



(51) International Patent Classification:
H04W 28/08 (2009.01)

(21) International Application Number:
PCT/CN2014/070399

(22) International Filing Date:
9 January 2014 (09.01.2014)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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

[Continued on next page]

(54) Title: METHOD AND APPARATUS

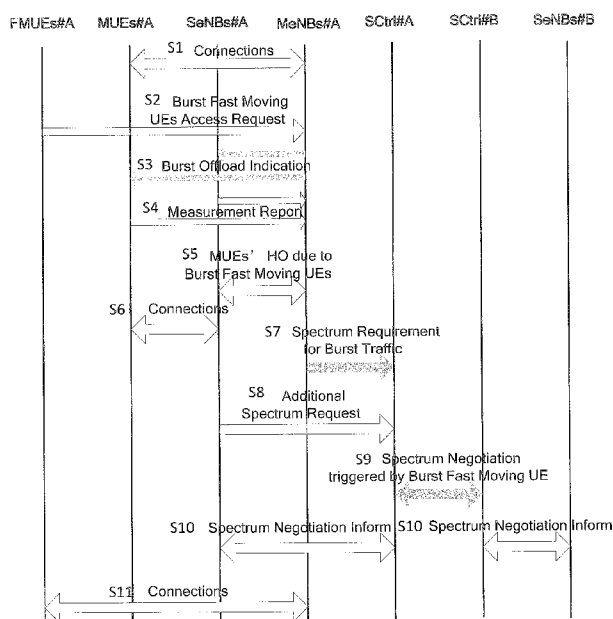


Figure 6

(57) Abstract: A method comprises causing information to be sent to at least one of a smaller cell base station and a plurality of user equipment, said information indicating that a burst of traffic is to be supported within a coverage area comprising a larger cell and at least part of at least one smaller cell provided by said at least one smaller cell base station.

Declarations under Rule 4.17:

— *of inventorship (Rule 4.17(iv))*

Published:

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

METHOD AND APPARATUS

Some embodiments relate to a method and apparatus and in particular but not exclusively to a method and apparatus which may be used for spectrum
5 sharing.

A communication system can be seen as a facility that enables communication sessions between two or more nodes such as fixed or mobile communication devices, access points such as base stations, servers, machine type servers, routers, and so on. A communication system and compatible
10 communicating devices typically operate in accordance with a given standard or specification which sets out what the various entities associated with the system are permitted to do and how that should be achieved. For example, the standards, specifications and related protocols can define the manner how communication devices shall communicate with the access points, how various aspects of the
15 communications shall be implemented and how the devices and functionalities thereof shall be configured.

A user can access the communication system by means of an appropriate communication device. A communication device of a user is often referred to as user equipment (UE) or terminal.

20 Signals can be carried on wired or wireless carriers. Examples of wireless systems include public land mobile networks (PLMN), satellite based communication systems and different wireless local networks, for example wireless local area networks (WLAN). Wireless systems can be divided into coverage areas referred to as cells, such systems being often referred to as
25 cellular systems. A cell can be provided by a base station, there being various different types of base stations. Different types of cells can provide different features. For example, cells can have different shapes, sizes, functionalities and other characteristics. A cell is typically controlled by a control node.

A communication device is provided with an appropriate signal receiving
30 and transmitting arrangement for enabling communications with other parties. In wireless systems a communication device provides a transceiver station that can communicate with another communication device such as e.g. a base station

and/or another user equipment. A communication device such as a user equipment (UE) may access a carrier provided by a base station, and transmit and/or receive on the carrier.

5 An example of cellular communication systems is an architecture that is being standardized by the 3rd Generation Partnership Project (3GPP). A recent development in this field is often referred to as the long-term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) radio-access technology. In LTE base stations providing the cells are commonly referred to as enhanced NodeBs (eNB). An eNB can provide coverage for an entire cell or similar radio
10 service area.

Cells can provide different service areas. For example, some cells may provide wide coverage areas while some other cells provide smaller coverage areas. The smaller radio coverage areas can be located wholly or partially within a larger radio coverage area. For example, in LTE a node providing a relatively wide
15 coverage area is referred to as a macro eNB. Examples of nodes providing smaller cells, or local radio service areas, include femto nodes such as Home eNBs (HeNB), pico nodes such as pico eNodeBs (pico-eNB) and remote radio heads.

According to an aspect, there is provided a method comprising: causing information to be sent to at least one of a smaller cell base station and a plurality
20 of user equipment, said information indicating that a burst of traffic is to be supported within a coverage area comprising a larger cell and at least part of at least one smaller cell provided by said at least one smaller cell base station.

The information may be configured to indicate that at least some traffic in said larger cell is to be offloaded to at least one smaller cell.

25 The method may comprise receiving measurement information from at least one of said at least one smaller cell base station and at least one of said plurality of user equipment.

The method may comprise determining that at least one smaller cell in a coverage area of a larger cell requires additional resource.

30 The determining may comprise determining that a plurality of moving user equipment are in or will be in said coverage area.

The method may comprise causing a request for additional resource from a different network to be sent to a resource controlling entity.

The request for additional resource may comprise at least one of offload information; target spectrum area information; and time period for which additional
5 spectrum is required information.

The target spectrum area information may comprise cell identity information.

The offload information may comprise information indicating a type of offload required.

The different network may be operated by a different network operator.

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

According to another aspect, there is provided a method comprising: receiving information, said information indicating that a burst of traffic is to be supported within a coverage area comprising a larger cell and at least part of at
15 least one smaller cell provided by said at least one smaller cell base station.

The information may be configured to indicate that at least some traffic in said larger cell is to be offloaded to at least one smaller cell.

The method may comprise causing measurement information to be sent.

The method may performed by an apparatus. The apparatus may be
20 provided in a user equipment or a base station.

According to another aspect, there is provided an apparatus comprising: means for causing information to be sent to at least one of a smaller cell base station and a plurality of user equipment, said information indicating that a burst of traffic is to be supported within a coverage area comprising a larger cell and at
25 least part of at least one smaller cell provided by said at least one smaller cell base station.

The information may be configured to indicate that at least some traffic in said larger cell is to be offloaded to at least one smaller cell.

The apparatus may comprise means for receiving measurement information
30 from at least one of said at least one smaller cell base station and at least one of said plurality of user equipment.

The apparatus may comprise means for determining that at least one smaller cell in a coverage area of a larger cell requires additional resource.

The determining means may be for determining that a plurality of moving user equipment are in or will be in said coverage area.

- 5 The apparatus may comprise means for causing a request for additional resource from a different network to be sent to a resource controlling entity.

The request for additional resource may comprise at least one of offload information; target spectrum area information; and time period for which additional spectrum is required information.

- 10 The target spectrum area information may comprise cell identity information.

The offload information may comprise information indicating a type of offload required.

The different network may be operated by a different network operator.

The apparatus may be provided in a base station.

- 15 According to another aspect, there is provided an apparatus comprising: means for receiving information, said information indicating that a burst of traffic is to be supported within a coverage area comprising a larger cell and at least part of at least one smaller cell provided by said at least one smaller cell base station.

- 20 The information may be configured to indicate that at least some traffic in said larger cell is to be offloaded to at least one smaller cell.

The apparatus may comprise means for causing measurement information to be sent.

The apparatus may be provided in a user equipment or a base station.

- 25 According to another aspect, there is provided an apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured, with the at least one processor, to cause the apparatus at least to: cause information to be sent to at least one of a smaller cell base station and a plurality of user equipment, said information indicating that a burst of traffic is to be supported

within a coverage area comprising a larger cell and at least part of at least one smaller cell provided by said at least one smaller cell base station.

The information may be configured to indicate that at least some traffic in said larger cell is to be offloaded to at least one smaller cell.

5 The at least one memory and the computer code may be configured, with the at least one processor, to receive measurement information from at least one of said at least one smaller cell base station and at least one of said plurality of user equipment.

10 The at least one memory and the computer code may be configured, with the at least one processor, to determine that at least one smaller cell in a coverage area of a larger cell requires additional resource.

The at least one memory and the computer code may be configured, with the at least one processor, to determine that a plurality of moving user equipment are in or will be in said coverage area.

15 The at least one memory and the computer code may be configured, with the at least one processor, to cause a request for additional resource from a different network to be sent to a resource controlling entity.

20 The request for additional resource may comprise at least one of offload information; target spectrum area information; and time period for which additional spectrum is required information.

The target spectrum area information may comprise cell identity information.

The offload information may comprise information indicating a type of offload required.

The different network may be operated by a different network operator.

25 The apparatus may be provided in a base station.

According to another aspect, there is provided an apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured, with the at least one processor, to cause the apparatus at least to: receive information,

said information indicating that a burst of traffic is to be supported within a coverage area comprising a larger cell and at least part of at least one smaller cell provided by said at least one smaller cell base station.

5 The information may be configured to indicate that at least some traffic in said larger cell is to be offloaded to at least one smaller cell.

The at least one memory and the computer code may be configured, with the at least one processor, to cause measurement information to be sent.

The apparatus may be provided in a user equipment or a base station.

10 According to another aspect, there is provided a method comprising; causing a request to be sent from a spectrum controller of one network to a spectrum controller of a different network, said request comprising at least one of requested spectrum information, reason information, and target spectrum area information.

15 The reason information may comprise information indicating a trigger for said request.

The trigger may comprise one or more of a plurality of moving user equipment, a moving relay, a service activation or a service update.

20 According to another aspect, there is provided a method comprising; causing a request to be received from a spectrum controller of one network at a spectrum controller of a different network, said request comprising at least one of requested spectrum information, reason information, and target spectrum area information.

The reason information may comprise information indicating a trigger for said request.

25 The trigger may comprise one or more of a plurality of moving user equipment, a moving relay, a service activation or a service update.

30 According to another aspect, there is provided an apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured, with the at least one processor, to cause the apparatus at least to: cause a request to be received from a spectrum controller of one network at a spectrum controller of a

different network, said request comprising at least one of requested spectrum information, reason information, and target spectrum area information.

The reason information may comprise information indicating a trigger for said request.

5 The trigger may comprise one or more of a plurality of moving user equipment, a moving relay, a service activation or a service update.

According to another aspect, there is provided an apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured, with
10 the at least one processor, to cause the apparatus at least to: cause a request to be sent from a spectrum controller of one network to a spectrum controller of a different network, said request comprising at least one of requested spectrum information, reason information, and target spectrum area information.

The reason information may comprise information indicating a trigger for
15 said request.

The trigger may comprise one or more of a plurality of moving user equipment, a moving relay, a service activation or a service update.

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

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

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

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

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

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

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

5 Figures 4a and 4b shows first and second spectrum allocations between small cells of different network operators;

Figure 5 schematically shows a macro cell of a first operator with secondary cells of the first operator and a second operator; and

Figure 6 shows a signal flow.

10 In the following certain exemplifying embodiments are explained with reference to a wireless or mobile communication system serving mobile communication devices. Before explaining in detail the exemplifying embodiments, certain general principles of a wireless communication system and nodes thereof and mobile communication devices are briefly explained with reference to Figures
15 1 to 3 to assist in understanding the context of the described examples.

A non-limiting example of the recent developments in communication system architectures is the long-term evolution (LTE) of the Universal Mobile Telecommunications System (UMTS) that is being standardized by the 3rd Generation Partnership Project (3GPP). The LTE employs a mobile architecture
20 known as the Evolved Universal Terrestrial Radio Access Network (E-UTRAN). Base stations of such systems are known as evolved or enhanced Node Bs (eNBs) and may provide E-UTRAN features such as user plane Radio Link Control/Medium Access Control/Physical layer protocol (RLC/MAC/PHY) and control plane Radio Resource Control (RRC) protocol terminations towards the
25 communication devices.

Other examples of radio access system include those provided by base stations of systems that are based on technologies such as wireless local area network (WLAN) and/or WiMax (Worldwide Interoperability for Microwave Access). Some WLANs are sometimes referred to by WiFi™, a trademark that is owned by
30 the Wi-Fi Alliance, a trade association promoting Wireless LAN technology and certifying products conforming to certain standards of interoperability.

Different types of communication devices 101, 102, 103 can be provided wireless access via base stations or similar wireless transmitter and/or receiver nodes providing radio service areas or cells. In Figure 1 different neighbouring and/or overlapping radio service areas or cells 100, 110, 117 and 119 are shown being provided by base stations 106, 107, 118 and 120. It is noted that the cell borders are schematically shown for illustration purposes only in Figure 1. It shall be understood that the sizes and shapes of the cells or other radio service areas may vary considerably from the omni-directional shapes of Figure 1. A base station site can provide one or more cells or sectors, each sector providing a cell or a subarea of a cell. Each communication device and base station may have one or more radio channels open at the same time and may send signals to and/or receive signals from more than one source.

Base stations are typically controlled by at least one appropriate control apparatus 108, 109 (for example as shown in Figure 3) so as to enable operation thereof and management of mobile communication devices in communication with the base stations. The control apparatus can be interconnected with other control entities. The control apparatus can typically be provided with memory capacity and at least one data processor. The control apparatus and functions may be distributed between a plurality of control units. In some embodiments, each base station can comprise a control apparatus. In alternative embodiments, two or more base stations may additionally or alternatively share a control apparatus. In some embodiments the control apparatus may be respectively provided in each base station.

Different types of possible cells include those known as macro cells, pico cells and femto cells. For example, transmission/reception points or base stations can comprise wide area network nodes such as a macro eNode B (eNB) which may, for example, provide coverage for an entire cell or similar radio service area. A base station can also be provided by a small or local radio service area network node, for example Home eNBs (HeNB), pico eNodeBs (pico-eNB), or femto nodes. Some applications utilise radio remote heads (RRH) that are connected to for example an eNB. As cells can overlap a communication device in an area can listen and transmit to more than one base station. Smaller radio service areas can

be located entirely or at least partially within a larger radio service area. A communication device may communicate with more than one cell.

In a particular example, Figure 1 depicts a larger cell 100. In this example the larger cell 100 can be provided by a wide area base station 106 provided by a macro eNB. The larger cell may be a macro cell. The macro eNB 106 transmits and receives data over the entire coverage of the cell 100. A smaller cell 110 in this example is a pico-cell. A smaller cell can also be provided by another suitable small area network node 118 such as Home eNBs (HeNB) (femto cell) or another pico eNodeBs (pico-eNB). A yet further cell 119 is shown to be provided by a remote radio head (RRH) 120 connected to the base station apparatus of cell 100. These smaller cells may be referred to as small cells in the document.

Base stations may communicate with each other via fixed line connection and/or air interface. The logical connection between the base station nodes can be provided for example by an X2 interface. In Figure 1 this interface is shown by the dashed line denoted by 105.

The base stations may communicate via one or more entities 111 and 112 with a core network 113. These one or more entities and/or one or more entities in the core network may have a spectrum control function.

One or more entities may provide a spectrum control function solely or in addition to one or more other functions. A spectrum control function or spectrum controller may be responsible for controlling the shared spectrum resources in the inter-operator situations.

The spectrum controller may be part of the O&M (operation and maintenance) system and/or part may be distributed within a network (e.g. in a base station). This may depend on how dynamic the spectrum control is. For example at a higher network level shared spectrum bands are determined with constraints (for example location, time, and/or power) and at a lower level the decisions could be made how to use the shared resources based on the local conditions. The lower level can be in a base station or a radio network controller. The higher level can be in the core network.

A possible mobile communication device for transmitting to and receiving from a plurality of base stations will now be described in more detail with reference to Figure 2 showing a schematic, partially sectioned view of a mobile communication device 200. Such a device is often referred to as user equipment (UE) or terminal. An appropriate mobile communication device or user equipment may be provided by any device capable of sending radio signals to and/or receiving radio signals from multiple cells. Non-limiting examples include a mobile station (MS) such as a mobile phone or what is known as a 'smart phone', a portable computer provided with a wireless interface card, and USB stick or 'dongle' with radio, or other wireless interface facility, personal data assistant (PDA) provided with wireless communication capabilities, or any combinations of these or the like. A mobile communication device may provide, for example, communication of data for carrying communications such as voice, electronic mail (email), text message, multimedia and so on. It should be appreciated that in some embodiments, the user equipment may be provided at a generally fixed location.

The mobile device may receive and transmit signals over an air interface 207 with one, two or more base stations via an appropriate transceiver apparatus. In Figure 2 transceiver apparatus is designated schematically by block 206. The transceiver apparatus 206 may be provided for example by means of a radio part and associated antenna arrangement. The radio part is arranged to communicate simultaneously with different stations. The radio part may also be arranged to communicate via different radio technologies. For example, the radio part can provide a plurality of different radios. The antenna arrangement may be arranged internally or externally to the mobile device.

A mobile communication device is also provided with at least one data processing entity 201, at least one memory 202 and other possible components 203 for use in software and hardware aided execution of tasks it is designed to perform, including control of access to and communications with access systems and other communication devices. The data processing, storage and other relevant control apparatus can be provided on an appropriate circuit board and/or in chipsets. This feature is denoted by reference 204.

The user may control the operation of the mobile device by means of a suitable user interface such as key pad 205, voice commands, touch sensitive

screen or pad, combinations thereof or the like. A display 208, a speaker and a microphone can also be provided. Furthermore, a mobile communication device may comprise appropriate connectors (either wired or wireless) to other devices and/or for connecting external accessories, for example hands-free equipment, thereto.

Figure 3 shows an example of a control apparatus for a communication system. In some embodiments a base station can comprise a control apparatus such as shown in Figure 3. This control apparatus may be provided in a spectrum control entity or function. The control apparatus 300 can be configured to provide control functions by means of the data processing facility in accordance with certain embodiments described below. For this purpose the control apparatus comprises at least one memory 301, at least one data processing unit 302, 303 and an input/output interface 304. Via the interface the control apparatus can be coupled to a receiver and a transmitter of the base station where the apparatus is provided in the base station. The control apparatus can be configured to execute an appropriate software code to provide the control functions.

Some embodiments relates to mobile wireless communication systems, such as 3GPP Long-Term Evolution Advanced (LTE-A).

Spectrum scarcity is an issue in wireless communication. The number of wireless service subscribers increases. The average data transmission rate of each subscriber continues to grow. This leads to an increase in the total traffic in wireless communication networks. Static spectrum allocation may lead to resource wastage.

Two or more operators sharing certain spectrum such as on a co-primary basis is a possible way to improve spectrum efficiency, which may address increasing demand. In a co-primary spectrum sharing scenario, two or more operators share the same spectrum slot with dedicated spectrum band for each operator, with a spectrum pool or with combination of the two. The allocated spectrum band for each operator may depend on time and location.

In current network deployments, the coexistence of two or more operators in adjacent areas occurs. Dynamic frequency management may be beneficial for the

uncoordinated self-deployment of small cells in LTE-A heterogeneous networks. Take land mobile communication as an example, spectrum is allocated to different operators for a very long period (more than ten years) and each operator can deliver their service only with its own spectrum. However, since the traffic is

5 naturally dynamic, at a specific time, one operator may have some spectrum unused while the other is fully loaded and has to refuse further traffic demand from its user devices. In this case, traditional spectrum allocation may result in low spectrum utilization for the first operator and low throughput for the second one.

Spectrum sharing has been previously proposed to exploit spectrum

10 efficiency. There may be a primary system and one or more secondary systems in the spectrum sharing system model. In this situation, when a frequency is needed by the primary system, the secondary system may concede. One spectrum sharing mechanism between two UMTS operators without spectrum pooling has the spare spectrum owner called the primary operator, and the one that needs

15 spare spectrum called the secondary operator. The operators may share the same radio network controller to coordinate the spectrum sharing between them. For example, in a two-operator region, when one operator is fully loaded, the other operator may have some spare spectrum. Then the latter operator can lease transmission rights on its spectrum to the former operator to improve the total

20 spectrum utilization.

Reference is made to Figure 5. In this example, a HetNet environment is shown where a number of small cells are deployed by different operators within the coverage of a macro cell. Figure 5 shows a macro base station 10 which provides a macro cell. The macro base station 10 may be associated with a first

25 operator. Within the coverage area of the macro base station 10 are provided small cell base stations 16, 18, 24 and 26. For illustrative purposes, small cell base station 16 and small cell base station 18 are provided in the vicinity of one another. Small cell base station 16 belongs to a first operator whilst small cell base station 18 belongs to a second, different operator. Likewise, small cell base

30 station 24 and 26 are provided in the vicinity of one another. Small cell base station 24 belongs to the first operator whilst small cell base station 26 belongs to the second operator.

Each small cell base station may provide one or more small cells. There may be at least some overlap between one or more of the cells of one small base station of the first operator with one or more cells of a small base station of the second operator, in this example. Alternatively or additionally, one or more of the
5 cells of one small base station of the first operator may be adjacent one or more cells of the small base station of the second operator.

Schematically shown in Figure 4 is the allocation of resources to the small cell base stations. In the example shown in Figure 4a, more spectrum is allocated to the small cell base stations $SeNB_B$ of the second operator than to
10 those $SeNB_A$ of the first. The small cells belonging to different operators can share a spectrum pool according to a pre-defined sharing rule.

However, if a relatively large traffic burst is caused by a relatively large number of fast moving UEs approaching the macro cell coverage area, the macro cell should aim to offload its general load to its small cells to guarantee the QoS
15 (quality of service) of the fast moving UEs' QoS, especially for mobility management. The relatively large number of fast moving UEs may be on transportation such as a bus, train or the like 40 and/or may be in cars 42.

As an example in Fig.5, initially the UEs 20, 22, 28 and 30 are associated with the macro cell of base station 10. UEs 20, 22 should be offloaded to small
20 cells of the first operator in coverage area 34 associated with small base station 16. UEs 28, 22 should be offloaded to small cells of the first operator in coverage area 32 associated with small base station 24. Thus, those small cells need more spectrum to meet the load requirement of these UEs. The spectrum requirement balance between different operators' small cells is broken due to the offloading
25 triggered by the burst of fast moving UEs. Figure 4b shows the spectrum sharing required by the first operator. As can be seen the first operator would like to have a greater share of the spectrum in order to guarantee the QoS of those fast moving UEs.

Similar problems may arise in other scenarios such as for example a traffic
30 burst to the macro cell caused by moving relay mobility (e.g. moving relay node moves into the coverage of macro cell) or eMBMS (broadcast/multicast service) activation and/or update in the macro cell.

Some embodiments may provide one or more mechanisms to optimize the behaviour of spectrum sharing between small cells belonging to different operators when, for example, a burst of fast moving UEs approaches.

5 In some embodiments, an inter-operator spectrum sharing mechanism is proposed with corresponding signalling procedures to guarantee that a data burst in the macro cell will be served with sufficient QoS. Some embodiments may use the feature that the small cells may have more flexibility to extend the capacity due to spectrum sharing. In some embodiments, a data burst may trigger offloading
10 handovers to the small cells. For example, if burst traffic is better served by a macro cell to avoid frequent handover of fast moving UEs and/or have a larger coverage area for the services of the data burst, some low mobility UEs served by macro cell may be offloaded to its overlapped small cells. Alternatively or additionally some or all of the burst traffic may be offloaded to the small cells
15 directly. Offloading to the small cells may lead to an increase in the spectrum demand of those small cells.

To coordinate the offloading handovers and spectrum sharing among small cells triggered by offloading oriented handovers one or more messages are provided. The one or more messages may comprise one or more a burst offload
20 indication, a spectrum request for burst traffic and a burst offload triggered spectrum negotiation indicator.

The one or more messages may be a part of other coordination information exchange for HetNet mobility management and/or part of O&M (operation and maintenance) messaging.

25 Since the data burst of the group of fast moving UEs may affect different macro cell coverage during their movements, the co-primary spectrum sharing mechanism may in some embodiments meet this requirement.

Some embodiments may support message exchange. The message exchange may be event triggered or carried out frequently to provide the updating
30 of co-primary spectrum sharing.

One example of a signaling of some embodiments is shown in Figure 6. In Figure 6, the subscript A refers to an entity of the first operator whilst the subscript B refers to an entity of the second operator. The relatively fast moving user equipment FMUEs are a group of relatively fast moving UEs which are approaching the macro cell coverage of the macro base station $MeNB_A$ of the first operator. MUEs_A denote those UEs served by macro cell of the first operator. SeNB_A are the small cell base stations associated with the macro cell and belong to the first operator. SeNB_B are the small cell base stations associated with a macro cell of the second operator and belong to the second operator. Each of the small cell base stations is able to provide one or more small cells. SCtrl_A is spectrum controller of the first operator and SCtrl_B is spectrum controller of the second operator.

In step S1, initially each UE is connected to its serving base station. The serving base station may be a macro eNB and/or a small cell eNB. The UEs may be attached to base stations according to conventional cell selection criterion, for example based on reference signal received power or any suitable criterion. In the example of Figure 6, the user equipment MUEs_A are attached to the macro base station.

In step S2, when there is a group of fast moving UEs approaching the coverage area of the macro cell of the macro base station $MeNB_A$, the load of the macro cell may increase significantly. The group of fast moving UEs may be the UEs of passengers in public transportation such as a high speed train or bus, user equipment in cars on a busy road, or the like. These fast moving UEs may request access to the macro base station $MeNB_A$.

In step S3 a burst offload indication may be broadcast by macro base station $MeNB_A$. This may be triggered by an increase or anticipated increase in the burst traffic in the cell. As mentioned previously the increase in burst traffic may be due to one or more of fast moving UE groups, moving a relay, MBMS service activation/update or the like. The indication may be broadcast or transmitted in any suitable way to the user equipment MUEs_A and the SeNBs_A of the first operator associated with the macro cell of the first operator.

The burst offload indication may have information indicating there is a data burst coming into the macro cell which requires that there be offloading to small cells. Some or all of the data burst may be offloaded to small cells directly and/or some other data, not part of the incoming burst, may need to be offloaded to the small cells. The amount of some other data to be offloaded may be equivalent to the incoming burst in some embodiments. This may depend on the loading in the cells. The offloading of the incoming data burst and/or the other data may depend on the nature of the incoming data burst.

In step S4, the burst offload indication is used to trigger the user equipment MUEs_A and/or the SeNBs_A of the first operator associated with the macro cell of the first operator to perform measurements and report information associated with the measurements or the measurements themselves to the macro base station MeNB_A. The user equipment MUEs_A may report the detected the SeNBs_A of the first operator associated with the macro cell of the first operator. The SeNBs_A of the first operator associated with the macro cell of the first operator may report detected SeNBs_B of the second operator that can offer some additional spectrum in the sharing band.

In some embodiments, in order to enhance the offloading opportunities to the the user equipment MUEs_A as much as possible, the SeNBs_A of the first operator associated with the macro cell of the first operator, based on the burst offload indication, may temporarily boost the transmission power if possible.

In step S5, based on the measurement report, the macro base station MeNB_A may select one or more user equipment MUEs_A and one or more the SeNBs_A to offload traffic from the macro cell to one or more selected small cells.

For example if a SeNB_B which can offer additional spectrum in the sharing band broadcasts a spectrum enabling indication, the one or more SeNB_A that has the most neighboring SeNBs_B broadcasting such an indication may be selected.

In another example, if a SeNB_B that cannot offer additional spectrum in the sharing band broadcasts a spectrum disabling indication, the one or more SeNB_A that did not report any such kind of SeNB_B may be selected.

If the user equipment MUEs_A report is taken into account, the one or more SeNBs_A that has been reported by the most number of the user equipment MUEs_A may be selected.

5 In step S6, since a group of fast moving UEs may be better served by a macro cell, the macro cell may offload the selected connect-mode UEs to the selected small cells to better support those fast moving UEs in the macro cell. The handover may be triggered by the data burst of the group of fast moving UEs. The user equipment MUEs_A are thus handed over to one or more SeNBs_A as determined in step S5.

10 In step S7, it is determined that the handover has increased the spectrum demand of small cells of the first operator. Thus, a current spectrum balance between different operators may no longer be appropriate and spectrum re-sharing or reallocation for small cells may be triggered.

15 In some embodiments, the macro base station may send a spectrum request for burst traffic to its operator spectrum controller SCtrl_A to register that some offload has been triggered.

The spectrum request for burst traffic may be transmitted from the macro base station MeNB_A and/or at least one small cell base station to the O&M or spectrum controller entity SCtrl_A. The request may be triggered by burst traffic
20 requiring support in the macro cell. This request may trigger SCtrl_A to contact another operator's SCtrl_B. The request may include one or more of an offload indicator and target spectrum request area e.g. in the form of macro/small cells' ID or the like. The offload indicator may be used to indicate the offload type such as a data burst of a group of fast moving UEs. The request may indicate a time period
25 that the burst traffic will last if the time period can be estimated beforehand. The information about the one or more target small cells may help to judge the small cells' position.

The spectrum request may be sent before the handover, during the handover or after the handover. This may depend on whether a proactive sharing or reactive
30 sharing is to provide. Therefore, this step may be performed before or in parallel with for example step S3 and/or step S4 or at any other suitable time.

In step S8, the one or more handover target small cells SeNBs_A may send a spectrum request to their operator spectrum controller SCtrl_A to request more spectrum to meet the requirement of the additional load. This step may be provided via a direct interface between the small cells and the spectrum controller if available. Alternatively this step may be omitted. The step may be provided indirectly in some embodiments, via the macro cell.

In step S9, once the operator spectrum controller SCtrl_A receives information from the macro cell and optionally one or more small cells with the same triggered reason, the spectrum controller SCtrl_A may start a co-primary spectrum sharing procedure with the corresponding entity SCtrl_B of the other operator.

In some embodiments, a burst offload triggered spectrum negotiation Indicator may be exchanged between the operators' O&M or spectrum controller entities. This information may comprise one or more of a negotiation indicator, required spectrum, sharing area information and any other suitable information. The negotiation indicator may be used to indicate that this co-primary spectrum sharing is triggered by a particular reason such as a data burst of a group of fast moving UEs etc. or simply that negotiation may be required. The requirement of spectrum and sharing area information may indicate how much spectrum and where the sharing would happen.

When the spectrum negotiation indicator is received, the other operator's O&M or spectrum controller may determine the corresponding service area and trigger the SeNBs_B in the determined service area to broadcast the spectrum sharing enabling/disabling indication to indicate if the small cells can offer some additional spectrum in the sharing band or not.

In step S10, after the spectrum negotiation is finished, the spectrum controllers may inform their respective small cells of the spectrum adjustment. This may be directly or via the respective macro cell.

In step S11, the group of fast moving UEs is connected to the macro cell.

Some embodiments may have one or more of the following advantages.

The QoS of the data burst of a group of relatively fast moving UEs may be guaranteed through co-primary spectrum sharing mechanism.

The update of co-primary spectrum sharing may be supported with one or more of event triggered messages and frequently exchanged messages.

- 5 The signalling of some embodiments may be mostly in the same operator and the inter-operator signalling may be negligible. The signalling overhead may be reasonable.

10 Some embodiments have been described where the increased loading has been the result of a group of fast moving UES. Alternatively or additionally the increased loading of small cells of one operator can occur for any other reason. This may be the result of an increase in traffic.

15 Some embodiments have described the offload of low mobility UEs. It should be appreciated that this is by way of example only and any suitable criteria can be applied in the alternative or additionally to select the UEs which are to be attached to the small cells.

Some embodiments may have a single spectrum controlling entity which is used to control the spectrum allocation of two or more networks.

20 In the above reference is made to small cells. It should be appreciated that other embodiments may alternatively or additionally be used with other sizes of cell. Some embodiments may be used with cells which are generally of the same size.

Some communications have been described as being via macro cells. It should be appreciated that in other embodiments, different communication paths may be provided.

- 25 In the above reference is made to inter operator situations. It should be appreciated that in other embodiments, there may be two separate networks. Those networks may be operated by the same operator.

In some embodiments, there may be two or more networks and/or operators.

A small cell is generally a cell which is smaller than for example a larger cell. The larger cell may be a macro cell. The smaller cell may be a pico cell, a femto cell, a home NB cell and/or any other suitable smaller cell.

5 It should be appreciated that some embodiments may be used with any suitable wireless network and not just cellular networks.

10 An appropriately adapted computer program code product or products may be used for implementing the embodiments, when loaded on an appropriate data processing apparatus, for example for control operations. The program code product for providing the operation may be stored on, provided and embodied by means of an appropriate carrier medium. An appropriate computer program can be embodied on a computer readable record medium. A possibility is to download the program code product via a data network. In general, the various embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Embodiments may thus be practiced in various components
15 such as integrated circuit modules. The design of integrated circuits is by and large a highly automated process. Complex and powerful software tools are available for converting a logic level design into a semiconductor circuit design ready to be etched and formed on a semiconductor substrate.

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

WHAT IS CLAIMED IS:

- 5 1. A method comprising:
 causing information to be sent to at least one of a smaller cell base station
 and a plurality of user equipment, said information indicating that a burst of traffic
 is to be supported within a coverage area comprising a larger cell and at least part
 of at least one smaller cell provided by said at least one smaller cell base station.
- 10 2. A method as claimed in claim 1, wherein said information is configured to
 indicate that at least some traffic in said larger cell is to be offloaded to at least one
 smaller cell.
- 15 3. A method as claimed in claim 1 or 2, comprising receiving measurement
 information from at least one of said at least one smaller cell base station and at
 least one of said plurality of user equipment.
- 20 4. A method as claimed in any preceding claim, comprising determining that at
 least one smaller cell in a coverage area of a larger cell requires additional
 resource.
- 25 5. A method as claimed in claim 4, wherein said determining comprises
 determining that a plurality of moving user equipment are in or will be in said
 coverage area.
- 30 6. A method as claimed in any preceding claim, comprising causing a request
 for additional resource from a different network to be sent to a resource controlling
 entity.

7. A method as claimed in claim 6, wherein said request for additional resource comprises at least one of offload information; target spectrum area information; and time period for which additional spectrum is required information.

5 8. A method as claimed in claim 7, wherein said target spectrum area information comprises cell identity information.

9. A method as claimed in claim 7 or 8, wherein said offload information comprises information indicating a type of offload required.

10

10. A method as claimed in any preceding claim, wherein said different network is operated by a different network operator.

11. A method comprising:

15 receiving information, said information indicating that a burst of traffic is to be supported within a coverage area comprising a larger cell and at least part of at least one smaller cell provided by said at least one smaller cell base station.

12. A method as claimed in claim 11, wherein said information is configured to
20 indicate that at least some traffic in said larger cell is to be offloaded to at least one smaller cell.

13. A method as claimed in claim 11 or 12, comprising causing measurement information to be sent.

25

14. A computer program comprising computer executable instructions which when run cause the method of any of the preceding claims to be performed.

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

apparatus at least to: cause information to be sent to at least one of a smaller cell base station and a plurality of user equipment, said information indicating that a burst of traffic is to be supported within a coverage area comprising a larger cell and at least part of at least one smaller cell provided by said at least one smaller cell base station.

10

16. An apparatus as claimed in claim 15, wherein the information is configured to indicate that at least some traffic in said larger cell is to be offloaded to at least one smaller cell.

15

17. An apparatus as claimed in claim 15 or 16, wherein the at least one memory and the computer code are configured, with the at least one processor, to receive measurement information from at least one of said at least one smaller cell base station and at least one of said plurality of user equipment.

20

18. An apparatus as claimed in claim 15, 16 or 17, wherein at least one memory and the computer code are configured, with the at least one processor, to determine that at least one smaller cell in a coverage area of a larger cell requires additional resource.

25

19. An apparatus as claimed in any of claims 15 to 18, wherein the at least one memory and the computer code are configured, with the at least one processor, to determine that a plurality of moving user equipment are in or will be in said coverage area.

20. An apparatus as claimed in any of claims 15 to 19, wherein the at least one memory and the computer code are configured, with the at least one processor, to cause a request for additional resource from a different network to be sent to a resource controlling entity.

21. An apparatus as claimed in claim 20, wherein the request for additional resource comprises at least one of offload information; target spectrum area information; and time period for which additional spectrum is required information.

5 22. An apparatus as claimed in claim 21, wherein the target spectrum area information comprises cell identity information.

23. An apparatus as claimed in 21 or 22, wherein the offload information comprises information indicating a type of offload required.

10

24. An apparatus an apparatus comprising at least one processor and at least one memory including computer code for one or more programs, the at least one memory and the computer code configured, with the at least one processor, to cause the apparatus at least to: receive information, said information indicating
15 that a burst of traffic is to be supported within a coverage area comprising a larger cell and at least part of at least one smaller cell provided by said at least one smaller cell base station.

25. An apparatus as claimed in claim 24, wherein the information is configured
20 to indicate that at least some traffic in said larger cell is to be offloaded to at least one smaller cell.

26. An apparatus as claimed in claim 24 or 25, wherein the at least one memory and the computer code are configured, with the at least one processor, to
25 cause measurement information to be sent.

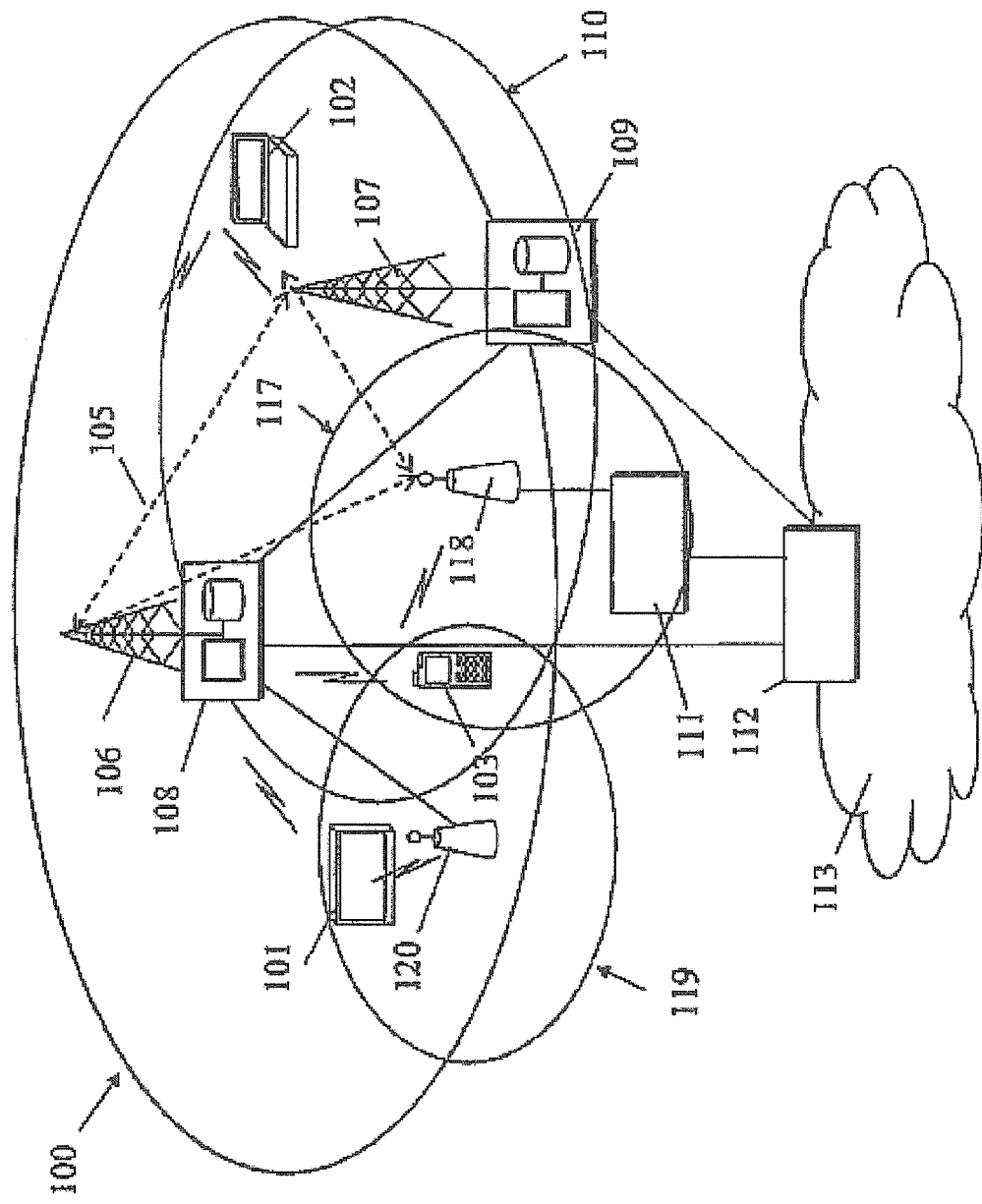


Figure 1

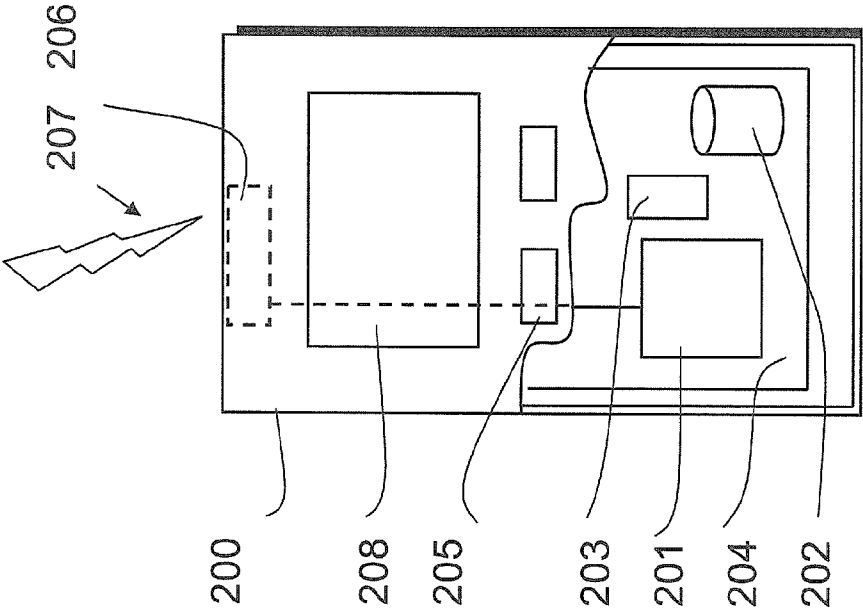


Figure 2

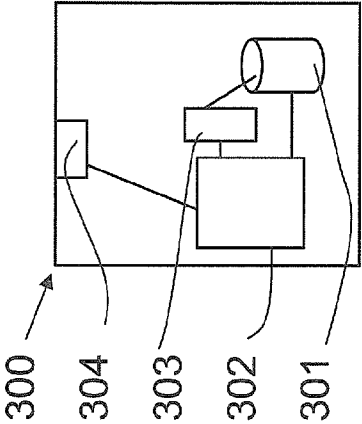


Figure 3

Figure 4a

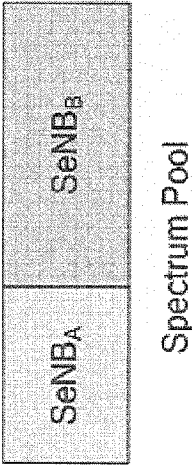


Figure 4b

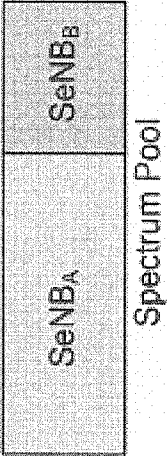
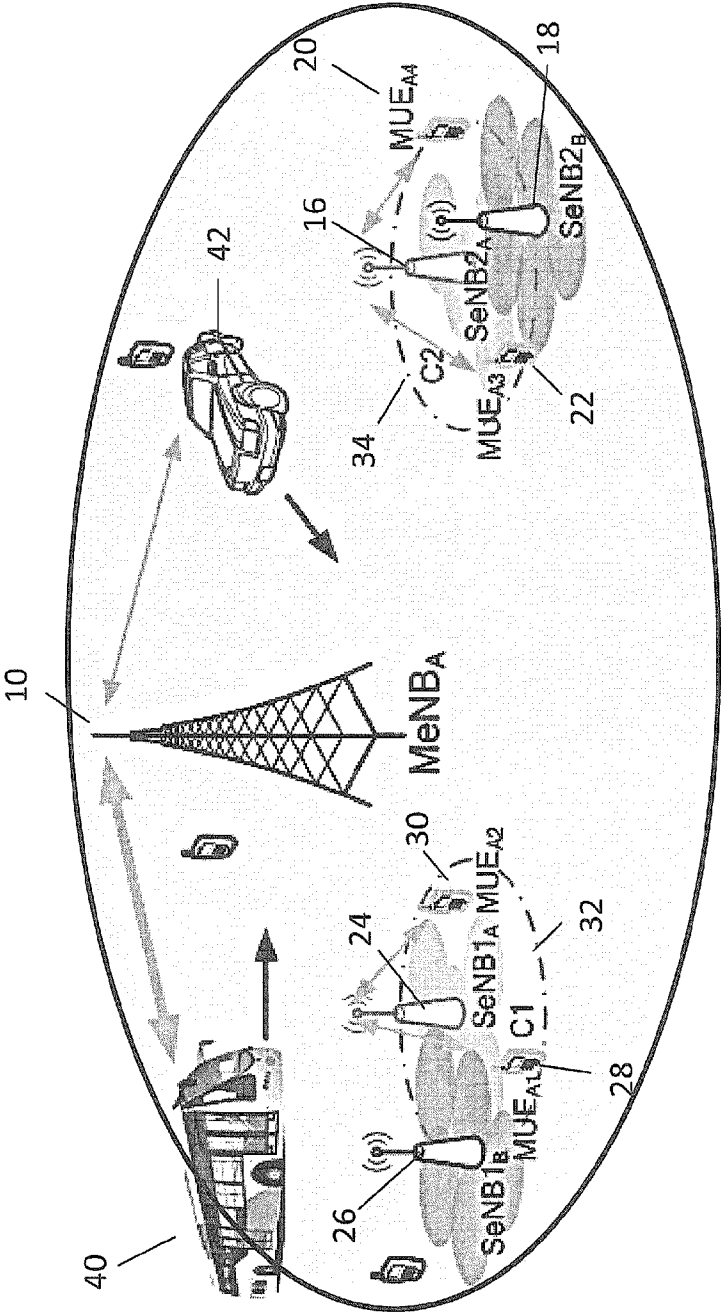


Figure 5



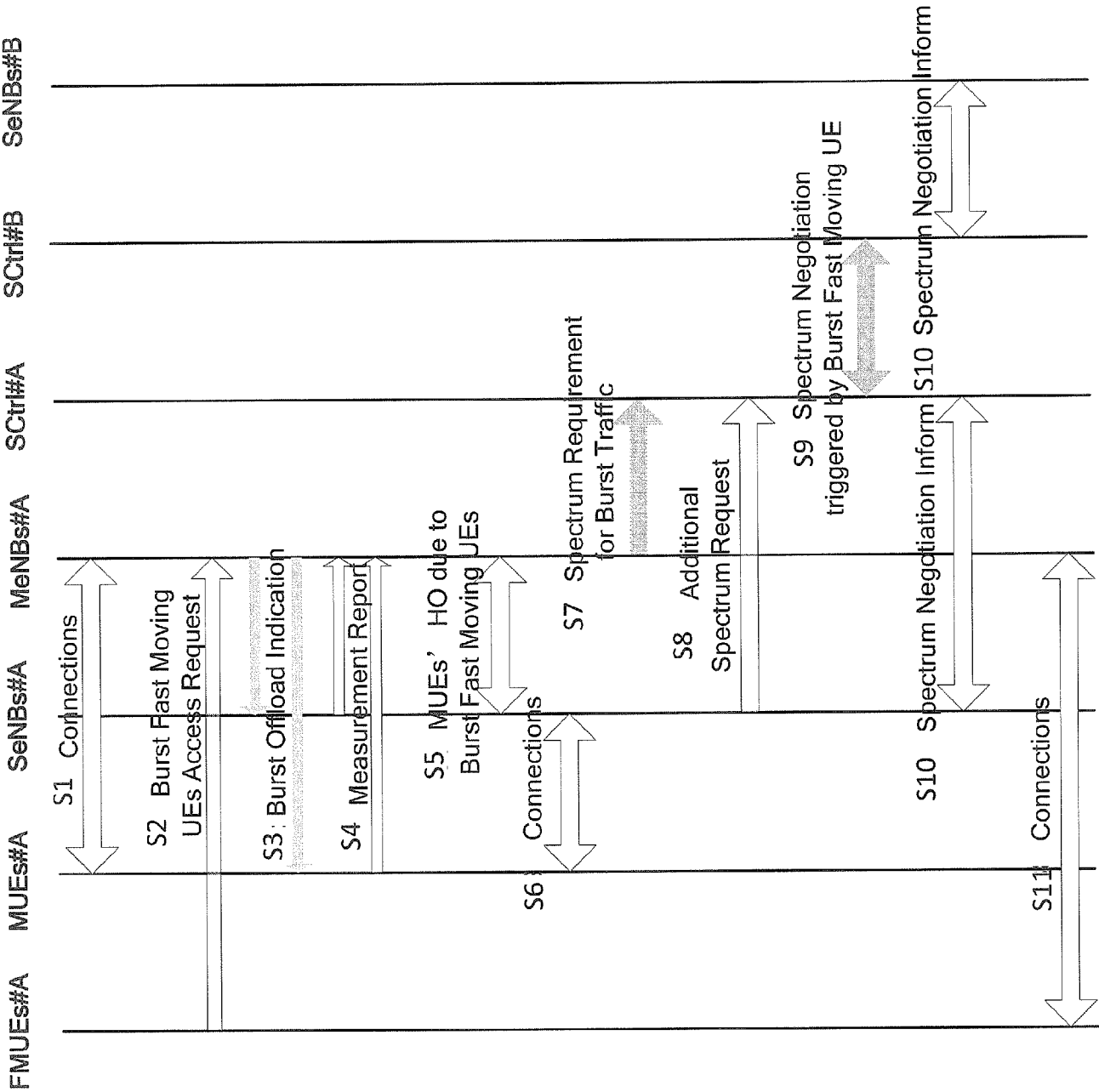


Figure 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2014/070399

A. CLASSIFICATION OF SUBJECT MATTER

H04W 28/08 (2009.01) i

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, H04Q

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)

CPRSABS,CNTXT,VEN,CNKI: load, burst traffic, service, balance, shar+, offload, switch+, hand off, handover, hand over, overlap, coverage, macro, pico, femto, smaller, base station, cell

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102378260 A (HINA MOBILE COMMUNICATION COR) 14 March 2012 (2012-03-14) description, paragraphs [0060] to [0095]	1-26
X	CN 102065475 A (BEIJING SAMSUNG TELECOM TECHNOLOGY CO LTD ET AL.) 18 May 2011 (2011-05-18) description, paragraphs [0049] to [0095]	1-26
A	CN 102665258 A (UNIV BEIJING POSTS&TELECOM) 12 September 2012 (2012-09-12) the whole document	1-26

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

“A”	document defining the general state of the art which is not considered to be of particular relevance	“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
“E”	earlier application or patent but published on or after the international filing date	“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
“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)	“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
“O”	document referring to an oral disclosure, use, exhibition or other means	“&”	document member of the same patent family
“P”	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search

24 September 2014

Date of mailing of the international search report

15 October 2014

Name and mailing address of the ISA/

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Telephone No. (86-10)62089401

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2014/070399

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN	102378260	A	14 March 2012	Non e	
CN	102065475	A	18 May 2011	Non e	
CN	102665258	A	12 September 2012	Non e	