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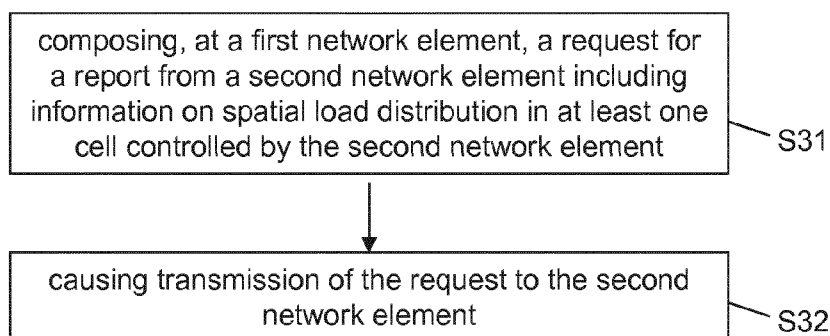
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(54) Title: EXCHANGE OF INFORMATION ON LOAD DISTRIBUTION IN NEIGHBOR CELLS

Fig. 3



(57) Abstract: Exchange of information on load distribution in neighbor cells The present invention provides methods, apparatuses and a computer program product relating to an exchange of information on load distribution in neighbor cells. The present invention includes composing, at a first network element, a request for a report from a second network element including information on spatial load distribution in at least one cell controlled by the second network element, and causing transmission of the request to the second network element.

DESCRIPTION

Title

Exchange of information on load distribution in neighbor cells

Field of the invention

The present invention relates to an exchange of information on load distribution in neighbor cells. In particular, the present invention relates to apparatuses, methods and a program for exchange of information on load distribution in neighbor cells.

Background of the invention

The present invention relates to mobile radio communications where flexible and dynamic deployment changes are enabled by active antenna systems (AAS) which are controlled in a self-organizing manner (self-organizing networks, SON).

Active antenna systems allow flexible adaptation of the cell deployment and aim on capacity optimization by changing the cell layout. The following methods can be applied and autonomous SON mechanisms should decide which method is most beneficial. The AAS methods that are considered normally are cell shaping, beam forming and cell splitting/merging.

In cell shaping, sector's length and width are adjusted, e.g. by tilt adaptation of group of adjacent cells. The intention of cell shaping is that the cell edge areas suffering from inter-cell interference can be placed in areas with less user density improving perceived signal quality and resulting in overall capacity enhancement.

Beam forming means concentration of radiation power for provisioning specific UEs or group of UEs by dedicated beam. The narrow beam increases antenna gain and, therefore, RX power while reducing interference emission. It improves Quality of Service (QoS) or capacity in the area where the beam is directed.

Cell splitting/merging is dealing with the method of cell densification. In contrast to cell shaping and beam forming, cell splitting increases the number of cells and consequently the number of radio resources per defined area.

The selection of the most appropriate AAS application can be done by an automated SON mechanism using the momentary traffic situation in a certain area as a criterion, particularly the traffic load and traffic distribution. That is, the load level information alone is not reliable as decision criterion. For instance, in case of cell splitting, the spatial traffic distribution in the overloaded cell plays a decisive role as demonstrated in Figs. 1 and 2.

The load of the cell in question (the cell 11 with the dots) is identical for both cases, however the spatial distribution of the traffic is different: in Fig. 1 a) cell splitting is beneficial since traffic can be shared between the new cells 12 and 13; in Fig. 1 b) cell splitting is useless, since inner sector 14 would be unused and all traffic would take place in new cell 15. For situations as shown in case b) cell shaping might be more beneficial, but cell shaping affects the neighboring cells and therefore also the information of the traffic situation of the neighboring cells is needed.

For this simple example, the knowledge of the traffic distribution of the own cell seems sufficient, but there are situations where also the traffic distribution within the neighboring cell is needed. Fig. 2 shows the situation of case b) of Fig. 1, including some neighboring cells 22 and 23 to cell 21. AAS is analyzing its own traffic distribution and realizes that overload situations results from a traffic cluster at a cell border where many resource block are needed to compensate the interference situation. With knowing also the traffic situation and distribution in the neighboring cells, AAS can analyze whether the use of another application like cell shaping is beneficial for capacity optimization. Knowing that most of the UEs are also located in close to the overloaded cell in question, i.e. cell 21, cell shaping is helpful in that the traffic hot spot is fully covered by extending (e.g. uptilt) cell 21. In order to keep interference limited, the coverage of the surrounding cells has to be reduced (e.g. downtilt), here, cells 22 and 23 are reduced, for example, as shown in Fig. 2.

In the LTE standards, load information exchange between cells is specified since Release 8. It has the form of total load information and of composite available capacity (CAC). This, however, offers no information about load distribution, because its purpose is load balancing.

Further, the 3GPP specifications offer tools to monitor interference, and possibly report problems (e.g. High Interference Indicator (HII) and Relative Narrowband TX Power (RNTP)). However, this is not a solution to the problem above, since the mechanisms are re-active and can be used to report problems that are already disturbing radio performance. In case of AAS configuration, their usage would require a trial-and-error approach.

Summary of the Invention

It is therefore an object of the present invention to overcome the above mentioned problems and to provide methods, apparatuses and a program for exchange of information on load distribution in neighbor cells.

According to an aspect of the present invention there is provided a method comprising:

- composing, at a first network element, a request for a report from a second network element including information on spatial load distribution in at least one cell controlled by the second network element, and

- causing transmission of the request to the second network element.

According to another aspect of the present invention there is provided a method comprising:

- causing reception of a request from a first network element at a second network element,

- composing a report including information on spatial load distribution in at least one cell controlled by the second network element.

According to another aspect of the present invention there is provided an apparatus comprising:

- at least one processor,

- at least one interface to at least one other network element, and

- at least one memory for storing instructions to be executed by the processor, wherein

- the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to perform:

- composing, at a first network element, a request for a report from a second network element including information on spatial load distribution in at least one cell controlled by the second network element, and

- causing transmission of the request to the second network element.

According to another aspect of the present invention there is provided an apparatus comprising:

- at least one processor,
- at least one interface to at least one other network element, and
- at least one memory for storing instructions to be executed by the processor, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to perform:

- causing reception of a request from a first network element at a second network element,

- composing a report including information on spatial load distribution in at least one cell controlled by the second network element.

According to another aspect of the present invention there is provided an apparatus comprising:

- means for composing, at a first network element, a request for a report from a second network element including information on spatial load distribution in at least one cell controlled by the second network element, and

- means for causing transmission of the request to the second network element.

According to another aspect of the present invention there is provided an apparatus comprising:

- means for causing reception of a request from a first network element at a second network element,

- means for composing a report including information on spatial load distribution in at least one cell controlled by the second network element.

According to another aspect of the present invention there is provided a computer program product comprising code means adapted to produce steps of any of the methods as described above when loaded into the memory of a computer.

According to a still further aspect of the invention there is provided a computer program product as defined above, wherein the computer program product comprises a computer-readable medium on which the software code portions are stored.

According to a still further aspect of the invention there is provided a computer program product as defined above, wherein the program is directly loadable into an internal memory of the processing device.

Brief Description of the Drawings

These and other objects, features, details and advantages will become more fully apparent from the following detailed description of aspects/embodiments of the present invention which is to be taken in conjunction with the appended drawings, in which:

Figs. 1a and 1b are diagrams illustrating dependency of cell splitting benefit from traffic distribution;

Fig. 2 is a diagram illustrating an influence of cell deployment adaptations based on cell shaping on neighboring cells;

Fig. 3 is a flowchart illustrating an example of a method according to certain embodiments of the present invention;

Fig. 4 is a flowchart illustrating another example of a method according to certain embodiments of the present invention;

Fig. 5 is a block diagram illustrating an example of an apparatus according to certain embodiments of the present invention.

Detailed Description

In the following, examples and embodiments of the present invention are described with reference to the drawings. For illustrating the present invention, the examples and embodiments will be described in connection with a cellular communication network based on a 3GPP based communication system, for example an LTE/LTE-A based system. However, it is to be noted that the present invention is not limited to an application using such types of communication system, but is also applicable in other types of communication systems and the like.

Basic system architecture of a communication network where examples of embodiments of the invention are applicable may comprise a commonly known architecture of one or more communication systems comprising a wired or wireless access network subsystem and a core network. Such an architecture may comprise one or more access network control elements, radio access network elements, access service network gateways or base transceiver stations, such as a base station or eNB, which control a coverage area also referred to as a cell and with which one or more communication elements or terminal devices such as a user equipment (UE) or another device having a similar function, such as a modem chipset, a chip, a module etc., which can also be part of a UE or attached as a separate element to a UE, or the like, are capable to communicate via one or more channels for transmitting several types of data. Furthermore, core network elements such as gateway network elements, policy and charging control network elements, mobility management entities and the like may be comprised.

The general functions and interconnections of the described elements, which also depend on the actual network type, are known to those skilled in the art and described in corresponding specifications, so that a detailed description thereof is omitted herein. However, it is to be noted that several additional network elements and signaling links may be employed for a communication to or from a communication element or terminal device like a UE and a communication network control element like a radio network controller, besides those described in detail herein below.

Furthermore, the described network elements, such as communication network control elements, like an eNB, and the like, as well as corresponding functions as described herein may be implemented by software, e.g. by a computer program product for a computer, and/or by hardware. In any case, for executing their respective functions, correspondingly used devices, nodes or network elements may comprise several means and components (not shown) which are required for control, processing and communication/signaling functionality. Such means may comprise, for example, one or more processor units including one or more processing portions for executing instructions, programs and for processing data, memory means for storing instructions, programs and data, for serving as a work area of the processor or processing portion and the like (e.g. ROM, RAM, EEPROM, and the like), input means for inputting data and instructions by software (e.g. floppy disc, CD-ROM, EEPROM, and the like), user interface means for providing monitor and manipulation possibilities to a user (e.g. a screen, a keyboard and the like), interface means for

establishing links and/or connections under the control of the processor unit or portion (e.g. wired and wireless interface means, an antenna, etc.) and the like. It is to be noted that in the present specification processing portions should not be only considered to represent physical portions of one or more processors, but may also be considered as a logical division of the referred processing tasks performed by one or more processors.

According to certain embodiments of the present invention, there are proposed means to bring the information of the spatial traffic distribution of the neighboring cells to the SON entity deciding about the AAS application.

According to certain embodiments of the present invention, there is provided a mechanism that provides information about part of load that is located next to the common cell border. As an example, this is proposed to be based on enhanced Resource Status Reporting Initiation and Resource Status Reporting X2 procedures. The enhanced procedures enable passing information about load level, or part of the total load that is generated by UEs that are located next to the cell border.

The Resource Status Request Initiation procedure enables the requesting eNB to specify the threshold that defines what “next to the cell border” means in radio terms. According to certain embodiments of the present invention, the enhanced procedure is as follows:

The eNB_1 requests eNB_2 about load level in given cells or fraction of the total load in given cells, that is generated by UEs served at eNB_2, but located next to the border to cells listed in the request, or any cell controlled by eNB_1. Therefore, the eNB_1 sends enhanced RESOURCE STATUS REQUEST to eNB_2. The enhancement according to certain embodiments of the present invention is:

1. threshold defining the proximity, which should correspond to radio signal quality/strength of the cells controlled by eNB_1, recorded at the UEs served at eNB_2;
2. optionally: list of cells controlled by eNB_1 that the proximity shall be measured to.

In view of the above, the eNB_1 sends a request to the eNB_2 and in order to get information from the eNB_2 like “what is the load in the proximity of X dB?”.

However, it is noted that according to certain embodiments of the present invention, it is also possible that the request is basically reversed, i.e. that the eNB_1 requests information from the eNB_2 about “at what distance (in dB) do you have X% of your load?”.

The eNB_2 responds as described in the Resource Status Reporting Initiation procedure as defined in 3GPP TS 36.423, i.e. by sending RESOURCE STATUS RESPONSE or RESOURCE STATUS FAILURE. If the requested measurements are accepted, it also starts reporting using enhanced RESOURCE STATUS UPDATE. The enhancement is the new type of report related to the enhanced request. It may, for example, be expressed in relation to the overall load, i.e. the percentage of load in certain proximity. Generally, the overall load level or composite available capacity (CAC) is expressed as percent of all available physical resource blocks (PRBs) and divided into uplink/downlink (DL/UL). Here, it is expressed not in relation to the available resources but in relation to the used resources.

The practical implementation of certain embodiments of the present invention described above relies on the ability to measure the load distribution. This is an intra-eNB feature, and therefore can be implemented in many specific ways. In the following, two methods according to certain embodiments of the present invention are presented as examples. However, as noted above, many other specific ways are conceivable and the present invention is not limited to the examples described in the following.

In all cases, the starting point is the reception of enhanced RESOURCE STATUS REQUEST, where the new request is the load level in the proximity of the cell border and the proximity is defined as offset between signal strength of Primary Cell (PCell) and a neighbour cell [dB]. The Request contains also a list of cells (identified with PCIs (physical cell identifiers) or ECGIs (E-UTRAN (Evolved UTRAN (UMTS (Universal Mobile Telecommunication System) Terrestrial Radio Access network) Cell Global Identifiers)) that the proximity information shall be applied to. Besides the load in the proximity, the request includes also already defined Radio Resource Status flag, so that the total load is to be reported, too. The request is assumed to be admitted.

In a first example according to certain embodiments of the present invention, the eNB that received the request configures dedicated measurement A3 events to its UEs. The event is configured so that the A3-Offset is set accordingly to the proximity definition in the enhanced RESOURCE STATUS REQUEST. The eNB sets the reportOnLeave to true, too.

The A3-Offset is an offset to be used in evaluation of EUTRA measurement report triggering condition for event A3 and corresponds to parameter *a3-Offset* specified in ReportConfigEUTRA IE in 3GPP TS 36.331 section 6.3.5. Mapping to actual values is specified in 3GPP TS 36.133.

The parameter “reportOnLeave” indicates whether or not the UE shall initiate the measurement reporting procedure when the leaving condition is met for event A3 for a cell in cellsTriggeredList, as specified in 3GPP TS 36.331 section 5.5.4.4.

The eNB collects reports from the UEs and if the reported PCI corresponds to the cell from the list, it considers this UE as located next to the cell border (in case of entering report) or leaving this area (in case of leaving report). Thus, it is able to know which UEs are in the requested proximity zone. Since the eNB serves the UEs, it is also able to tell how many PRBs are allocated to those UEs.

The event A3 (Neighbor becomes offset better than PCell) is defined in TS 36.331 section 5.4.4.4 as follows.

The UE shall:

- consider the entering condition for this event to be satisfied when condition A3-1, as specified below, is fulfilled;
- consider the leaving condition for this event to be satisfied when condition A3-2, as specified below, is fulfilled;

NOTE The cell(s) that triggers the event is on the frequency indicated in the associated *measObject* which may be different from the (primary) frequency used by the PCell.

Inequality A3-1 (Entering condition)

$$Mn + Ofn + Ocn - Hys > Mp + Ofp + Ocp + Off$$

Inequality A3-2 (Leaving condition)

$$Mn + Ofn + Ocn + Hys < Mp + Ofp + Ocp + Off$$

The variables in the formula are defined as follows:

Mn is the measurement result of the neighbouring cell, not taking into account any offsets.
Ofn is the frequency specific offset of the frequency of the neighbour cell (i.e. *offsetFreq* as defined within *measObjectEUTRA* corresponding to the frequency of the neighbour cell).

Ocn is the cell specific offset of the neighbour cell (i.e. *cellIndividualOffset* as defined within *measObjectEUTRA* corresponding to the frequency of the neighbour cell), and set to zero if not configured for the neighbour cell.

Mp is the measurement result of the PCell, not taking into account any offsets.

Ofp is the frequency specific offset of the primary frequency (i.e. *offsetFreq* as defined within *measObjectEUTRA* corresponding to the primary frequency).

Ocp is the cell specific offset of the PCell (i.e. *cellIndividualOffset* as defined within *measObjectEUTRA* corresponding to the primary frequency), and is set to zero if not configured for the PCell.

Hys is the hysteresis parameter for this event (i.e. *hysteresis* as defined within *reportConfigEUTRA* for this event).

Off is the offset parameter for this event (i.e. *a3-Offset* as defined within *reportConfigEUTRA* for this event).

Mn, *Mp* are expressed in dBm in case of RSRP, or in dB in case of RSRQ.

Ofn, *Ocn*, *Ofp*, *Ocp*, *Hys*, *Off* are expressed in dB.

This first example according to certain embodiments of the present invention is based on existing standard measurement and precise (UE reporting).

In a second example according to certain embodiments of the present invention, the eNB collects statistics related indirectly to UE location: namely, the recorded (at the eNB) UL Power Headroom and Timing Advance (TA). This is correlated with RSRP/RSRQ (Reference Signal Received Power / Reference Signal Received Quality) of UEs reporting handover (HO) opportunity. This way, assuming also particular radio propagation model, a mapping relation is built that enables to estimate or extrapolate RSRP/RSRQ of UEs with particular UL Power Headroom and/or Timing Advance. Using the mapping relation, the eNB can estimate how many of served UEs are in the requested proximity zone to particular neighbor cell.

This second example according to certain embodiments of the present invention does not involve UE measurements/reporting. Further, it enables to consider dynamism of the load distribution changes.

It is noted that another possibility to specify proximity would be directly based on Timing Advance (TA) measurements, namely the load generated by UEs with the x% highest TA values, or a combination of all measurements which even renders a more precise proximity zone.

In both cases according to the first and second example described above, the enhanced RESOURCE STATUS UPDATE message can be compiled and it includes:

- Total load in the requested cells;
- Load in the proximity zone.

The eNB receiving the status update is therefore aware of the load distribution and load level in the proximity area around its cell(s).

According to certain embodiments of the present invention, the accuracy in reporting load in neighbor cells can be improved.

Fig. 3 is a flowchart illustrating an example of a method according to certain embodiments of the present invention.

According to certain embodiments of the present invention, the method may be implemented in a network element like an eNB or part of the eNB and comprises composing, at a first network element, a request for a report from a second network element including information on spatial load distribution in at least one cell controlled by the second network element in a step S31, and causing transmission of the request to the second network element in a step S32.

According to certain embodiments of the present invention, the request for the report concerns the load generated by user equipments that are located in a certain proximity to cell borders of the at least one cell controlled by the second network element bordering to at least one specific cell controlled by the first network element.

According to certain embodiments of the present invention, the method further comprises causing reception of the report from the second network element, the report including information according to the request.

According to certain embodiments of the present invention, the at least one specific cell is a cell included in a list in the request or any cell controlled by the first network element.

According to certain embodiments of the present invention, the proximity is defined by a threshold corresponding to radio signal quality or radio signal strength of the at least one cell controlled by the first network element recorded at the user equipments served by the second network element.

According to certain embodiments of the present invention, the method further comprises configuring, at the first network element, the request indicating the proximity and the cells of interest controlled by the second network element.

According to certain embodiments of the present invention, the request is included in a resource status request message and the report is included in a resource status update message.

Fig. 4 is a flowchart illustrating another example of a method according to certain embodiments of the present invention.

According to certain embodiments of the present invention, the method may be implemented in a network element like an eNB or part of the eNB and comprises causing reception of a request from a first network element at a second network element in a step S41, and composing a report including information on spatial load distribution in at least one cell controlled by the second network element in a step S42.

According to certain embodiments of the present invention, the report includes information on load generated by user equipments that are located in proximity to cell borders of at least one cell controlled by the second network element bordering to at least one specific cell controlled by the first network element.

According to certain embodiments of the present invention, the method further comprises causing transmission of the report to the first network element in a step S43.

According to certain embodiments of the present invention, the method further comprises configuring, at the second network element, dedicated measurement events to the user equipments controlled by the second network element, causing reception of measurement reports from the user equipments, and determining whether the user equipment is located in the proximity to the cell borders based on the received measurement report.

According to certain embodiments of the present invention, it is determined that a user equipment is located in the proximity to the cell borders when the measurement reports indicates that the user equipment has entered the proximity to the cell borders, and it is determined that a user equipment is not located in the proximity to the cell borders when the measurement reports indicates that the user equipment has left the proximity to the cell borders, the determination being made based on predetermined conditions.

According to certain embodiments of the present invention, the method further comprises estimating, at the second network element, reference signal received power or reference signal received quality of user equipment based on uplink power headroom and timing advance of the user equipment recorded at the second network element, and determining whether the user equipment is located in the proximity to the cell borders based on the reference signal received power or reference signal received quality.

According to certain embodiments of the present invention, the at least one specific cell is a cell included in a list in the request or any cell controlled by the first network element.

According to certain embodiments of the present invention, the proximity is defined by a threshold corresponding to radio signal quality or radio signal strength of the at least one cell controlled by the first network element recorded at the user equipments served by the second network element.

According to certain embodiments of the present invention, the method further comprises configuring, at the first network element, the request indicating the proximity and the cells of interest controlled by the second network element.

According to certain embodiments of the present invention, the request is included in a resource status request message and the report is included in a resource status update message.

Fig. 5 is a block diagram showing an example of an apparatus according to certain embodiments of the present invention.

In Fig. 5, a block circuit diagram illustrating a configuration of an apparatus 50, such as of a network element like a base station, eNB or the like, is shown, which is configured to implement the above described aspects of the invention. It is to be noted that the apparatus 50 shown in Fig. 5 may comprise several further elements or functions besides those described herein below, which are omitted herein for the sake of simplicity as they are not essential for understanding the invention. Furthermore, even though reference is made to a base station or network element, the apparatus may be also another device having a similar function, such as a chipset, a chip, a module etc., which can also be part of a base station or network element or attached as a separate element to a base station or network element, or the like.

The apparatus 50 may comprise a processing function or processor 51, such as a CPU or the like, which executes instructions given by programs or the like related to the flow control mechanism. The processor 51 may comprise one or more processing portions dedicated to specific processing as described below, or the processing may be run in a single processor. Portions for executing such specific processing may be also provided as discrete elements or within one or more further processors or processing portions, such as in one physical processor like a CPU or in several physical entities, for example. Reference sign 52 denotes transceiver or input/output (I/O) units (interfaces) connected to the processor 51. The I/O units 52 may be used for communicating with one or more network elements and/or user equipments. The I/O units 52 may be a combined unit comprising communication equipment towards several network elements, or may comprise a distributed structure with a plurality of different interfaces for different network elements. Reference sign 53 denotes a memory usable, for example, for storing data and programs to be executed by the processor 51 and/or as a working storage of the processor 51.

The processor 51 is configured to execute processing related to the above described aspects. In particular, the processor 51 is configured to perform composing, at a first network element, a request for a report from a second network element including information on spatial load distribution in at least one cell controlled by the second network element, and causing transmission of the request to the second network element.

Further, the processor 51 is configured to perform causing reception of a request from a first network element at a second network element, and composing a report including information on spatial load distribution in at least one cell controlled by the second network element.

For further functions of the apparatus according to further example embodiments of the present invention, reference is made to the above description of methods according to certain embodiments of the present invention, as described in connection with Figs. 3 and 4.

According to certain aspects of the present invention, there is also provided a network element like, e.g. a base station that comprises any apparatus as defined above.

In the foregoing exemplary description of the apparatuses, only the units/means that are relevant for understanding the principles of the invention have been described using functional blocks. The apparatus may comprise further units/means that are necessary for its respective operation as network element, respectively. However, a description of these units/means is omitted in this specification. The arrangement of the functional blocks of the apparatus is not construed to limit the invention, and the functions may be performed by one block or further split into sub-blocks.

When in the foregoing description it is stated that the apparatus (or some other means) is configured to perform some function, this is to be construed to be equivalent to a description stating that a (i.e. at least one) processor or corresponding circuitry, potentially in cooperation with computer program code stored in the memory of the respective apparatus, is configured to cause the apparatus to perform at least the thus mentioned function. Also, such function is to be construed to be equivalently implementable by specifically configured circuitry or means for performing the respective function (i.e. the expression "unit configured to" is construed to be equivalent to an expression such as "means for").

For the purpose of the present invention as described herein above, it should be noted that - method steps likely to be implemented as software code portions and being run using a processor at an apparatus (as examples of devices, apparatuses and/or modules thereof, or as examples of entities including apparatuses and/or modules therefore), are software code independent and can be specified using any known or future developed programming language as long as the functionality defined by the method steps is preserved;

- generally, any method step is suitable to be implemented as software or by hardware without changing the idea of the aspects/embodiments and its modification in terms of the functionality implemented;
- method steps and/or devices, units or means likely to be implemented as hardware components at the above-defined apparatuses, or any module(s) thereof, (e.g., devices carrying out the functions of the apparatuses according to the aspects/embodiments as described above) are hardware independent and can be implemented using any known or future developed hardware technology or any hybrids of these, such as MOS (Metal Oxide Semiconductor), CMOS (Complementary MOS), BiMOS (Bipolar MOS), BiCMOS (Bipolar CMOS), ECL (Emitter Coupled Logic), TTL (Transistor-Transistor Logic), etc., using for example ASIC (Application Specific IC (Integrated Circuit)) components, FPGA (Field-programmable Gate Arrays) components, CPLD (Complex Programmable Logic Device) components or DSP (Digital Signal Processor) components;
- devices, units or means (e.g. the above-defined apparatuses, or any one of their respective units/means) can be implemented as individual devices, units or means, but this does not exclude that they are implemented in a distributed fashion throughout the system, as long as the functionality of the device, unit or means is preserved;
- an apparatus may be represented by a semiconductor chip, a chipset, or a (hardware) module comprising such chip or chipset; this, however, does not exclude the possibility that a functionality of an apparatus or module, instead of being hardware implemented, be implemented as software in a (software) module such as a computer program or a computer program product comprising executable software code portions for execution/being run on a processor;
- a device may be regarded as an apparatus or as an assembly of more than one apparatus, whether functionally in cooperation with each other or functionally independently of each other but in a same device housing, for example.

In general, it is to be noted that respective functional blocks or elements according to above-described aspects can be implemented by any known means, either in hardware and/or software, respectively, if it is only adapted to perform the described functions of the respective parts. The mentioned method steps can be realized in individual functional blocks or by individual devices, or one or more of the method steps can be realized in a single functional block or by a single device.

Generally, any method step is suitable to be implemented as software or by hardware without changing the idea of the present invention. Devices and means can be implemented as individual devices, but this does not exclude that they are implemented in a distributed fashion throughout the system, as long as the functionality of the device is preserved. Such and similar principles are to be considered as known to a skilled person.

Software in the sense of the present description comprises software code as such comprising code means or portions or a computer program or a computer program product for performing the respective functions, as well as software (or a computer program or a computer program product) embodied on a tangible medium such as a computer-readable (storage) medium having stored thereon a respective data structure or code means/portions or embodied in a signal or in a chip, potentially during processing thereof.

It is noted that the aspects/embodiments and general and specific examples described above 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 which fall within the scope of the appended claims are covered.

CLAIMS

1. A method, comprising:

composing, at a first network element, a request for a report from a second network element including information on spatial load distribution in at least one cell controlled by the second network element, and

causing transmission of the request to the second network element.

2. The method according to claim 1, wherein

the request for the report concerns the load generated by user equipments that are located in a certain proximity to cell borders of the at least one cell controlled by the second network element bordering to at least one specific cell controlled by the first network element

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

causing reception of the report from the second network element, the report including information according to the request.

4. A method, comprising:

causing reception of a request from a first network element at a second network element,

composing a report including information on spatial load distribution in at least one cell controlled by the second network element.

5. The method according to claim 4, wherein

The report includes information on load generated by user equipments that are located in proximity to cell borders of at least one cell controlled by the second network element bordering to at least one specific cell controlled by the first network element.

6. The method according to claim 4 or 5, further comprising

causing transmission of the report to the first network element.

7. The method according to any one of claims 4 to 6, further comprising

configuring, at the second network element, dedicated measurement events to the user equipments controlled by the second network element,

causing reception of measurement reports from the user equipments, and
determining whether the user equipment is located in the proximity to the cell borders
based on the received measurement report.

8. The method according to claim 7, wherein

it is determined that a user equipment is located in the proximity to the cell borders
when the measurement reports indicates that the user equipment has entered the proximity
to the cell borders, and

it is determined that a user equipment is not located in the proximity to the cell
borders when the measurement reports indicates that the user equipment has left the
proximity to the cell borders,

the determination being made based on predetermined conditions.

9. The method according to any one of claims 4 to 6, further comprising

estimating, at the second network element, reference signal received power or
reference signal received quality of user equipment based on uplink power headroom and
timing advance of the user equipment recorded at the second network element, and

determining whether the user equipment is located in the proximity to the cell borders
based on the reference signal received power or reference signal received quality.

10. The method according to any one of claims 1 to 9, wherein

the at least one specific cell is a cell included in a list in the request or any cell
controlled by the first network element.

11. The method according to any one of claims 1 to 10, wherein

the proximity is defined by a threshold corresponding to radio signal quality or radio
signal strength of the at least one cell controlled by the first network element recorded at the
user equipments served by the second network element.

12. The method according to any one of claims 1 to 11, further comprising

configuring, at the first network element, the request indicating the proximity and the
cells of interest controlled by the second network element.

13. The method according to any one of claims 1 to 12, wherein

the request is included in a resource status request message and the report is included in a resource status update message.

14. An apparatus, comprising:

at least one processor,

at least one interface to at least one other network element, and

at least one memory for storing instructions to be executed by the processor, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to perform:

composing, at a first network element, a request for a report from a second network element including information on spatial load distribution in at least one cell controlled by the second network element, and

causing transmission of the request to the second network element.

15. The apparatus according to claim 14, wherein

the request for the report concerns the load generated by user equipments that are located in a certain proximity to cell borders of the at least one cell controlled by the second network element bordering to at least one specific cell controlled by the first network element.

16. The apparatus according to claim 14 or 15, wherein the at least one memory and the instructions are further configured to, with the at least one processor, cause the apparatus to perform:

causing reception of the report from the second network element, the report including information according to the request.

17. An apparatus, comprising:

at least one processor,

at least one interface to at least one other network element, and

at least one memory for storing instructions to be executed by the processor, wherein the at least one memory and the instructions are configured to, with the at least one processor, cause the apparatus at least to perform:

causing reception of a request from a first network element at a second network element,

composing a report including information on spatial load distribution in at least one cell controlled by the second network element.

18. The apparatus according to claim 17, wherein

The report includes information on load generated by user equipments that are located in proximity to cell borders of at least one cell controlled by the second network element bordering to at least one specific cell controlled by the first network element.

19. The apparatus according to claim 17 or 18, wherein the at least one memory and the instructions are further configured to, with the at least one processor, cause the apparatus to perform

causing transmission of the report to the first network element.

20. The apparatus according to any one of claims 17 to 19, wherein the at least one memory and the instructions are further configured to, with the at least one processor, cause the apparatus to perform

configuring, at the second network element, dedicated measurement events to the user equipments controlled by the second network element,

causing reception of measurement reports from the user equipments, and

determining whether the user equipment is located in the proximity to the cell borders based on the received measurement report.

21. The apparatus according to claim 20, wherein

it is determined that a user equipment is located in the proximity to the cell borders when the measurement reports indicates that the user equipment has entered the proximity to the cell borders, and

it is determined that a user equipment is not located in the proximity to the cell borders when the measurement reports indicates that the user equipment has left the proximity to the cell borders,

the determination being made based on predetermined conditions.

22. The apparatus according to any one of claims 17 to 19, wherein the at least one memory and the instructions are further configured to, with the at least one processor, cause the apparatus to perform

estimating, at the second network element, reference signal received power or reference signal received quality of user equipment based on uplink power headroom and timing advance of the user equipment recorded at the second network element, and

determining whether the user equipment is located in the proximity to the cell borders based on the reference signal received power or reference signal received quality.

23. The apparatus according to any one of claims 14 to 22, wherein

the at least one specific cell is a cell included in a list in the request or any cell controlled by the first network element.

24. The apparatus according to any one of claims 14 to 23, wherein

the proximity is defined by a threshold corresponding to radio signal quality or radio signal strength of the at least one cell controlled by the first network element recorded at the user equipments served by the second network element.

25. The apparatus according to any one of claims 14 to 24, wherein the at least one memory and the instructions are further configured to, with the at least one processor, cause the apparatus to perform

configuring, at the first network element, the request indicating the proximity and the cells of interest controlled by the second network element.

26. The apparatus according to any one of claims 14 to 25, wherein

the request is included in a resource status request message and the report is included in a resource status update message.

27. An apparatus, comprising:

means for composing, at a first network element, a request for a report from a second network element including information on spatial load distribution in at least one cell controlled by the second network element, and

means for causing transmission of the request to the second network element.

28. An apparatus, comprising:

means for causing reception of a request from a first network element at a second network element,

means for composing a report including information on spatial load distribution in at least one cell controlled by the second network element.

29. A computer program product including a program for a processing device, comprising software code portions for performing the steps of any one of claims 1 to 13 when the program is run on the processing device.

30. The computer program product according to claim 29, wherein the computer program product comprises a computer-readable medium on which the software code portions are stored.

31. The computer program product according to claim 29, wherein the program is directly loadable into an internal memory of the processing device.

Fig. 1a

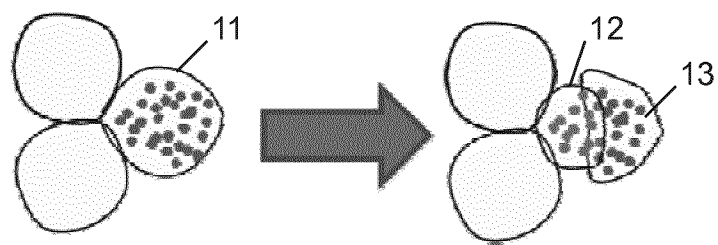


Fig. 1b

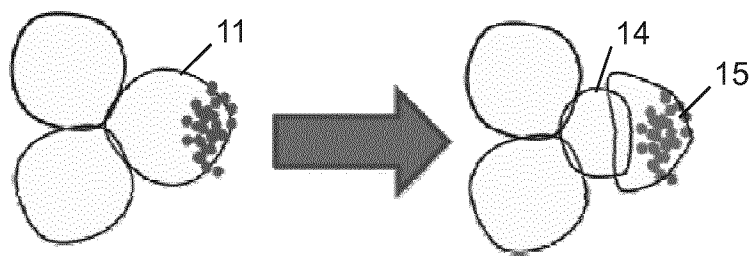


Fig. 2

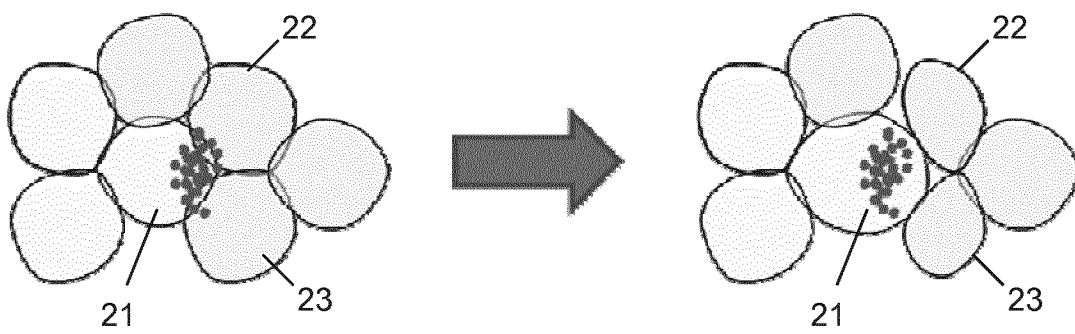


Fig. 3

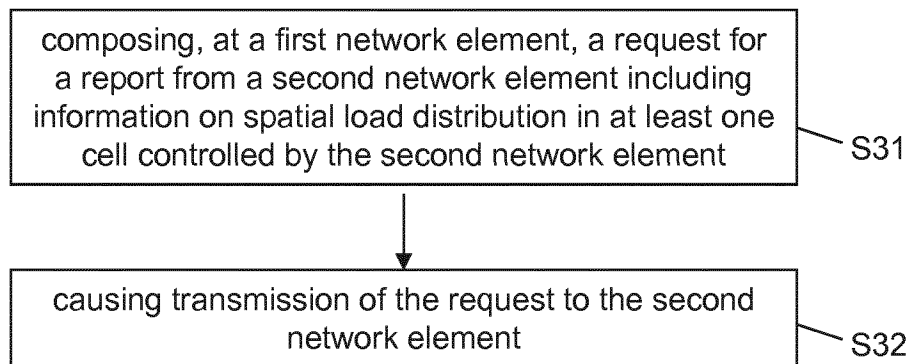


Fig. 4

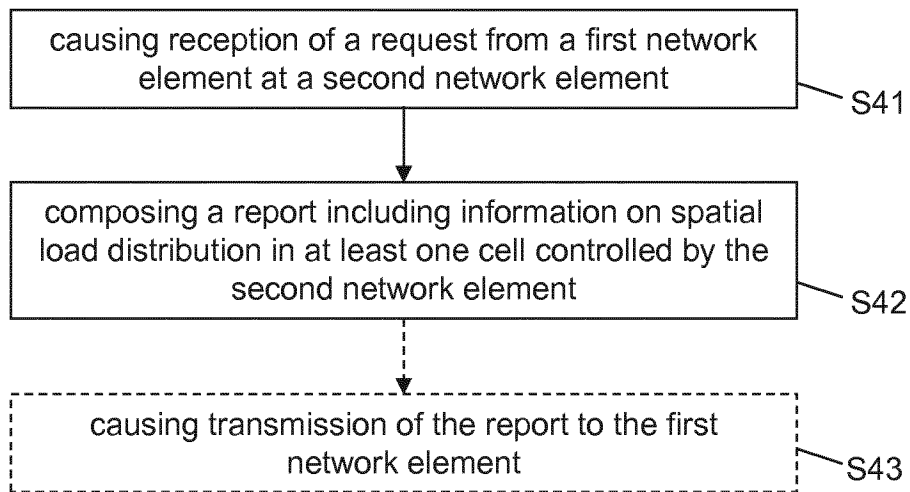
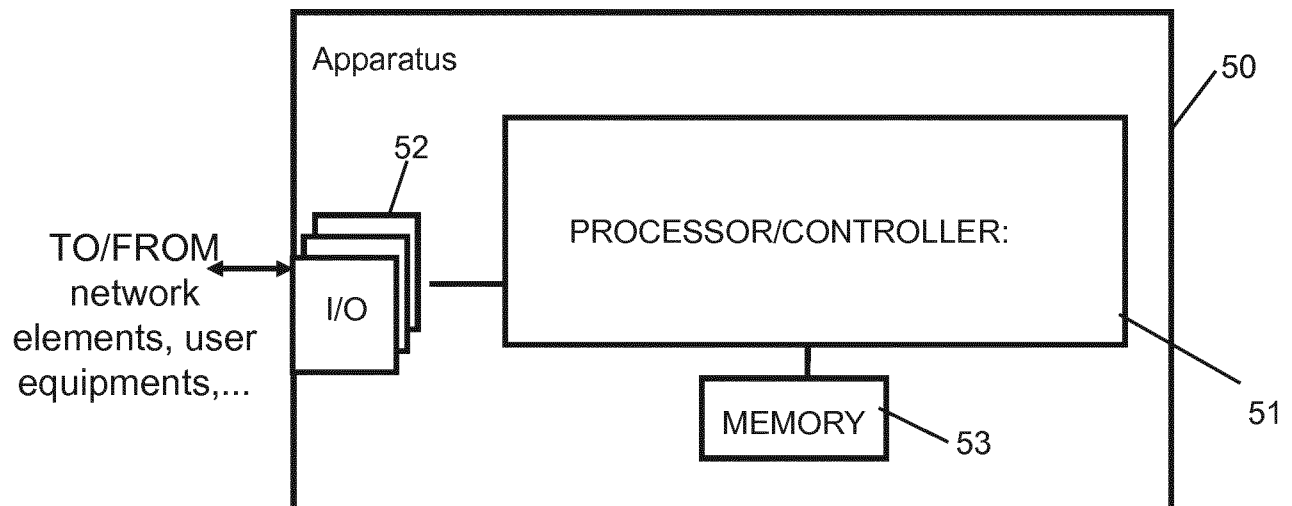


Fig. 5



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2013/069809

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W28/08
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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, COMPENDEX, 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	US 2013/072212 A1 (NAKAMURA KAZUTAKA [JP] ET AL) 21 March 2013 (2013-03-21) column 6 - column 15 column 90 - column 111	1-31
X	WO 2013/071756 A1 (ZTE CORP [CN]; CHEN BEI [CN]; LI WEI [CN]; LIU ZHI [CN]) 23 May 2013 (2013-05-23) abstract	1,4,14, 17,27-29
X	CN 102 685 811 A (ZTE CORP) 19 September 2012 (2012-09-19) abstract	1,4,14, 17,27-29
A	US 2013/090126 A1 (XING SHUQING [US] ET AL) 11 April 2013 (2013-04-11) the whole document	1-31
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☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"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

14 May 2014

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22/05/2014

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2013/069809

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2012/152306 A1 (NOKIA SIEMENS NETWORKS OY [FI]; HAMALAINEN SEPPO OLAVI [FI]; YILMAZ OS) 15 November 2012 (2012-11-15) the whole document -----	1-31

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2013/069809

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		WO 2013071756 A1	23-05-2013

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		US 2014113676 A1	24-04-2014
		WO 2012152306 A1	15-11-2012
