 4

Figure 5

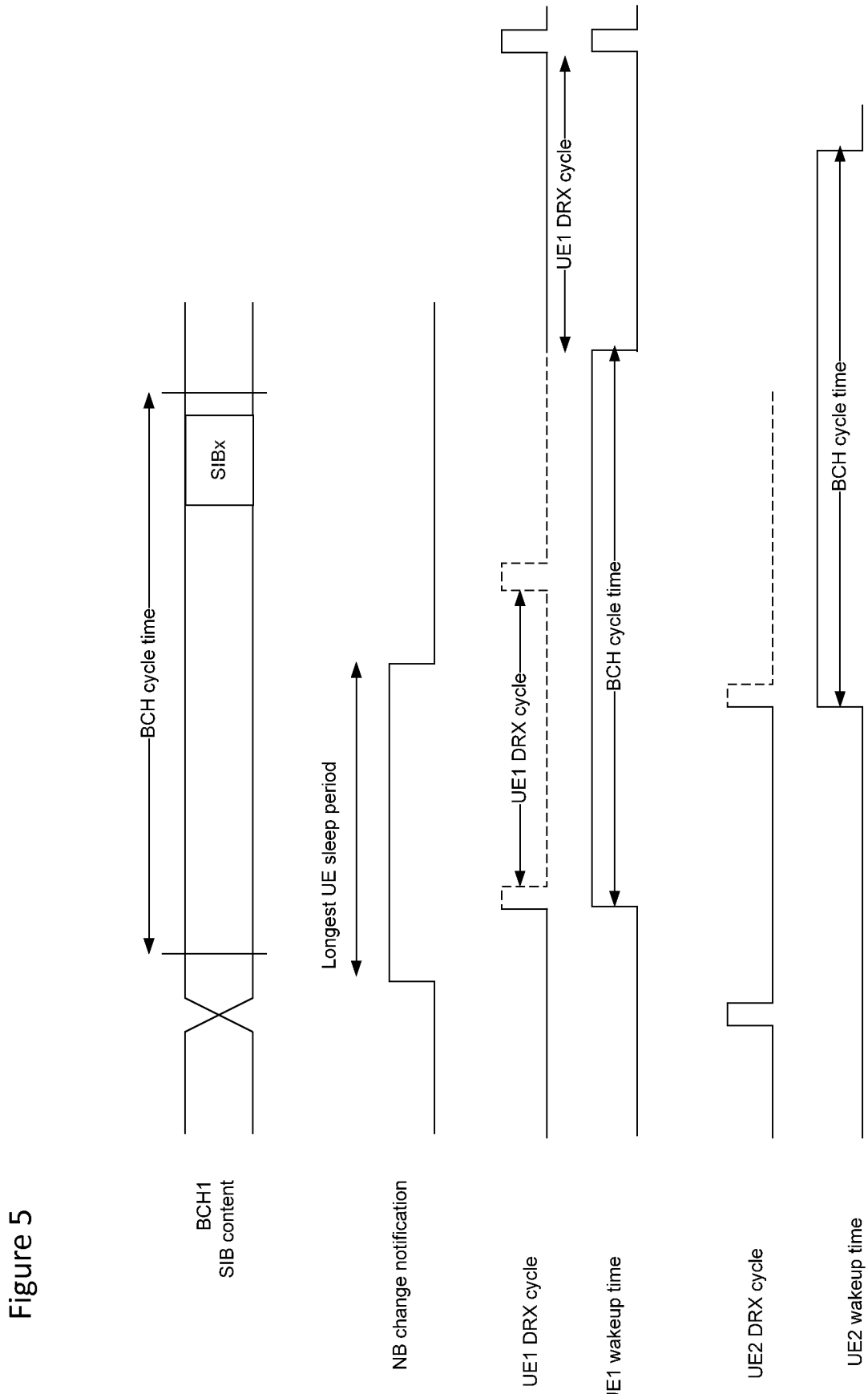

BCH1
SIB content
BCH cycle time
SIBx
NB change notification
Longest UE sleep period
UE1 DRX cycle
UE1 wakeup time
BCH cycle time
UE1 DRX cycle
UE2 DRX cycle
BCH cycle time
UE2 wakeup time

Figure 6

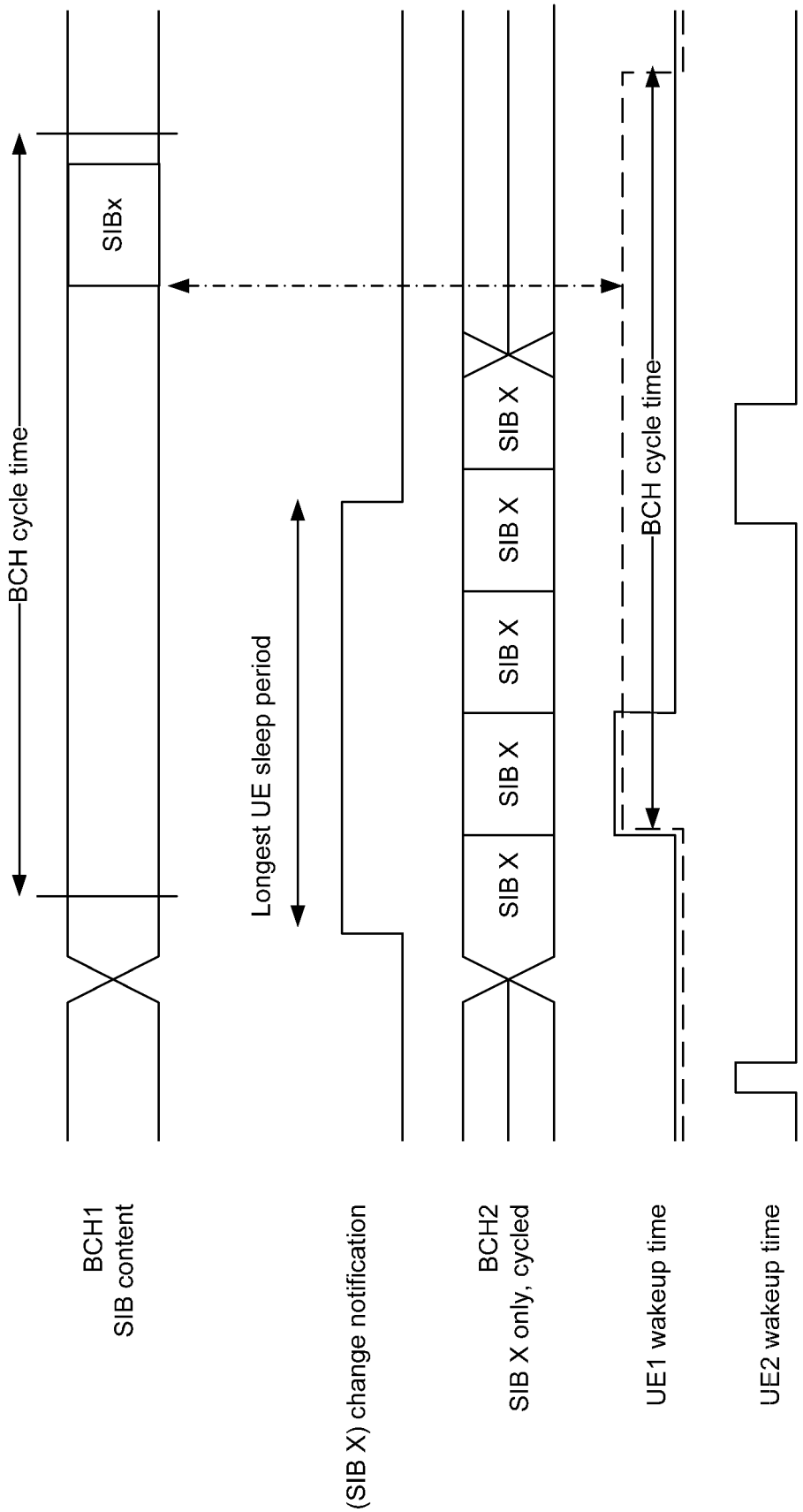
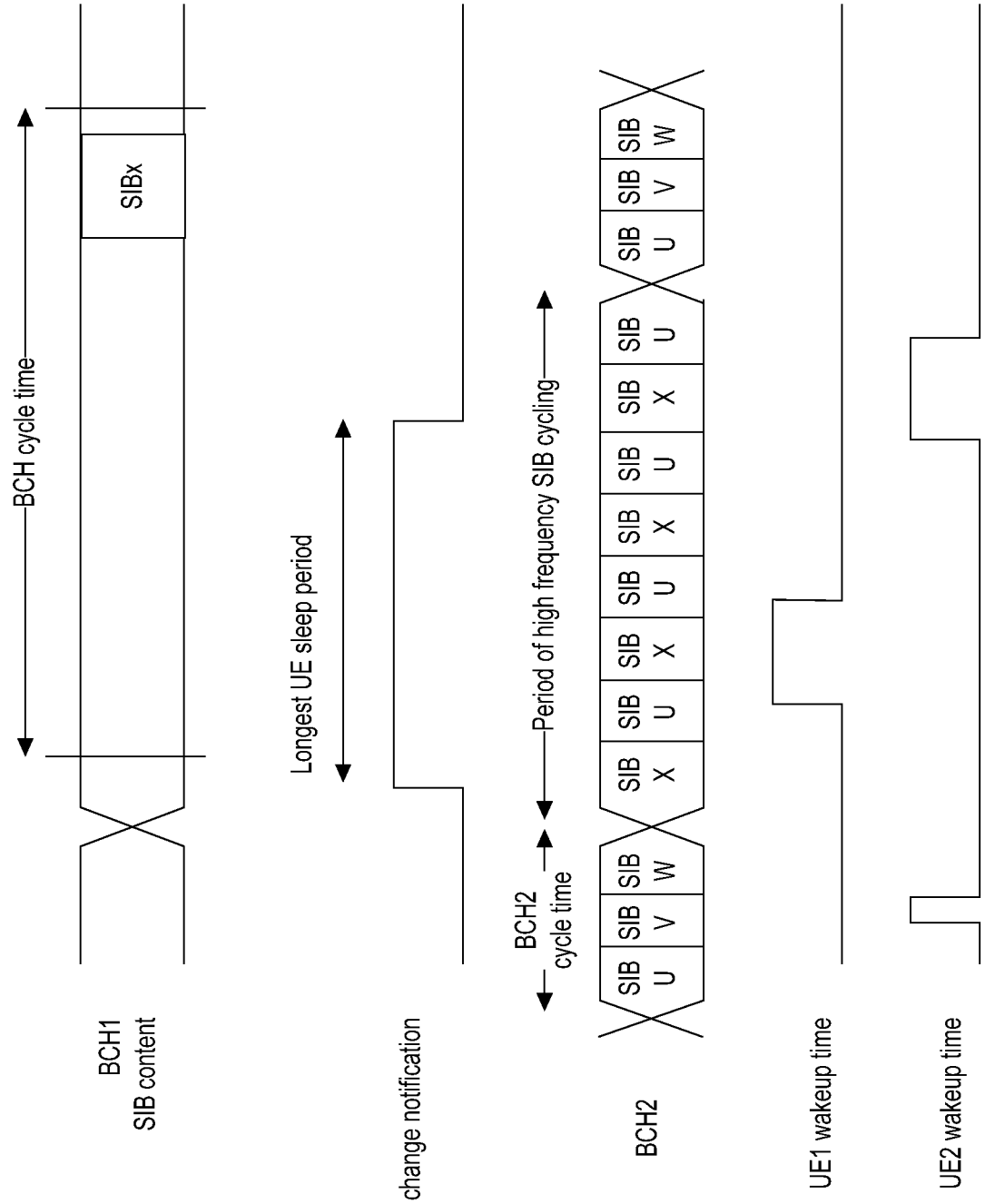

BCH cycle time
SIBx
Longest UE sleep period
SIB X
SIB X
SIB X
SIB X
BCH cycle time
BCH1
SIB content
(SIB X) change notification
BCH2
SIB X only, cycled
UE1 wakeup time
UE2 wakeup time

Figure 7


BCH cycle time
SIBx
BCH1
SIB content
Longest UE sleep period
(SIB X) change notification
Period of high frequency SIB cycling
BCH2
cycle time
SIB U
SIB V
SIB W
SIB X
SIB U
SIB X
SIB U
SIB X
SIB U
SIB V
SIB W
BCH2
UE1 wakeup time
UE2 wakeup time

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2014/051356

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-18, 20-22

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/051356

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W48/12
ADD. H04W48/16

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

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, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ITRI: "BCH load reduction by sharing with DL-SCH", 3GPP DRAFT; R2-061247, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. Shanghai, China; 20060503, 3 May 2006 (2006-05-03), XP050131193,	1-3, 7-15,18, 20-22
Y	Sections 2 and 3	4-6,16, 17

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

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"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	Date of mailing of the international search report
7 November 2014	14/01/2015

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

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/051356

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	"Scheduling of system information", INTERNET CITATION, August 1999 (1999-08), XP002245811, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/TSGR2_06/Docs/Pdfs/r2-99810.pdf [retrieved on 2003-06-20] Section 2	1,13, 20-22
X	FUJITSU: "System Information Support for Deep Hole Low Cost MTC UEs", 3GPP DRAFT; R1-135134 SYSTEM INFORMATION SUPPORT FOR DEEP HOLE LOW COST MTC, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CE , vol. RAN WG1, no. San Francisco, US; 20131111 - 20131115 13 November 2013 (2013-11-13), XP050734836, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN/RAN1/Docs/ [retrieved on 2013-11-13] Section 2.1	1,13, 20-22
Y	NOKIA ET AL: "System Information Change Indication", 3GPP DRAFT; R2-072937 SYSTEM INFORMATION CHANGE INDICATIONS, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. Orlando, U.S.A; 20070625 - 20070629, 2 July 2007 (2007-07-02), XP050603132, Section 2.2	4-6,16, 17

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-18, 20-22

causing first system information to be transmitted/received; causing system information which has changed to be transmitted/received, the system information which has been changed being transmitted more frequently than the first information.

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2. claims: 19, 23

receiving first system information on a first channel and subsequently receiving changed system information on a second channel, and retaining unchanged system information such that after said changed system information has been received, said unchanged system information is retained.
