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(54) **Title**: REDUCED INTERFERENCE BETWEEN LOCAL AREA CELL AND WIDE AREA CELL

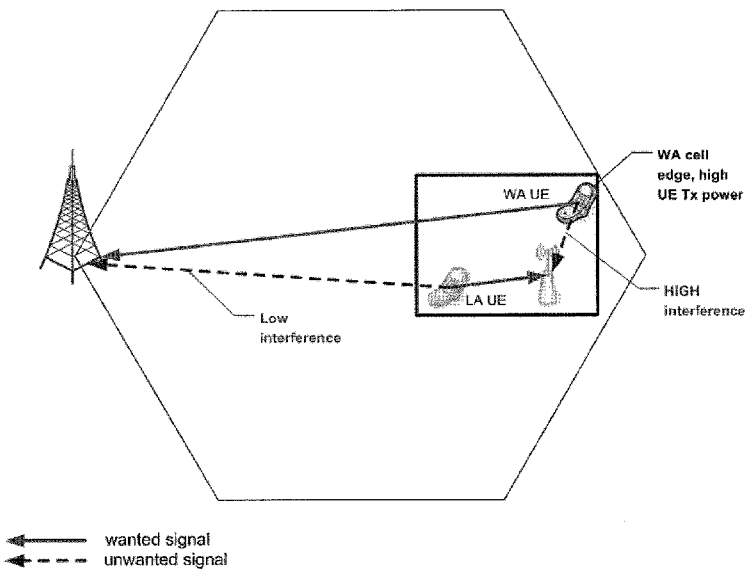


Fig. 1

(57) **Abstract**: An apparatus, method, system and computer program product reduce interference between a local area cell and a wide area cell. A wide area cell of a wide area overlay macro communication network transmitting the highest signal strength is identified. Further, a communication resources configuration used in a transmission of the wide area cell is identified. Based thereon, a communication resources configuration for use in a local area cell using a same access protocol as the wide area cell can then be determined such that it is determined different from the communication resources configuration used in the transmission of the wide area cell so that interference between the transmission of the wide area cell and a transmission of the local area cell is reduced.

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# Reduced Interference between Local Area Cell and Wide Area Cell

## Field of the Invention

The present invention relates to an apparatus, method, system and computer program product for reducing interference between a local area cell and a wide area cell.

## Related Background Art

Prior art which is related to this technical field can e.g. be found by the technical specifications TS 36.211 (current version: 8.6.0), TR 25.820 (current version: 8.2.0) and TS 22.220 (current version: 1.0.1) of the 3GPP, by the contributions document R4-081345, document R4-0701494, and document R4-082338 of the working group 4 of the 3GPP related to radio access networks, and by the contribution document R1-083661, and document R1-084035 of the working group 1 of the 3GPP related to radio access networks.

The following meanings for the abbreviations used in this specification apply:

3GPP: 3rd Generation Partnership Project
ACK: Acknowledgement
ARQ: Automatic Repeat Request
BCCH: Broadcast Control Channel
CQI: Channel Quality Indicator
CP: Cyclic Prefix
CS: Cyclic Shift
CSG: Closed Subscriber Group
DL: Downlink
DMRS: Demodulation Reference Signal

| | |
|---|---|
| eNB: | Evolved NodeB |
| HARQ | Hybrid Automatic Repeat Request |
| HeNB: | Home eNodeB |
| HII: | High Interference Indicator |
| LA: | Local Area |
| LTE: | Long Term Evolution |
| LTE-A: | LTE-Advanced |
| NACK: | Negative Acknowledgement |
| OFDM: | Orthogonal Frequency-Division Multiplexing |
| O&M: | Operations and Maintenance |
| PRACH: | Physical Random Access Channel |
| PRB: | Physical Resource Block |
| PUCCH: | Physical Uplink Control Channel |
| PUSCH: | Physical Uplink Shared Channel |
| RAN: | Radio Access Network |
| Rel: | Release |
| RS: | Reference Signal/Symbol |
| SFN: | System Frame Number |
| SINR: | Signal-to-Noise Ratio |
| SRI: | Scheduling Request Indicator |
| SRS: | Sounding RS |
| TTI: | Transmission Time Interval |
| Tx: | Transmission |
| UE: | User Equipment |
| UL: | Uplink |
| WA: | Wide Area |
| WCDMA: | Wideband Code Division Multiple Access |

Recently, for mobile wireless communication systems such as those according to 3GPP LTE low transmission power eNBs (which in the following are called Home eNodeBs) are proposed. These nodes can be operated at the same frequency layer, i.e. the same carrier frequency in the same frequency band, as a wide area eNB. A similar situation is provided by general small nodes with local services and/or

CSG applied, and which are under an overlay wide area macro network operated on the same frequency layer.

It is typical for nodes such as these HeNBs that they are low cost and in general deployed in indoor environment. In terms of radio network planning, the deployment is in most cases uncoordinated so the exact position where the HeNBs are located is not known to the operator.

HeNBs may support either any nearby UE or only UEs belonging to a single closed subscriber group (CSG). Therefore, HeNBs may be seen as additional interfering nodes with no possibility of handover for UEs not belonging to the supported CSG. This makes it reasonable to limit the HeNB transmission power to provide indoor coverage, which typically is 5, 10 MHz and 20 MHz for the LTE deployments with a transmission power smaller than or equal to 20 dBm.

The HeNB shall be able to use a range of frequency bands according to an operator's needs, and a relevant scenario for radio investigations there is that the frequency band of operation shall be different from the frequency band used by the macro layer. Though, this approach has one major disadvantage which is the need for an operator to have an additional band/frequency carrier for HeNB operation.

Therefore, it is presently studied under what conditions co-existence of the eNB and the HeNB in the same geographical area and frequency carrier is possible (co-channel case) and what mechanisms are needed or may be useful to mitigate the problem in uplink, that the local area communication is disturbed due to interference from high-power wide area UEs in co-channel deployments with CSG, resulting in a poor performance of home UE to HeNB UL

communication, if the HeNB is located close to the WA cell edge.

A table with an example link budget for LA HeNB communication in a residential house located near the WA cell edge is shown below. As can be seen in the example, the scenario depicted in Fig. 1 results in an unacceptably low SINR at the LA HeNB due to the high interference of the visiting WA UE, which is not included in the HeNB CSG.

| Description | Value | Unit | Comment |
|---|---|---|---|
| LA UE Tx power | 10 | dBm | Lower max Tx power for LA UEs (max 15dBm) |
| LA UE ↔ HeNB pathloss | -55,8 | dB | (4.2 m) |
| LA UE ↔ HeNB received power | -45,8 | dBm | |
| WA UE Tx power | 24 | dBm | |
| WA UE ↔ HeNB pathloss | -58,5 | dB | (5 m) |
| WA UE ↔ HeNB received power | -34,5 | dBm | |
| SINR | -11,3 dB | | |

In the working group 4 of the 3GPP related to RAN (hereinafter: RAN4), partial co-channel deployment operation was discussed in document R4-071494. One solution to the above uplink interference problem is described in document R4-081345, and a related issue of reduction of maximum allowed power for LA UEs is described in document R4-082338.

Basically, it is possible to solve the issue by additional attenuation at H(e)NB and increase the LA UL transmission

power. However, this approach has drawbacks and the most prominent one is that LA layer efficiency is reduced. Especially with another feature currently in discussion in RAN4, the reduction of the maximum allowed power for LA UEs, this additional attenuation at H(e)NB may not be possible, anymore.

Taking the fact into account that not all UL LA physical channels are equally harmed by the unwanted high interference signal a more advanced approach is needed.

Summary of the Invention

It is an object of the present invention to overcome at least some of the drawbacks of the prior art. According to certain embodiments of the present invention, interference between a local area cell and a wide area cell can be reduced.

According to a first aspect of the present invention, this is accomplished by an apparatus, comprising an identifying processor configured to identify a wide area cell of a wide area overlay macro communication network transmitting the highest signal strength, and to identify a communication resources configuration used in a transmission of the wide area cell; and a determining processor configured to determine a communication resources configuration for use in a local area cell using a same access protocol as the wide area cell, wherein the communication resources configuration for use in the local area cell is determined different from the communication resources configuration used in the transmission of the wide area cell such that interference between the transmission of the wide area cell and a transmission of the local area cell is reduced.

Modifications of the first aspect may be as follows.

The apparatus according to the first aspect may be configured to be suitable for reducing interference between a local area cell and a wide area cell. The communication resources configuration for use in a local area cell can be an uplink communication resources configuration for use in a local area cell.

The apparatus may further comprise a transmission controller configured to control communication in the local area cell such that it is based on the communication resources configuration for use in the local area cell.

The apparatus may further comprise a set of hardware configured to provide a base station functionality for the local area cell. Alternatively or in combination, the base station functionality can be provided by software run on a general purpose digital signal processor and/or application specific integrated circuits. The base station functionality may provide the functionality of a Node B or an evolved Node B.

The identifying processor may be further configured to provide information on the identified wide area cell transmitting the highest signal strength and the communication resources configuration used in a transmission of the wide area cell for submission to a local area cell central element, and the determining processor may be further configured to provide the communication resources configuration for use in the local area cell for submission to the local area cell central element, and to receive an acknowledgement from the local

area cell central element on the communication resources configuration for use in the local area cell.

The communication resources configuration used in a transmission of the wide area cell may comprise a wide area cell identity and an uplink reference signal configuration from a broadcast control channel of the transmission of the wide area cell, and the uplink reference signal configuration from a broadcast control channel may include one or more from the group comprising enabled group hopping, enabled sequence hopping, and a sequence shift pattern.

The communication resources configuration used in a transmission of the wide area cell may comprise resources used for a physical random access channel of the transmission of the wide area cell, and the communication resources configuration for use in the local area cell may comprise resources which are orthogonal to the resources used for a physical random access channel of the transmission of the wide area cell.

The communication resources configuration used in a transmission of the wide area cell may comprise resources used for a physical uplink control channel of the transmission of the wide area cell, and the communication resources configuration for use in the local area cell may comprise selection of physical resource blocks for a physical uplink control channel of a transmission of the local area cell over which the physical uplink control channel is not transmitted in the wide area cell.

The identifying processor may be further configured to identify the wide area cell of an wide area overlay macro communication network transmitting the highest signal

strength, and to identify the communication resources configuration used in a transmission of the wide area cell based upon receipt of a high interference indicator informing on physical resource blocks scheduled for use in the wide area cell.

According to a second aspect of the present invention, the above object is accomplished by an apparatus, comprising means for identifying a wide area cell of a wide area overlay macro communication network transmitting the highest signal strength, and for identifying a communication resources configuration used in a transmission of the wide area cell; and means for determining a communication resources configuration for use in a local area cell using a same access protocol as the wide area cell, wherein the communication resources configuration for use in the local area cell is determined different from the communication resources configuration used in the transmission of the wide area cell such that interference between the transmission of the wide area cell and a transmission of the local area cell is reduced.

Modifications of the second aspect may correspond to the modifications of the first aspect.

According to a third aspect of the present invention, the above object is accomplished by a system, comprising the apparatus according to the first aspect modified by the identifying processor being further configured to provide information on the identified wide area cell transmitting the highest signal strength and the communication resources configuration used in a transmission of the wide area cell for submission to a local area cell central element, and the determining processor being further configured to provide the communication resources configuration for use

in the local area cell for submission to the local area cell central element, and to receive an acknowledgement from the local area cell central element on the communication resources configuration for use in the local area cell; and the local area cell central element comprising a checking processor configured to acknowledge the communication resources configuration for use in the local area cell, and to reject the communication resources configuration for use in the local area cell.

Modifications of the third aspect may be as follows.

The system according to the third aspect may be configured to be suitable for reducing interference between a local area cell and a wide area cell.

The determining processor may be further configured to provide another communication resources configuration for use in the local area cell for submission to the local area cell central element, if no acknowledgement from the local area cell central element is received.

The local area cell central element may further comprise one of an operation and maintenance functionality and a gateway functionality.

According to a fourth aspect of the present invention, the above object is accomplished by an apparatus comprising a checking processor configured to acknowledge a communication resources configuration for use in a local area cell, and to reject the communication resources configuration for use in the local area cell.

Modifications of the fourth aspect may be as follows.

The apparatus according to the fourth aspect may be configured to be suitable for reducing interference between a local area cell and a wide area cell.

The apparatus may be implemented as a local area cell central element.

The apparatus or the local area cell central element may further comprise one of an operation and maintenance functionality and a gateway functionality.

According to a fifth aspect of the present invention, the above object is accomplished by an apparatus comprising a means for acknowledging a communication resources configuration for use in a local area cell, and means for rejecting the communication resources configuration for use in the local area cell.

Modifications of the fifth aspect may correspond to the modifications of the fourth aspect.

According to a sixth aspect of the present invention, the above object is accomplished by a system, comprising the apparatus according to the second aspect modified by identifying means being further configured to provide information on the identified wide area cell transmitting the highest signal strength and the communication resources configuration used in a transmission of the wide area cell for submission to a local area cell central element, and determining means being further configured to provide the communication resources configuration for use in the local area cell for submission to the local area cell central element, and to receive an acknowledgement from the local area cell central element on the communication resources configuration for use in the local area cell; and the

apparatus according to the fifth aspect or any of its modifications.

According to a seventh aspect of the present invention, the above object is accomplished by a method, comprising identifying a wide area cell of an wide area overlay macro communication network transmitting the highest signal strength; identifying a communication resources configuration used in a transmission of the wide area cell; and determining a communication resources configuration for use in a local area cell using a same access protocol as the wide area cell, wherein the communication resources configuration for use in the local area cell is determined different from the communication resources configuration used in the transmission of the wide area cell such that interference between the transmission of the wide area cell and a transmission of the local area cell is reduced.

Modifications of the seventh aspect may be as follows.

The method according to the seventh aspect may be configured to be suitable of reducing interference between a local area cell and a wide area cell.

The identifying may be performed by an identifying processor and the determining may be performed by a determining processor.

The communication resources configuration for use in a local area cell may be an uplink communication resources configuration for use in a local area cell.

The method may further comprise controlling communication in the local area cell such that it is based on the

communication resources configuration for use in the local area cell.

The controlling may be performed by a transmission controller.

The method may further comprise providing a base station functionality for the local area cell. The base station functionality may be provided by a set of hardware. Alternatively or in combination, the base station functionality can be provided by software run on a general purpose digital signal processor and/or application specific integrated circuits. The base station functionality may provide the functionality of a Node B or an evolved Node B.

The method may further comprise providing information on the identified wide area cell transmitting the highest signal strength and the communication resources configuration used in a transmission of the wide area cell for submission to a local area cell central element; providing the communication resources configuration for use in the local area cell for submission to the local area cell central element; and receiving an acknowledgement from the local area cell central element on the communication resources configuration for use in the local area cell.

The providing information may be performed by the identifying processor, and the providing the communication resources configuration and the receiving may be performed by the determining processor.

The communication resources configuration used in a transmission of the wide area cell may comprise a wide area cell identity and an uplink reference signal configuration

from a broadcast control channel of the transmission of the wide area cell, and the uplink reference signal configuration from a broadcast control channel may include one or more from the group comprising enabled group hopping, enabled sequence hopping, and a sequence shift pattern.

The communication resources configuration used in a transmission of the wide area cell may comprise resources used for a physical random access channel of the transmission of the wide area cell, and the communication resources configuration for use in the local area cell may comprise resources which are orthogonal to the resources used for a physical random access channel of the transmission of the wide area cell.

The communication resources configuration used in a transmission of the wide area cell may comprise resources used for a physical uplink control channel of the transmission of the wide area cell, and the communication resources configuration for use in the local area cell may comprise selection of physical resource blocks for a physical uplink control channel of a transmission of the local area cell over which the physical uplink control channel is not transmitted in the wide area cell.

The method may further comprise identifying the wide area cell of an wide area overlay macro communication network transmitting the highest signal strength; and identifying the communication resources configuration used in a transmission of the wide area cell based upon receipt of a high interference indicator informing on physical resource blocks scheduled for use in the wide area cell.

Both identifying may be performed by the identifying processor.

The method may further comprise acknowledging or rejecting the communication resources configuration for use in the local area cell by the local area cell central element.

The method may further comprise providing another communication resources configuration for use in the local area cell for submission to the local area cell central element, if no acknowledgement from the local area cell central element is received.

The providing may be performed by the determining processor.

The method may further comprise providing one of an operation and maintenance functionality and a gateway functionality by the local area cell central element.

According to an eighth aspect of the present invention, the above object is accomplished by a computer program product comprising computer-executable components which perform, when the program is run on a computer identifying a wide area cell of an wide area overlay macro communication network transmitting the highest signal strength; identifying a communication resources configuration used in a transmission of the wide area cell; and determining a communication resources configuration for use in a local area cell using a same access protocol as the wide area cell, wherein the communication resources configuration for use in the local area cell is determined different from the communication resources configuration used in a transmission of the wide area cell such that interference

between a transmission of the wide area cell and a transmission of the local area cell is reduced.

Modifications of the eighth aspect may be as follows.

The computer program product according to the eighth aspect may be configured to be suitable for reducing interference between a local area cell and a wide area cell.

The computer program product according to the eighth aspect may be embodied as a computer-readable storage medium.

Otherwise, modifications of the eighth aspect may correspond to the modifications of the seventh aspect.
It is to be understood that any of the above modifications can be applied singly or in combination to the respective aspects to which they refer, unless they are explicitly stated as excluding alternatives.

## Brief Description of the Drawings

The above and other objects, features, details and advantages will become more fully apparent from the following detailed description of the preferred embodiments which is to be taken in conjunction with the appended drawings, in which:

Fig. 1 shows uplink interference at a home evolved Node B which is located close to a wide area cell edge;

Fig. 2 shows an example for the signaling flow according to certain embodiments of the present invention;

Fig. 3 shows the usage of PUCCH parameters for normal cyclic prefix according to document R1-083661;

Fig. 4 shows a PUCCH resource partitioning for a wide area and local area co-channel case according to certain embodiments of the present invention;

Fig. 5 shows a principle configuration of an apparatus according to certain embodiments of the present invention; and

Fig. 6 shows a principle flowchart of a method according to certain embodiments of the present invention.

Detailed Description of the preferred Embodiments

In the following, description is made to what are presently considered to be preferred embodiments of the present invention. It is to be understood, however, that the description is given by way of example only, and that the described embodiments are by no means to be understood as limiting the present invention thereto.

For example, for illustration purposes, in some of the following exemplary embodiments, interference reduction between a 3GPP LTE overlay wide area macro network and a 3GPP LTE local area network is described. However, it should be appreciated that these exemplary embodiments are not limited for use among these particular types of wireless communication systems, and according to further exemplary embodiments, the present invention can be applied also to other types of communication systems and access networks such as e.g. to WLAN (wireless local area network) and WIMAX (worldwide interoperability for microwave access) techniques and standards.

Thus, certain embodiments of the present invention relate to mobile wireless communication systems, such as 3GPP LTE. In more detail, certain embodiments of the present invention are related to auto-configuration of small hotspots and low transmission power eNBs which are in the following called Home eNodeBs (HeNBs) and the case where these nodes are operated at the same frequency layer, i.e. at the same carrier frequency in the same frequency band, as the wide area eNBs.

However, as indicated above, the present invention is not limited to HeNB, but other embodiments of the present invention are related to general small nodes with local services and/or CSG applied, and which are under an overlay wide area macro network operated on the same frequency layer.

Fig. 5 shows a principle configuration of an apparatus according to certain embodiments of the present invention. That is, as shown in Fig. 5, an apparatus comprises an identifying processor 51 configured to identify a wide area cell of a wide area overlay macro communication network transmitting the highest signal strength, and to identify a communication resources configuration used in a transmission of the wide area cell; and a determining processor 52 configured to determine a communication resources configuration for use in a local area cell using a same access protocol as the wide area cell, wherein the communication resources configuration for use in the local area cell is determined different from the communication resources configuration used in the transmission of the wide area cell such that interference between the transmission of the wide area cell and a transmission of the local area cell is reduced.

Fig. 6 shows a principle flowchart of a method according to certain embodiments of the present invention. Specifically, as shown in Fig. 6, a method comprises identifying 61 a wide area cell of an wide area overlay macro communication network transmitting the highest signal strength; identifying 62 a communication resources configuration used in a transmission of the wide area cell; and determining 63 a communication resources configuration for use in a local area cell using a same access protocol as the wide area cell, wherein the communication resources configuration for use in the local area cell is determined different from the communication resources configuration used in the transmission of the wide area cell such that interference between the transmission of the wide area cell and a transmission of the local area cell is reduced.

The identifying a wide area cell transmitting a highest signal strength and the identifying a communication resources configuration used in a transmission of the wide area cell can be performed by the identifying processor 51 shown in Fig. 5, while the determining a different communication resources configuration for use in a local area cell can be performed by the determining processor shown in Fig. 5.

In the following, for illustration purposes, certain embodiments of the present invention are described by referring to the frequency and time allocations of the affected uplink control and data channels, and solutions reducing or eliminating wide area and local area collision probability are provided.

As described above, if wide area (WA) and local area (LA) networks are deployed in the same frequency band (co-channel deployment), interference experienced by a HeNB

coming from the WA UEs is significantly higher than in adjacent-channel deployments, and collisions result in a significant performance degradation, especially for example in dense urban areas with a dense HeNB deployment.

Herein below, certain embodiments are described which minimize or eliminate the uplink control/data channel collision probability.

Fig. 2 shows an example for the signaling flow in case a centralized network element for HeNB parameter management is available.

It is to be noted that certain embodiments as described below are applicable for specific control channels and can be applied in combination or alone.

Local area base sequence linked to overlay wide area base sequence

The uplink reference symbols (UL RS) are distributed in time and take consecutive resource elements in the frequency domain. There are two types of UL RS:

- Demodulation reference signal (DMRS) associated with PUSCH or PUCCH transmission, and
- Sounding Reference Signal (SRS).

The UL RS, as currently specified by the 3GPP, is defined by a cyclic shift of one of 30 base sequence groups. Each group contains one or two base sequences depending on the allocated UL PRBs (c.f. document TS 36.211). The UL RS sequences to be used in a cell are defined by:

- A group hopping pattern which depends on the cell ID; there are 17 such patterns (derived from the cell ID)

and this hopping can be enabled or disabled by higher layers on a cell basis.

- A sequence shift pattern; there are 30 such patterns derived from the cell ID for PUCCH DMRS and for the PUSCH DMRS. This pattern can be additionally offset by higher layers.
- A base sequence within a group can hop according to sequence hopping. This hopping is enabled or disabled by higher layers signaling and can be used only if group hopping is disabled (the base sequence hopping pattern is linked to the cell ID and PUSCH DMRS configuration).

According to certain embodiments of the present invention, the HeNB is enabled by a corresponding configuration of one or more of its components to listen to a BCCH of a wide area call, to identify the wide area cell's UL RS configuration, and to autonomously or in coordination with other local area cells via apparatuses such as a femto gateway or a central parameter management network element select its UL RS configuration so that its base sequence group hopping pattern (if enabled) and/or sequence shift pattern (and sequence hopping pattern if applied) will differ compared to the corresponding configuration of the WA eNB.

According to certain embodiments of the present invention, a typical procedure comprises one or more of the following processes:

A UE receiver which may be either camped/connected to a certain HeNB or integrated with a certain HeNB listens and identifies the strongest WA cell. For example, the WA cell ID and the UL RS configuration are identified from the BCCH (Group-hopping-enabled, $\Delta_{SS}$, Sequence-Hopping Enabled, $n_{DMRS}^{(1)}$,

see document TS 36.211).

The HeNB determines its own cell ID (and $\Delta_{SS}$, $n_{DMRS}^{(1)}$) and assures that WA and LA base sequence group hopping patterns and/or sequence shift pattern and/or sequence hopping pattern are different, thus minimizing the mutual UL RS cross-correlation and interference.

The HeNB uses (controls) the chosen UL RS configurations for UL transmission of its UEs.

Optionally, the HeNB may report to a central element, e.g. an O&M center or a femto gateway, the strongest measured WA cell (e.g. physical cell ID) together with a proposal for its own cell ID and a proposal for its UL RS configuration, and gets an acknowledgement (ACK) from the central element. However, if the central element sees problems with the proposed values and there is no acknowledgement (NACK indicated from central element to the HeNB), the HeNB suggests new and different values for its own physical cell ID and the UL RS configuration, or the central element signals appropriate values.

Local area PRACH resources linked to overlay WA PRACH resources

The physical random access channel (PRACH) is transmitted over six resource blocks in a sub-frame or set of sub-frames reserved for random access preamble transmissions as described e.g. in document TS 36.211. The PRACH frequency allocation (the first PRB of the six PRACH PRBs) is adjustable and signaled over the BCCH by each cell (the $n_{PRBoffset}^{RA}$ parameter in document TS 36.211). The PRACH can carry a lot of energy, especially at the WA cell edge due

to open loop power control. This particular effect may significantly lower the HeNB performance.

Therefore, according to certain embodiments of the present invention, the HeNB obtains the WA PRACH location and chooses a different, non-overlapping location for its own PRACH transmissions.

As an option, it can be assumed that time synchronization of the HeNB to the overlay WA cell (the strongest received WA cell) is available. Then, the HeNB obtains the time domain configuration of the WA eNB and selects a different, non-overlapping time domain PRACH configuration. It is to be noted that in a high UL WA interference case, the interference mitigation procedure by selecting different PRACH preamble sequence parameters like an orthogonal cyclic shift or a different Zadoff-Chu root sequence index might be not sufficient due to the high dynamic range between the interferer and the wanted signal.

According to certain embodiments of the present invention, a typical procedure comprises one or more of the following processes:

A UE receiver which may be either camped/connected to a certain HeNB or integrated with a certain HeNB listens and identifies the strongest WA cell and its resources used for PRACH.

The HeNB autonomously chooses own orthogonal (in time or frequency) PRACH resources as described above.

A UE trying to access WA and LA in the same geographical area transmits (is controlled to transmit) the PRACH over different orthogonal resources.

Optionally, the HeNB may report to a central element such as e.g. an O&M center or a femto gateway the strongest measured WA cell (e.g. physical cell ID) and its PRACH allocation as well as the own cell ID and the chosen PRACH allocation, and then gets an acknowledgement (ACK) from the central element. However, if the central element sees problems with the proposed allocation and there is no acknowledgement (NACK indicated from central element to HeNB), the HeNB can suggest new and different values or the central element can signal appropriate values.

Local area PUCCH resources linked to overlay wide area PUCCH resources

The PUCCH is located at band edges, but the exact configuration of these regions may differ for different base stations. If both WA UEs and LA UEs use the same physical resource blocks for PUCCH transmissions it is likely that a HeNB located near to a WA cell edge is not able to decode the content properly.

A mechanism for reducing adjacent channel interference due to PUCCH transmission has already been proposed e.g. in documents R1-083661 and R1-084035, and is referred to as PUCCH blanking or over-provisioning.

However, according to certain embodiments of the present invention, this concept is modified to avoid co-channel PUCCH interference. The HeNB could signal that more PRBs are allocated for PUCCH, but schedule (allow) PUCCH transmissions only over resources which are not used by WA UEs for PUCCH transmission.

Fig. 3 shows the usage of PUCCH parameters for normal cyclic prefix according to document R1-083661.

In Fig. 3:

- $N_{RB}^{(2)}$ denotes the number of RBs that are reserved for CQI transmission;
- $n_{PUCCH}^{(2)}$ denotes a dedicated CQI resource in terms of CS for a UE;
- $N_{cs}^{(1)}$ denotes the number of CS used for SRI/HARQ-ACK in a mixed RB, where CQI and SRI/HARQ-ACK are transmitted;
- $N_{PUCCH}^{(1)}$ denotes the offset value in terms of indices of the reserved resources for SRI/HARQ-ACK;
- $n_{PUCCH}^{(1)}$ denotes a dedicated resource index of SRI/HARQ-ACK for a UE; and
- $\Delta_{shift}^{PUCCH}$ denotes the separation between adjacent resources of SRI/HARQ-ACK in terms of CS.

For the identification of the parameters, reference is also made to document TS 36.211.

As shown in Fig. 3, by setting large values for $N_{RB}^{(2)}$ and $n_{PUCCH}^{(2)}$, actual PRBs used for PUCCH can be placed towards the middle of the system band. In addition, although $N_{RB}^{(2)}$ indicates the reserved RBs for CQI, the reserved RBs can be used by PRACH and/or PUSCH based on current agreements.

According to certain embodiments of the present invention, a typical procedure comprises one or more of the following processes:

A UE receiver which may be either camped/connected to a certain HeNB or integrated with a certain HeNB listens and identifies the strongest WA cell as well as resources used

for PUCCH by this cell (e.g. the $N_{RB}^{HO}$, defined in document TS 36.211).

The HeNB autonomously chooses its own PUCCH resources. A wider margin compared to an overlay WA cell is reserved for PUCCH transmissions (set by the $N_{RB}^{(2)}$ parameter). Only PRBs over which a WA PUCCH is not transmitted are used for the LA PUCCH (selected by the $n_{PUCCH}^{(2)}$).

A UE connected to WA and LA in the same geographical area transmits PUCCCH over different frequency resources thus avoiding a PUCCH co-channel interference.

Optionally, a HeNB may report to a central element such as e.g. an O&M center or a femto gateway the strongest measured WA cell (e.g. physical cell ID) and its PUCCH configuration as well as its own cell ID and a PUCCH configuration, and then gets an acknowledgement (ACK) from the central element. However, if the central element sees problems with the proposed resource allocation and there is no acknowledgement (NACK indicated from central element to HeNB), the HeNB can suggest a new and different value or the central element can signal an appropriate value.

An example for PUCCH resource partitioning is shown in Fig. 4. The H(e)NB uses only PUCCH blocks closer to the center of the band and utilizes/needs only e.g. PUCCH 10 and PUCH 11 due to the smaller number of users in LA compared to WA. As depicted, WA uses PUCCH 0-7, and optionally e.g. PUCCH 8 and PUCCH 9 is utilized as guard band so that the HeNB can filter out high interference from WA PUCCH 0-7 by an appropriate band of the filter. Though, this is optional, since even with the same band of the LA filter exclusive PUCCH resources for LA and WA will bring significant reduction of PUCCH-to-PUCCH interference.

PUSCH (data) transmission

The WA-to-LA interference to the LA's PUSCH may not be considered as a critical issue because the HeNB can rely on UL HARQ retransmissions and UL sounding with UL frequency domain packet scheduling to overcome or avoid interference.

However, according to certain embodiments of the present invention, the interference issue in this connection can be further mitigated.

In Rel-8 of the 3GPP, a mechanism called high interference indicator (HII) is supported. With this mechanism one eNB can inform its neighbor eNBs via X2 interface signaling on which UL PRBs it is going to schedule its cell-edge UEs in the future and thus inject high interference on these PRBs. The eNB can send different HIIs to different neighbors or for simplicity the same HII to all neighbors.

According to certain embodiments of the present invention, this mechanism is enhanced to inform the HeNBs about the high interference UL PRBS of its WA cell. Because there is no X2 interface between LA and WA, the WA cell sends the HIIs not (only) on the X2 interface, but also on the radio interface, e.g. on the BCCH, or emulates X2 interface via S1 connection, so that the HeNB can listen to the WA's HII, identify the PRBs on which high interference can be injected from the WA cell and avoid data/control transmission on these PRBs to mitigate the interference.

Furthermore, to overcome the problem of high dynamics between the wanted UL signal from home UEs and the unwanted (high interference) signal from WA UEs, the interference indicator enables time domain coordination between WA and

LA (compared to frequency domain coordination by the HHI according to Rel-8). Thus, it is e.g. indicated to the HeNB in which frames/subframes of the WA system high interference can occur. For example, if WA SFN mod x = 0 and x is configurable (x = 2, 3, 4, etc.), high WA interference can occur, but not during other SFNs. It is to be understood that this can be applied on the subframe level as well, e.g. subframes # {1, 3, 5, 7, 9} can be marked as HII by the WA cell. Also here it is assumed that HeNBs are synchronized to their WA overlay cell (strongest received WA cell), and that the SFN timing difference of HeNB to WA NB is known.

As indicated above, it is considered that certain embodiments of the present invention can advantageously be applied to 3GPP based environments such as a LTE compliant HeNB product and local area eNBs with CSG capability.

According to the above description, it should thus be apparent that exemplary embodiments of the present invention provide, for example from the perspective of a network element such as a home evolved Node B, or a component thereof, an apparatus embodying the same, a method for controlling and/or operating the same, and computer program(s) controlling and/or operating the same as well as mediums carrying such computer program(s) and forming computer program product(s).

For example, described above are apparatuses, methods and computer program products capable of providing reduced interference between a local area cell and a wide area cell. A wide area cell of a wide area overlay macro communication network transmitting the highest signal strength is identified. Further, a communication resources configuration used in a transmission of the wide area cell

is identified. Based thereon, a communication resources configuration for use in a local area cell using a same access protocol as the wide area cell can then be determined such that it is determined different from the communication resources configuration used in the transmission of the wide area cell so that interference between the transmission of the wide area cell and a transmission of the local area cell is reduced. Implementations of any of the above described blocks, apparatuses, systems, techniques or methods include, as non limiting examples, implementations as hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

What is described above is what is presently considered to be preferred embodiments of the present invention. However, as is apparent to the skilled reader, these are provided for illustrative purposes only and are in no way intended that the present invention is restricted thereto. Rather, it is the intention that all variations and modifications be included which fall within the spirit and scope of the appended claims.

Claims:

1. An apparatus, comprising:

an identifying processor configured to identify a wide area cell of a wide area overlay macro communication network transmitting the highest signal strength, and to identify a communication resources configuration used in a transmission of the wide area cell; and

a determining processor configured to determine a communication resources configuration for use in a local area cell using a same access protocol as the wide area cell, wherein the communication resources configuration for use in the local area cell is determined different from the communication resources configuration used in the transmission of the wide area cell such that interference between the transmission of the wide area cell and a transmission of the local area cell is reduced.

2. The apparatus according to claim 1, wherein the communication resources configuration for use in a local area cell is an uplink communication resources configuration for use in a local area cell.

3. The apparatus according to claim 1 or claim 2, further comprising:

a transmission controller configured to control communication in the local area cell such that it is based on the communication resources configuration for use in the local area cell.

4. The apparatus according to any one of claims 1 to 3, further comprising:

a set of hardware configured to provide a base station functionality for the local area cell.

5. The apparatus according to any one of claims 1 to 4, wherein

the identifying processor is further configured to provide information on the identified wide area cell transmitting the highest signal strength and the communication resources configuration used in a transmission of the wide area cell for submission to a local area cell central element, and

the determining processor is further configured to provide the communication resources configuration for use in the local area cell for submission to the local area cell central element, and to receive an acknowledgement from the local area cell central element on the communication resources configuration for use in the local area cell.

6. The apparatus according to any one of claims 1 to 5, wherein the communication resources configuration used in a transmission of the wide area cell comprises a wide area cell identity and an uplink reference signal configuration from a broadcast control channel of the transmission of the wide area cell, and the uplink reference signal configuration from a broadcast control channel includes one or more from the group comprising enabled group hopping, enabled sequence hopping, and a sequence shift pattern.

7. The apparatus according to any one of claims 1 to 5, wherein the communication resources configuration used in a transmission of the wide area cell comprises resources used for a physical random access channel of the transmission of the wide area cell, and the communication resources configuration for use in the local area cell comprises resources which are orthogonal to the resources used for a physical random access channel of the transmission of the wide area cell.

8. The apparatus according to any one of claims 1 to 5, wherein the communication resources configuration used in a transmission of the wide area cell comprises resources used for a physical uplink control channel of the transmission of the wide area cell, and the communication resources configuration for use in the local area cell comprises selection of physical resource blocks for a physical uplink control channel of a transmission of the local area cell over which the physical uplink control channel is not transmitted in the wide area cell.

9. The apparatus according to any one of claims 1 to 5, wherein the identifying processor is further configured to identify the wide area cell of an wide area overlay macro communication network transmitting the highest signal strength, and to identify the communication resources configuration used in a transmission of the wide area cell based upon receipt of a high interference indicator informing on physical resource blocks scheduled for use in the wide area cell.

10. A system, comprising:

the apparatus according to claim 5; and

a local area cell central element comprising a checking processor configured to acknowledge the communication resources configuration for use in the local area cell, and to reject the communication resources configuration for use in the local area cell.

11. The system according to claim 10, wherein the determining processor is further configured to provide another communication resources configuration for use in the local area cell for submission to the local area cell

central element, if no acknowledgement from the local area cell central element is received.

12. The system according to claim 10 or 11, wherein the local area cell central element further comprises one of an operation and maintenance functionality and a gateway functionality.

13. A method, comprising:

identifying a wide area cell of an wide area overlay macro communication network transmitting the highest signal strength;

identifying a communication resources configuration used in a transmission of the wide area cell; and

determining a communication resources configuration for use in a local area cell using a same access protocol as the wide area cell, wherein the communication resources configuration for use in the local area cell is determined different from the communication resources configuration used in the transmission of the wide area cell such that interference between the transmission of the wide area cell and a transmission of the local area cell is reduced.

14. The method according to claim 13, wherein the communication resources configuration for use in a local area cell is an uplink communication resources configuration for use in a local area cell.

15. The method according to any one of claims 13 or 14, further comprising:

controlling communication in the local area cell such that it is based on the communication resources configuration for use in the local area cell.

16. The method according to any one of claims 13 to 15, further comprising:

providing a base station functionality for the local area cell.

17. The method according to any one of claims 13 to 16, further comprising:

providing information on the identified wide area cell transmitting the highest signal strength and the communication resources configuration used in a transmission of the wide area cell for submission to a local area cell central element;

providing the communication resources configuration for use in the local area cell for submission to the local area cell central element; and

receiving an acknowledgement from the local area cell central element on the communication resources configuration for use in the local area cell.

18. The method according to any one of claims 13 to 17, wherein the communication resources configuration used in a transmission of the wide area cell comprises a wide area cell identity and an uplink reference signal configuration from a broadcast control channel of the transmission of the wide area cell, and the uplink reference signal configuration from a broadcast control channel includes one or more from the group comprising enabled group hopping, enabled sequence hopping, and a sequence shift pattern.

19. The method according to any one of claims 13 to 17, wherein the communication resources configuration used in a transmission of the wide area cell comprises resources used for a physical random access channel of the transmission of the wide area cell, and the communication resources configuration for use in the local area cell comprises

resources which are orthogonal to the resources used for a physical random access channel of the transmission of the wide area cell.

20. The method according to any one of claims 13 to 17, wherein the communication resources configuration used in a transmission of the wide area cell comprises resources used for a physical uplink control channel of the transmission of the wide area cell, and the communication resources configuration for use in the local area cell comprises selection of physical resource blocks for a physical uplink control channel of a transmission of the local area cell over which the physical uplink control channel is not transmitted in the wide area cell.

21. The method according to any one of claims 13 to 17, further comprising:

identifying the wide area cell of an wide area overlay macro communication network transmitting the highest signal strength; and

identifying the communication resources configuration used in a transmission of the wide area cell based upon receipt of a high interference indicator informing on physical resource blocks scheduled for use in the wide area cell.

22. The method according to claim 17, further comprising:

acknowledging or rejecting the communication resources configuration for use in the local area cell by the local area cell central element.

23. The method according to claim 22, further comprising:

providing another communication resources configuration for use in the local area cell for submission to the local area cell central element, if no

acknowledgement from the local area cell central element is received.

24. The method according to claim 22 or 23, further comprising:

providing one of an operation and maintenance functionality and a gateway functionality by the local area cell central element.

25. A computer program product comprising computer-executable components which perform, when the program is run on a computer:

identifying a wide area cell of an wide area overlay macro communication network transmitting the highest signal strength;

identifying a communication resources configuration used in a transmission of the wide area cell; and

determining a communication resources configuration for use in a local area cell using a same access protocol as the wide area cell, wherein the communication resources configuration for use in the local area cell is determined different from the communication resources configuration used in a transmission of the wide area cell such that interference between a transmission of the wide area cell and a transmission of the local area cell is reduced.

26. The computer program product according to claim 25, embodied as a computer-readable storage medium.

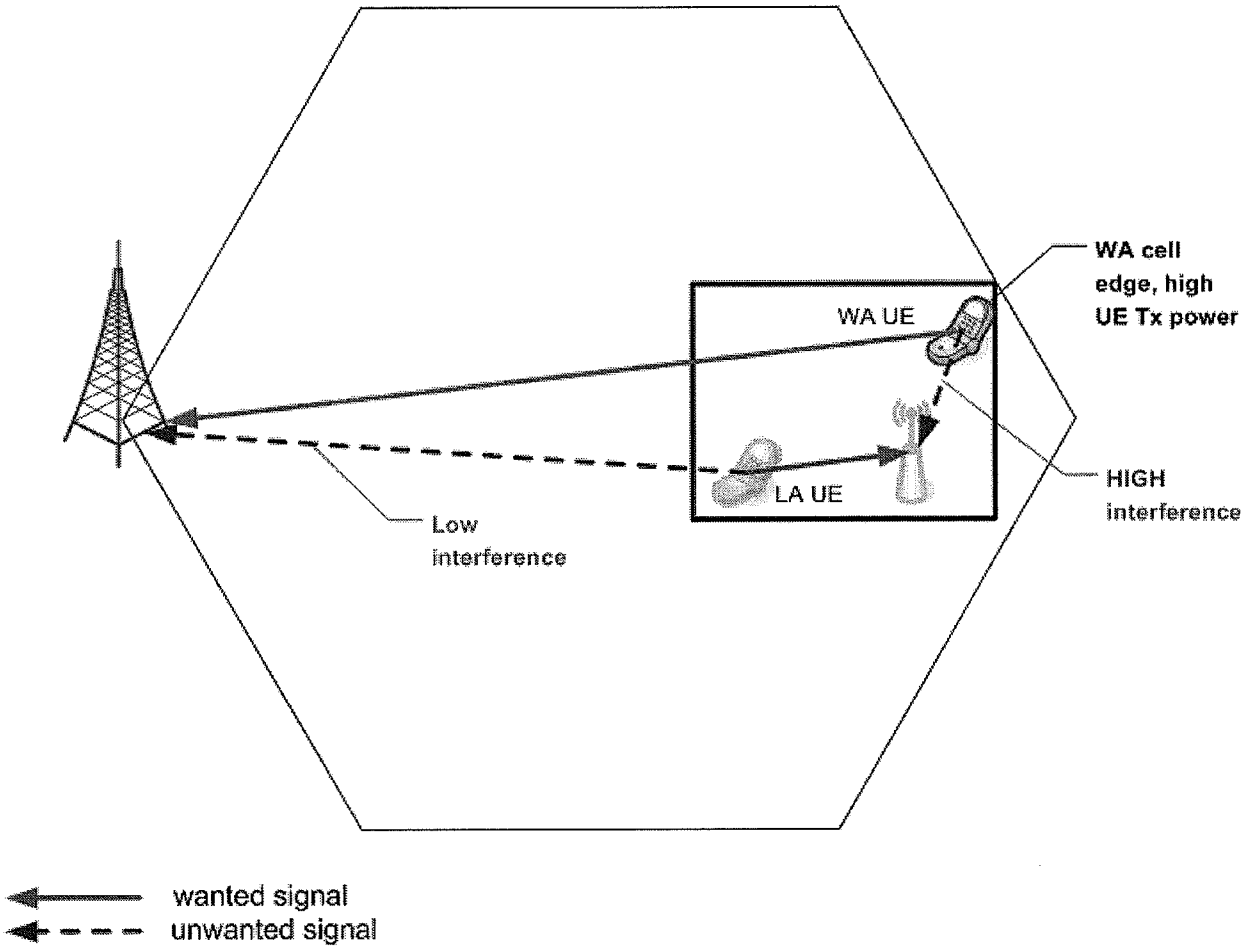
WA cell
edge, high
UE Tx power
WA UE
LA UE
HIGH
interference
Low
interference
wanted signal
unwanted signal

Fig. 1

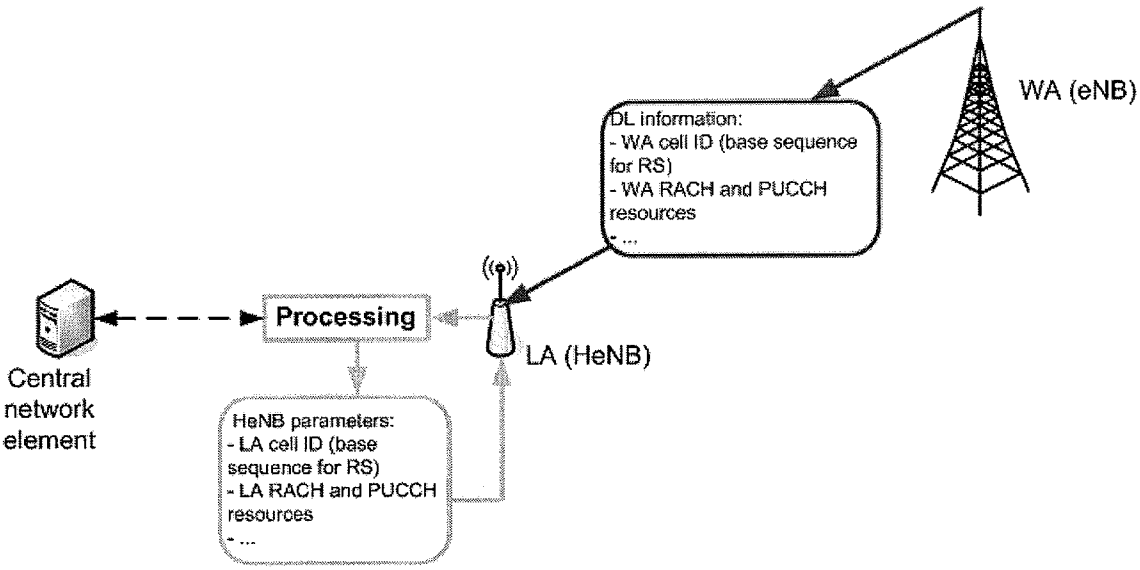
WA (eNB)
DL information:
- WA cell ID (base sequence for RS)
- WA RACH and PUCCH resources
- ...
Processing
LA (HeNB)
Central network element
HeNB parameters:
- LA cell ID (base sequence for RS)
- LA RACH and PUCCH resources
- ...

Fig. 2

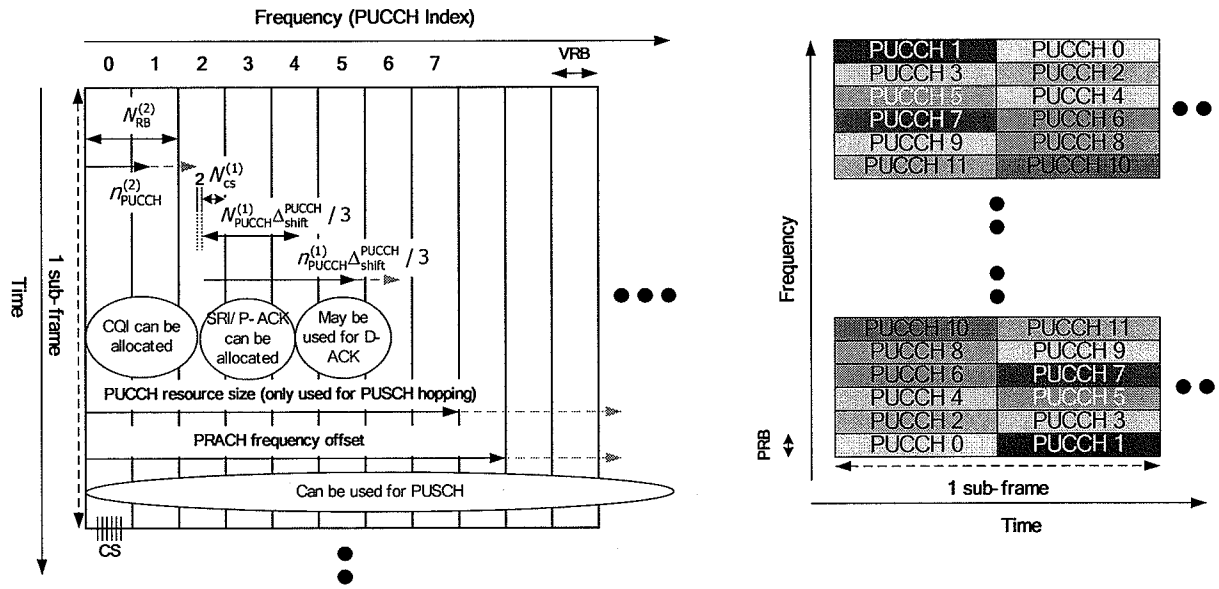
Frequency (PUCCH Index)
VRB
0 1 2 3 4 5 6 7
Time
1 sub-frame
CQI can be allocated
SRI/ P- ACK can be allocated
May be used for D-ACK
PUCCH resource size (only used for PUSCH hopping)
PRACH frequency offset
Can be used for PUSCH
CS
PUCCH 1
PUCCH 0
PUCCH 3
PUCCH 2
PUCCH 5
PUCCH 4
PUCCH 7
PUCCH 6
PUCCH 9
PUCCH 8
PUCCH 11
PUCCH 10
Frequency
PRB
1 sub-frame
Time

Fig. 3

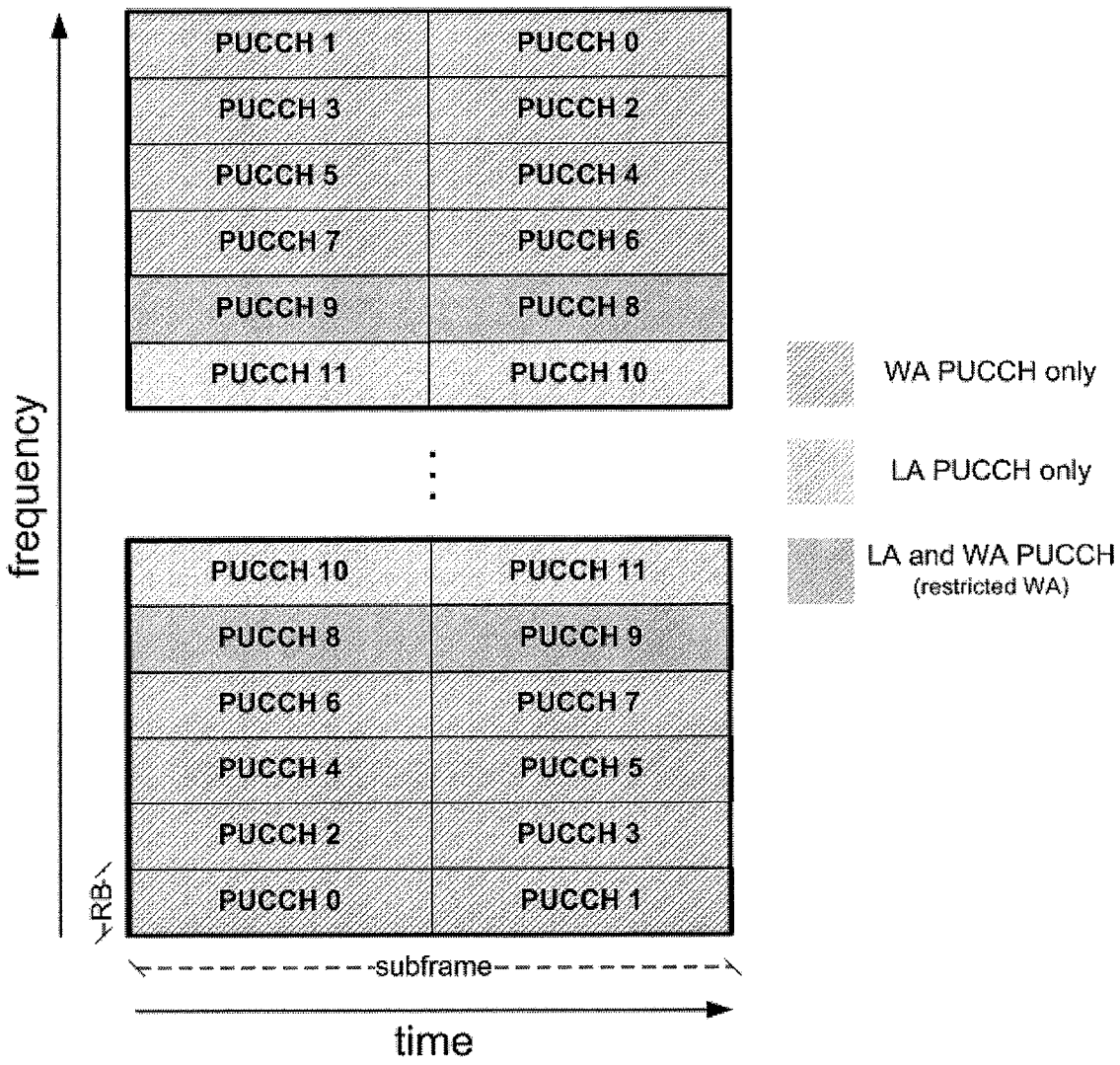
PUCCH 1
PUCCH 0
PUCCH 3
PUCCH 2
PUCCH 5
PUCCH 4
PUCCH 7
PUCCH 6
PUCCH 9
PUCCH 8
PUCCH 11
PUCCH 10
PUCCH 10
PUCCH 11
PUCCH 8
PUCCH 9
PUCCH 6
PUCCH 7
PUCCH 4
PUCCH 5
PUCCH 2
PUCCH 3
PUCCH 0
PUCCH 1
frequency
RB
subframe
time
WA PUCCH only
LA PUCCH only
LA and WA PUCCH
(restricted WA)

Fig. 4

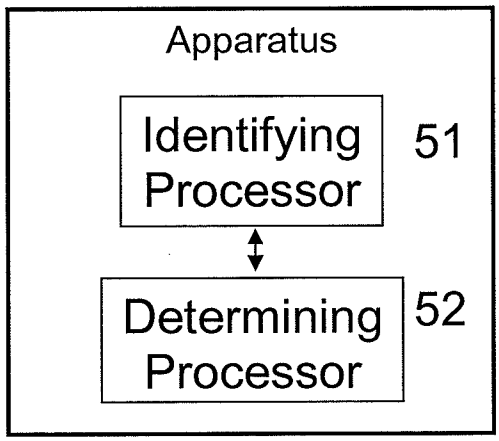
Apparatus
Identifying Processor
51
Determining Processor
52

Fig. 5

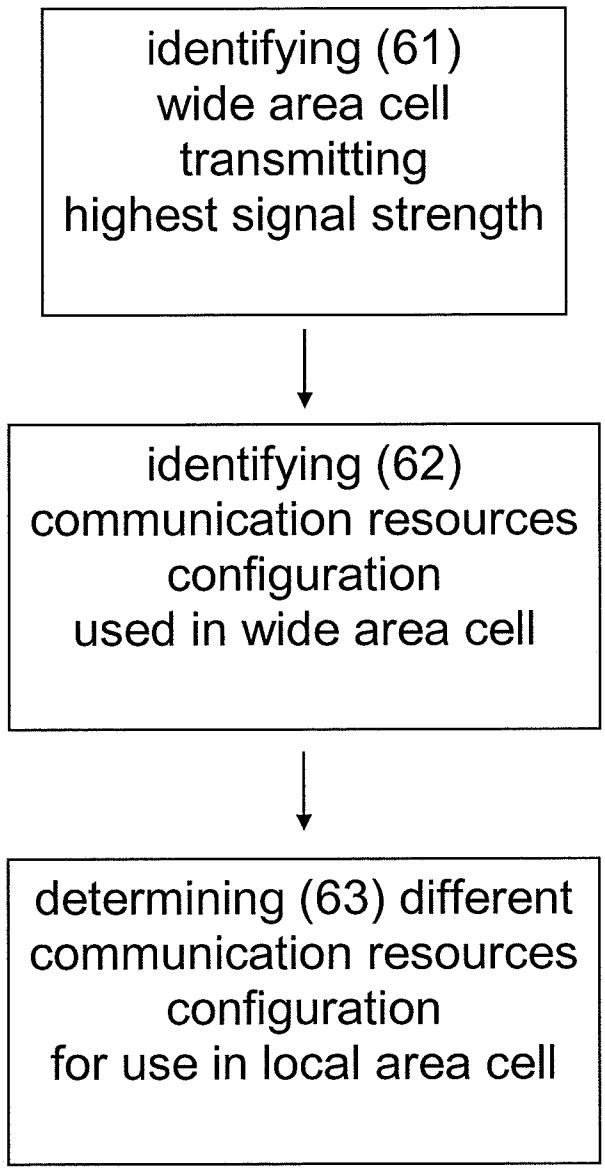
identifying (61)
wide area cell
transmitting
highest signal strength
identifying (62)
communication resources
configuration
used in wide area cell
determining (63) different
communication resources
configuration
for use in local area cell

Fig. 6

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/053314

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W16/16

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 practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | WO 98/39939 A (ERICSSON TELEFON AB L M [SE]) 11 September 1998 (1998-09-11) page 4, line 30 - page 5, line 10 | 1-26 |
| X | US 2007/097939 A1 (NYLANDER TOMAS [SE] ET AL) 3 May 2007 (2007-05-03) paragraph [0027] paragraph [0067] - paragraph [0076] | 1-26 |
| A | WO 98/09465 A (ERICSSON TELEFON AB L M [SE]) 5 March 1998 (1998-03-05) page 9, line 18 - page 10, line 18 | 1-26 |

-/--

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

[X] 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 document 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 |
|---|---|
| 12 February 2010 | 02/03/2010 |

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

# INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/053314

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
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| A | "3GPP TR 25.820 v8.2.0; 3rd Generation Partnership Project; Technical Specification Group Radio Access Networks; 3G Home NodeB Study Item Technical Report (Release 8)" 3GPP TR 25.820 V8.2.0,, vol. 25.820, no. v8.2.0, 1 September 2008 (2008-09-01), pages 1-40, XP002525355 cited in the application page 13 - page 24 | 1-26 |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2009/053314

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| | | AU 6641398 A | 22-09-1998 |
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| | | EE 9900383 A | 17-04-2000 |
| | | EP 0965243 A2 | 22-12-1999 |
| | | JP 3986566 B2 | 03-10-2007 |
| | | JP 2001513970 T | 04-09-2001 |
| US 2007097939 A1 | 03-05-2007 | NONE | |
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| | | US 5794157 A | 11-08-1998 |