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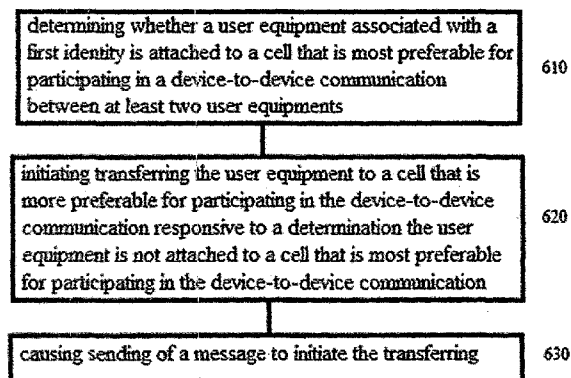


FIGURE 6

(57) Abstract: In accordance with an example embodiment of the present invention, there is provided an apparatus, comprising at least one processor configured to determine whether a user equipment associated with a first identity is attached to a cell that is most preferable for participating in a device-to-device communication between at least two user equipments, the at least one processor being configured to, responsive to a determination the user equipment is not attached to a cell that is most preferable for participating in the device-to-device communication, initiate transferring the user equipment to a cell that is more preferable for participating in the device-to-device communication, and a transmitter that is caused by the at least one processor to send a message to initiate the transferring.

CONNECTION MANAGEMENT IN WIRELESS COMMUNICATIONS

TECHNICAL FIELD

[0001] The present application relates generally to managing mobile
5 communication devices, such as radio-enabled mobile communication devices.

BACKGROUND

[0002] Wireless communication, such as radio communication, may be arranged
to occur between mobile units, such as cellular telephones, wireless-enabled laptops or
wireless sensors or other radio-enabled mobile devices, and base stations. A telephone call,
10 for example, may be placed from a smartphone, from where it may be routed via an air
interface to a base station. From the base station, the call may be routed through a cellular
core network to a call recipient. Alternatively, a smartphone may be arranged to access the
Internet, for example, via the air interface to the base station, and from the base station
directly to a data communication network whereby a core network is in this case not
15 needed to access the Internet.

[0003] Mobile radio-enabled devices, such as suitably enabled cellular
telephones, may be capable of communicating with each other directly or locally. Such
communication may be known as device-to-device, or D2D, communication. D2D
communication may comprise that a first mobile transmits information encoded in a radio
20 signal, and a second mobile receives the radio signal, wherein the radio signal isn't re-
transmitted along the way. In other words, radio energy encoded with information
transmitted from the first mobile is received in the second mobile.

[0004] D2D communication may be useful, for example, when coverage of a
mobile communication network is insufficient. As a yet further option, D2D
25 communication may be used to offload communication between two nearby mobiles to
D2D mode, so that resources of the mobile communication network may be used to serve
more users and mobile device power consumption can be reduced.

[0005] Mobiles may be enabled to have more than one radio carrier active at a
given time. For example, a mobile may receive data via a wireless local area network,
30 WLAN, radio network while being engaged in a video call over a wideband code division
multiple access, WCDMA, network. Likewise some mobiles may simultaneously have
active a D2D connection with another mobile, and at least one connection to a non-D2D
wireless network, such as WLAN, WCDMA or long term evolution, LTE.

SUMMARY

[0006] Various aspects of examples of the invention are set out in the claims.

[0007] According to a first aspect of the present invention, there is provided an apparatus, comprising at least one processor configured to determine whether a user
5 equipment associated with a first identity is attached to a cell that is most preferable for participating in a device-to-device communication between at least two user equipments, the at least one processor being configured to, responsive to a determination the user equipment is not attached to a cell that is most preferable for participating in the device-to-device communication, initiate transferring the user equipment to a cell that is more
10 preferable for participating in the device-to-device communication, and a transmitter that is caused by the at least one processor to send a message to initiate the transferring.

[0008] According to a second aspect of the present invention, there is provided a method, comprising determining whether a user equipment associated with a first identity is attached to a cell that is most preferable for participating in a device-to-device
15 communication between at least two user equipments, responsive to a determination the user equipment is not attached to a cell that is most preferable for participating in the device-to-device communication, initiating transferring the user equipment to a cell that is more preferable for participating in the device-to-device communication, and causing
20 sending of a message to initiate the transferring.

[0009] According to a third aspect of the present invention, there are provided computer programs configured to cause methods in accordance with the second aspect to be performed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] For a more complete understanding of example embodiments of the
25 present invention, reference is now made to the following descriptions taken in connection with the accompanying drawings in which:

[0011] FIGURE 1 illustrates an example system capable of supporting at least some embodiments of the invention;

[0012] FIGURE 2 illustrates an example system capable of supporting at least
30 some embodiments of the invention;

[0013] FIGURE 3 illustrates a block diagram of an apparatus in accordance with an example embodiment of the invention;

[0014] FIGURE 4 illustrates a block diagram of an apparatus in accordance with an example embodiment of the invention;

[0015] FIGURE 5 is a signaling diagram illustrating signaling in accordance with at least some embodiments of the invention, and

5 [0016] FIGURE 6 is a flow diagram illustrating a method in accordance with at least some embodiments of the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

10 [0017] When D2D communication is used for a group of at least two cellular mobiles, it is useful from the network point of view that the cells which the D2D-communicating mobiles are attached to are capable of exchanging information rapidly. In an optimal case, the mobiles concerned are attached to the same cell, and in other cases it is generally more beneficial the shorter the latency there is in communications between the cells to which mobiles engaged in the D2D communication are attached to. D2D

15 communication may comprise, firstly, direct D2D communication wherein a first mobile transmits information encoded in a radio signal, and a second mobile receives the radio signal, wherein the radio signal isn't re-transmitted along the way. In other words, radio energy encoded with information transmitted from the first mobile is received in the second mobile. D2D communication may comprise, secondly, local D2D communication

20 wherein a first mobile transmits information encoded in a radio signal, a base station receives the information encoded in the radio signal, and the base station re-transmits the information encoded in a second radio signal, to be received by a second mobile. In local D2D communication, the base station is configured to re-transmit the information without forwarding it to further non-mobile network nodes.

25 [0018] FIGURE 1 illustrates an example system capable of supporting at least some embodiments of the invention. Illustrated is mobile 110, which may comprise, for example, a user equipment, cellular telephone, laptop computer, tablet computer, personal digital assistant, PDA, wireless sensor or other mobile device with connectivity functions. An example of structure of mobile 110 is presented in FIG. 3. Mobile 110 is illustrated as

30 being disposed in the cell coverage area of cell 101. Cell 101 is controlled by base station 120, which may be configured to operate in accordance with a radio access technology. Examples of radio access technologies include WLAN, WCDMA and LTE. Mobile 110 is illustrated as being in radio communication with base station 120 via wireless link 115. When base station 120 operates according to a certain radio access technology, RAT,

wireless link 115 operates according to the same RAT. Wireless link 115 may comprise an uplink for conveying information from mobile 110 to base station 120. Wireless link 115 may comprise a downlink for conveying information from base station 120 to mobile 110. Mobile 110 is in the example of FIG. 1 attached to a cell of base station 120, namely cell 101. Being attached to a cell may comprise that mobile 110 has a state, such as active or idle, with respect to the cell. Being attached may comprise having an active bearer with the cell. Being attached to a cell may comprise that the cell is the cell mobile 110 will signal to in case mobile 110 needs connectivity.

[0019] Mobile 110 may access services of a cellular communications network via wireless link 115 and base station 120. For example, base station 120 may be operably connected to further nodes, which are not illustrated in FIG. 1. Such further nodes may comprise, for example, radio access network controllers or core network nodes, such as switches or gateways. Mobile 110 may request, and receive, content from the Internet via such further nodes, base station 120, and wireless link 115.

[0020] Illustrated in FIG. 1 are further mobiles 140 and 150. Mobile 140 and mobile 150 are illustrated as being interconnected by D2D wireless link 145. D2D wireless link 145 may operate in accordance with a cellular RAT, or another RAT suitable for such use. D2D wireless link 145 may operate on a different frequency band than cellular cells, such as for example an unlicensed band or a dedicated D2D band. Alternatively, D2D wireless link 145 may operate on a same frequency band as cellular cells such as cell 101 and/or 102. Mobile 150 is illustrated as being in radio communication with base station 130 via wireless link 155. Wireless link 155 may be essentially similar to wireless link 115. Base station 130 controls cell 102, which is adjacent to cell 101. Cell coverage areas of cell 101 and cell 102 overlap to a degree to allow for seamless service provision to mobiles roaming in the area. Should a mobile cross over from the cell coverage area of cell 101 to that of cell 102, a handover procedure may be triggered to cause attachment of the mobile to change from cell 101 to cell 102. In FIG. 1, mobile 110 is near the overlap area of cell coverage areas of cell 101 and cell 102.

[0021] Mobile 110 may learn of the D2D communication between mobiles 140 and 150. Mobile 110 may learn of it from an advertisement it receives from mobile 140 or mobile 150 via the cellular network, or mobile 110 may receive a D2D beacon transmission from mobile 140 or mobile 150. Mobile 150, for example, may advertise via wireless link 155 to mobiles attached to base stations comprised in the same network as base station 130 that a D2D communication opportunity exists. The location of the D2D

opportunity may be given in such an advertisement as in cell 102, as geolocation coordinates or as a street address, for example. If mobile 110 receives this advertisement and determines it is close to the advertised location, it may attempt to join the D2D communication.

5 **[0022]** To join the D2D communication, mobile 110 may signal a D2D join request to base station 120 via wireless link 115. Base station 120 may forward the D2D join request via base station 130 and wireless link 155 to the mobiles engaged in the D2D communication mobile 110 is asking to join, in the example of FIG. 1 this is mobiles 140 and 150. Mobiles 140 and 150 may decide on admitting mobile 110 to the D2D
10 communication. If mobiles 140 and 150 decide to admit mobile 110 to the D2D communication, they may signal to mobile 110 via base stations 130 and 120 of their decision. Responsively, mobile 110 may perform, instructed by base station 120 or autonomously, measurements to determine if D2D communication is possible with mobiles 140 and 150, which may comprise determining whether a direct D2D link to at least one of
15 mobiles 140 and 150 is possible from the location where mobile 110 finds itself. Such determination may comprise measuring for energy transmitted by mobile 140 and/or mobile 150. In some embodiments, mobile 110 measures to determine whether a D2D opportunity exists with mobile 140 and/or mobile 150 before transmitting the D2D join request to base station 120. In some embodiments, base station 120 or base station 130
20 may decide on admitting mobile 110 to the D2D communication, instead of mobiles 140 and 150 deciding this. In some embodiments, mobiles 140 and/or 150 send advertisements of the D2D communication only to mobiles they are willing to admit, which makes separate admission decisions unnecessary. In some embodiments, for example when is not possible to set up a direct D2D communication, a local D2D communication can be used
25 for mobile 110 to join the group of mobiles 140 and 150, wherein mobile 110 may attach to cell 102 and communicate with at least one of mobiles 140 and 150 locally via base station 130.

[0023] Base station 120 may be configured to determine, if cell 101 is the most preferable cell available for mobile 110 to be attached to when participating in the D2D
30 communication with mobiles 140 and 150. In some embodiments, D2D communications are allocated resources using radio resource allocations from the network, which is easier to manage if all mobiles participating in the D2D communication are attached to the same cell. In local D2D communication, D2D communication uses a local cellular data path for the data communicated, for example when a direct D2D communication is not available.

This, too, is easier and faster to arrange if the mobiles are attached to the same cell, or at least cells that can communicate with each other with low latency.

[0024] Base station 120 may thus conclude, that in order to most efficiently participate in D2D communication with mobile 140 and mobile 150, mobile 110 should
5 attach to cell 102, which is controlled by base station 130. Base station 120 may thus initiate actions to handover mobile 110 to cell 102 of base station 130. This may be possible, since mobile 110 is located near the cell edge between cells 101 and 102. This may often prove to be the case, since mobile 110 is likely to be near the cell edge if it's close enough to mobiles in the other cell to participate in D2D communications with them.

10 [0025] In some embodiments, mobile 110 itself may conclude that cell 102 would be preferable to cell 101 for participating in the D2D communication with mobiles 140 and 150. In these cases, mobile 110 may request from base station 120 to be handed over to cell 102, or at least for the possibility of handover to be explored. In some embodiments, mobile 110 may even autonomously cause a change of attachment to cell
15 102 without requesting this from base station 120.

[0026] FIGURE 2 illustrates an example system capable of supporting at least some embodiments of the invention. The system of FIG. 2 resembles that of FIG. 1 with the following differences. The network of FIG. 2 is a heterogeneous network, wherein small cells 161 and 171 are disposed mostly in the cell coverage area of macro cell 102.
20 Macro cell 102 is controlled by base station 130 as in FIG. 1. Base station 160 and base station 170 are connected to base station 130 via a wire-line or wireless links 132. Small cell 161 is controlled by base station 160, and small cell 171 is controlled by base station 170. Base station 130 in turn controls both base station 160 and base station 170 via links 132. Base station 130 may be seen as indirectly controlling small cells 161 and 171, since
25 it controls the base stations that control these cells. The term "base station" in connection with small cells is a terminological choice only as these units may be referred to by other names as well, such as access points. Small cells 161 and 171 may operate in accordance with the same RAT or a different RAT as macro cell 102. Mobile 150 is in communication with base station 160 via wireless link 155. Mobiles 140 and 150 are attached to small cell
30 161, and not macro cell 102 as in FIG. 1.

[0027] In the FIG. 2 embodiments, mobile 110 is not capable for radio reasons of handing over to cell 161 to be in the same cell as mobiles 140 and 150. This may be due to, for example, radio pathloss being too high for communication between mobile 110 and base station 160. However, small cell 171 is accessible to mobile 110 and it is preferable to

cell 101 from the point of view of D2D communication with mobiles 140 and 150, since small cell 171 is controlled by base station 170, which like base station 160 is controlled by base station 130. Therefore, signaling can be exchanged directly between base station 170 and base station 160 with low latency or via base station 130. In this sense, small cell 170 is more preferable than cell 101 which is controlled by base station 120. In general, a small cell that is controlled by a base station controlled by the same macro base station as a base station that controls a small cell where other D2D communicating mobiles are attached may be seen as more preferable for the D2D communication, than cells controlled by other macro base stations, or by base stations controlled by these other macro base stations. In other words, a small cell indirectly controlled by the same macro base station may be seen as preferable, as signaling via the macro base station provides lower latency than if more than one macro base station is involved.

[0028] In cases where a macro base station controls more than one macro cell, macro cells of the same macro base station may be seen as preferable, since again signaling and packet data may be conveyed with low latency via the macro base station controlling both the macro cell where other D2D communicating mobiles are attached, and the macro cell into which the mobile seeking to join the D2D communication is capable of handing over to. This may occur where, for example, a base station controls sectorized macro cells. It may occur that other D2D communicating mobiles are attached to a first sector of the macro cell, and the mobile seeking to join the D2D communication is only capable of handing over to another sector of the same macro base station.

[0029] In cases where mobile 110 cannot handover to the same cell where other D2D communicating mobiles are attached, or to a cell of the same macro base station, or to a small cell indirectly controlled by the same macro base station, it may be preferable for mobile 110 to handover to a cell that is controlled, directly or indirectly, by a base station that has a direct interface with a base station controlling, directly or indirectly, the cell where other D2D communicating mobiles are attached. Indirectly controlling in this sense may comprise that a macro base station controls a small cell base station that in turn controls a cell where the other D2D communicating mobiles are attached. An example of a direct interface is an X2-interface interconnecting two LTE base stations, eNBs. Alternatively, a connection such as connections 132 of FIG. 2 may be seen as a direct interface. In this sense, in the example of FIG. 2, macro cell 102 may be seen as preferable to cell 101 for mobile 110 since macro cell 102 is controlled by base station 130, which has

a direct interface to base station 160 which controls cell 161, which is the cell where the other D2D communicating mobiles are attached to.

[0030] In a heterogeneous network, the direct interface may comprise a combination of an inter-macro base station interface and a macro base station-small cell interfaces. In terms of FIG. 2, if base station 120 indirectly controls small cells and there is a direct interface, such as X2, between base stations 120 and 130, the small cells indirectly controlled by base station 120 may be seen as more preferable than cells controlled by altogether different macro base stations, which are not illustrated in FIG. 2. This is again due to the fact that relatively low-latency communication can be effected from such small cells to cell 161, via the connection 132-like connections connecting such cells to base station 120, the direct interface between base station 120 and base station 130, and connections 132 between base station 130 and base station 160.

[0031] The above-described principles apply equally in cases where a majority of mobiles already participating in a D2D communication are attached in a certain cell, which is then considered the cell where the other D2D communicating mobiles are attached to. In other words, all the D2D communicating mobiles needn't be attached in the same cell in order to derive the benefits of the present invention.

[0032] In some embodiments, an order of preference may be defined: Firstly, the most preferable cell is the cell where the other D2D communicating mobiles are attached to. Second-most preferable are cells controlled by the same base station. Third-most preferable are cells controlled by a same macro base station as indirectly controls the most preferable cell. Fourth-most preferable are cells controlled indirectly by a same macro base station as indirectly controls the most preferable cell. Fifth-most preferable are cells controlled by a macro base station with a direct interface to the most preferable cell or a base station indirectly controlling the most preferable cell. Sixth-most preferable are small cells indirectly controlled by a macro base station with a direct interface to a macro base station indirectly controlling the most preferable cell.

[0033] In some embodiments of the invention, an order of preference of cells depends on whether the D2D communication is direct D2D communication or local D2D communication. For example, in terms of FIG. 2, if the D2D communication of mobiles 140 and 150 were local D2D, in other words being routed via base station 160 instead of via D2D wireless link 145, macro cell 102 may be seen as more preferable for mobile 110 than small cell 171.

[0034] In general there is provided an apparatus, such as for example a mobile 110 or base station 120 as illustrated in FIG. 1. The apparatus may alternatively comprise a control apparatus for inclusion in a mobile 110 or base station 120, to control the functioning thereof. The apparatus may comprise at least one processor configured to determine whether a user equipment associated with a first identity is attached to a cell that is most preferable for participating in a device-to-device communication between at least two user equipments. In some embodiments, the user equipment associated with the first identity is not comprised in the at least two user equipments participating in the device-to-device communication when the determining takes place. In this sense, the determining may comprise whether a first user equipment associated with a first identity is attached to a cell that is most preferable for participating in a device-to-device communication between at least two second user equipments.

[0035] If the determination result is that the user equipment is attached to a most preferable cell, there may be no need to handover the user equipment for the reason of attaching to a more preferable cell for D2D communication. The at least one processor may comprise at least one processing core comprised in a processing device or chipset, for example. Responsive to a determination the user equipment is not attached to a cell that is most preferable for participating in the device-to-device communication, the at least one processor may be configured to initiate transferring the user equipment to a cell that is more preferable than the current cell for participating in the device-to-device communication. The more preferable cell the at least one processor selects may be the most preferable cell from the point of view of participating in the D2D communication that is accessible for the user equipment. The apparatus may further comprise a transmitter that is caused by the at least one processor to send a message to initiate the transferring. When the apparatus comprises a control device, the transmitter may comprise a data output port of the control device, such as for example a serial port and pin of an integrated circuit. When the apparatus comprises a base station, the transmitter may comprise an output port of the base station, capable of signaling to another base station, for example. When the apparatus comprises a mobile, the transmitter may comprise a radio transmitter of the mobile.

[0036] In some embodiments, the apparatus further comprises a receiver configured to receive a request to join the device-to-device communication, the request comprising the first identity. The request may comprise a D2D join request. A D2D join request may be received in a base station from a mobile, for example. The first identity

may comprise a telephone number of a cellular mobile, an international mobile station equipment identity, IMEI, a session initiation protocol, SIP, identity of the mobile or a name or identity of a subscriber operating a mobile that sent the request.

[0037] FIGURE 5 is a signaling diagram illustrating signaling in accordance with at least some embodiments of the invention. On the vertical axes are illustrated, from left to right, MOBILE 1, which is a mobile seeking to join a D2D communication, such as mobile 110 in FIG. 1. BS 1 is a base station that controls a cell to which MOBILE 1 is attached. D2D group is a group of mobiles participating in the D2D communication in which MOBILE 1 seeks to join. BS2 is a base station controlling cells Cell 1 and Cell 2. D2D group comprises mobiles attached to Cell 1. At least the majority of the mobiles comprised in D2D group are attached in Cell 1, while none or a minority of them may be attached in other cells, such as Cell 2 of BS 2.

[0038] In phase 510, MOBILE 1 is attached to Cell 1 of BS 1. In phase 520, which may occur at the same time as phase 510, at least most of mobiles participating in D2D group are attached to Cell 1 of BS 2. Some of them may be attached in Cell 2 of BS 2, for example. In phase 530, MOBILE 1 may initiate a D2D join request, requesting participation in D2D group, to BS 1. Responsively, BS 1 may forward a request to BS2, phase 540, BS 2 in turn inquires in phase 550 from D2D group, whether MOBILE 1 should be allowed to participate in D2D group. The message of phase 540 may comprise an identity of MOBILE 1. In phase 560, should D2D group indicate responsively that MOBILE 1 shouldn't be allowed to participate, the signaling will end. Should D2D group in phase 560 however indicate MOBILE 1 is allowed to participate, processing continues to phase 570 where BS 2 informs BS 1 of the permission granted to MOBILE 1 to participate in D2D group. In some embodiments, where admission of MOBILE 1 to D2D group is automatic due to a specific invitation or advertisement, or where MOBILE 1 is in a pass-list or member list of D2D group, phases 550 and 560 may be absent. A pass list may comprise at least one identity of a mobile, or a user of a mobile, the mobile being thereby pre-configured as having access to D2D group. In some cases, phases 540, 550, 560 and 570 may all be absent if BS 1 knows MOBILE 1 will be allowed in D2D group, or if the embodiment doesn't comprise D2D group admission control.

[0039] In phase 580, BS 1 instructs MOBILE 1 to perform measurements to determine if participating in the D2D communication of D2D group is possible for MOBILE 1. In phase 590, MOBILE 1 responsively performs these measurements, which may comprise at least one of receiving energy transmitted from at least one mobile

comprised in D2D group and measuring a pathloss to at least one mobile comprised in D2D group. In some embodiments, phase 590 comprises determining if attachment of MOBILE 1 to a cell where D2D group is attached to is possible. In some embodiments, MOBILE 1 is configured to perform these measurements on its own initiative without
5 being instructed to perform them by BS 1. In these cases, these measurements may precede phase 530. In phase 5100, MOBILE 1 may indicate to BS 1 the results of the measurements. The results may indicate, for example, that a D2D connection, which may be direct or local, to D2D group is possible. The measurement results of phase 5100 may also comprise information enabling BS 1 to determine cells that MOBILE 1 is capable of
10 handing over to.

[0040] In phase 5110, BS 1 determines whether Cell 1 of BS 1, to which MOBILE 1 is attached, is the most preferable available cell for MOBILE 1 to be attached to, when participating in D2D group. In the illustrated example, both cells of BS 2 are available handover candidates for MOBILE 1. Since D2D group is entirely, predominantly
15 or largely attached to Cell 1 of BS 2, this cell may be considered most preferable, and Cell 2 of BS 2 also as more preferable than Cell 1 of BS 1. Responsive to the determination of phase 5110, BS 1 transmits in phase 5120 a request to Cell 1 of BS 2 for MOBILE 1 to be handed over. The message of phase 5120 may be considered a handover request. Responsive to receiving the message of phase 5120, BS 2 in phase 5130 performs
20 admission control to decide whether to admit MOBILE 1 to Cell 1 of BS 2. If BS 2 decides to admit MOBILE 1, BS 2 will transmit an instruction to BS 1 informing of this and MOBILE 1 will handover to Cell 1 of BS 2. In the illustrated example, the admission decision of phase 5130 is negative. This may be due to high load in Cell 1 of BS 2, for example. BS 1 is informed of the refusal to admit MOBILE 1 to Cell 1 of BS 2 in phase
25 5140. Responsively, BS 1 transmits another request message, for example a handover request, to BS 2 this time requesting for MOBILE 1 to be admitted to Cell 2 of BS 2, which is also considered more preferable for participating in D2D group than Cell 1 of BS 1, which is the cell MOBILE 1 is attached to originally. This request is illustrated as message 5150. BS 2 may responsive to receiving the request of phase 5150 decide to admit
30 MOBILE 1 to Cell 2 of BS 2, and inform BS 1 of this in phase 5160. Finally, BS 1 may transmit a handover command to MOBILE 1, phase 5170, instructing MOBILE 1 to handover to Cell 2 of BS 2 for participating in D2D group. As an alternative, BS2 may accept MOBILE 1 to Cell 1 of BS 2 and thereafter cause MOBILE 1 to be transferred within BS 2 from Cell 1 to Cell 2.

[0041] FIGURE 3 illustrates a block diagram of an apparatus 10 such as, for example, a mobile terminal such as mobile 110, in accordance with an example embodiment of the invention. While several features of the apparatus are illustrated and will be hereinafter described for purposes of example, other types of electronic devices, such as mobile telephones, mobile computers, portable digital assistants, PDAs, pagers, laptop computers, desktop computers, gaming devices, televisions, routers, home gateways, and other types of electronic systems, may employ various embodiments of the invention.

[0042] As shown, the mobile terminal 10 may include at least one antenna 12 in communication with a transmitter 14 and a receiver 16. Alternatively transmit and receive antennas may be separate. The mobile terminal 10 may also include a processor 20 configured to provide signals to and receive signals from the transmitter and receiver, respectively, and to control the functioning of the apparatus. Processor 20 may be configured to control the functioning of the transmitter and receiver by effecting control signaling via electrical leads to the transmitter and receiver. Likewise processor 20 may be configured to control other elements of apparatus 10 by effecting control signaling via electrical leads connecting processor 20 to the other elements, such as for example a display or a memory. The processor 20 may, for example, be embodied as various means including circuitry, at least one processing core, one or more microprocessors with accompanying digital signal processor(s), one or more processor(s) without an accompanying digital signal processor, one or more coprocessors, one or more multi-core processors, one or more controllers, processing circuitry, one or more computers, various other processing elements including integrated circuits such as, for example, an application specific integrated circuit, ASIC, or field programmable gate array, FPGA, or some combination thereof. A processor comprising exactly one processing core may be referred to as a single-core processor, while a processor comprising more than one processing core may be referred to as a multi-core processor. Accordingly, although illustrated in FIG. 3 as a single processor, in some embodiments the processor 20 comprises a plurality of processors or processing cores. Signals sent and received by the processor 20 may include signaling information in accordance with an air interface standard of an applicable cellular system, and/or any number of different wireline or wireless networking techniques, comprising but not limited to Wi-Fi, wireless local access network, WLAN, techniques such as Institute of Electrical and Electronics Engineers, IEEE, 802.11, 802.16, and/or the like. In addition, these signals may include speech data, user generated data, user

requested data, and/or the like. In this regard, the apparatus may be capable of operating with one or more air interface standards, communication protocols, modulation types, access types, and/or the like. More particularly, the apparatus may be capable of operating in accordance with various first generation, 1G, second generation, 2G, 2.5G, third-
5 generation, 3G, communication protocols, fourth-generation, 4G, communication protocols, Internet Protocol Multimedia Subsystem, IMS, communication protocols, for example, session initiation protocol, SIP, and/or the like. For example, the apparatus may be capable of operating in accordance with 2G wireless communication protocols IS-136, Time Division Multiple Access TDMA, Global System for Mobile communications, GSM,
10 IS-95, Code Division Multiple Access, CDMA, and/or the like. Also, for example, the mobile terminal may be capable of operating in accordance with 2.5G wireless communication protocols General Packet Radio Service, GPRS, Enhanced Data GSM Environment, EDGE, and/or the like. Further, for example, the apparatus may be capable of operating in accordance with 3G wireless communication protocols such as Universal
15 Mobile Telecommunications System, UMTS, Code Division Multiple Access 2000, CDMA2000, Wideband Code Division Multiple Access, WCDMA, Time Division-Synchronous Code Division Multiple Access, TD-SCDMA, and/or the like. The apparatus may be additionally capable of operating in accordance with 3.9G wireless communication protocols such as Long Term Evolution, LTE, or Evolved Universal Terrestrial Radio
20 Access Network, E-UTRAN, and/or the like. Additionally, for example, the apparatus may be capable of operating in accordance with fourth-generation, 4G, wireless communication protocols such as LTE Advanced and/or the like as well as similar wireless communication protocols that may be developed in the future.

[0043] Some Narrow-band Advanced Mobile Phone System, NAMPS, as well as
25 Total Access Communication System, TACS, mobile terminal apparatuses may also benefit from embodiments of this invention, as should dual or higher mode phone apparatuses, for example, digital/analogue or TDMA/CDMA/analogue phones. Additionally, apparatus 10 may be capable of operating according to Wi-Fi or Worldwide Interoperability for Microwave Access, WiMAX, protocols.

30 [0044] It is understood that the processor 20 may comprise circuitry for implementing audio/video and logic functions of apparatus 10. For example, the processor 20 may comprise a digital signal processor device, a microprocessor device, an analogue-to-digital converter, a digital-to-analogue converter, and/or the like. Control and signal processing functions of the mobile terminal may be allocated between these devices

according to their respective capabilities. The processor may additionally comprise an internal voice coder, VC, 20a, an internal data modem, DM, 20b, and/or the like. Further, the processor may comprise functionality to operate one or more software programs, which may be stored in memory. In general, processor 20 and stored software instructions may be configured to cause apparatus 10 to perform actions. For example, processor 20 may be capable of operating a connectivity program, such as a web browser. The connectivity program may allow the mobile terminal 10 to transmit and receive web content, such as location-based content, according to a protocol, such as wireless application protocol, WAP, hypertext transfer protocol, HTTP, and/or the like

[0045] Apparatus 10 may also comprise a user interface including, for example, an earphone or speaker 24, a ringer 22, a microphone 26, a display 28, a user input interface, and/or the like, which may be operationally coupled to the processor 20. In this regard, the processor 20 may comprise user interface circuitry configured to control at least some functions of one or more elements of the user interface, such as, for example, the speaker 24, the ringer 22, the microphone 26, the display 28, and/or the like. The processor 20 and/or user interface circuitry comprising the processor 20 may be configured to control one or more functions of one or more elements of the user interface through computer program instructions, for example, software and/or firmware, stored on a memory accessible to the processor 20, for example, volatile memory 40, non-volatile memory 42, and/or the like. Although not shown, the apparatus may comprise a battery for powering various circuits related to the mobile terminal, for example, a circuit to provide mechanical vibration as a detectable output. The user input interface may comprise devices allowing the apparatus to receive data, such as a keypad 30, a touch display, which is not shown, a joystick, which is not shown, and/or at least one other input device. In embodiments including a keypad, the keypad may comprise numeric 0-9 and related keys, and/or other keys for operating the apparatus.

[0046] As shown in FIG. 3, apparatus 10 may also include one or more means for sharing and/or obtaining data. For example, the apparatus may comprise a short-range radio frequency, RF, transceiver and/or interrogator 64 so data may be shared with and/or obtained from electronic devices in accordance with RF techniques. The apparatus may comprise other short-range transceivers, such as, for example, an infrared, IR, transceiver 66, a BluetoothTM, BT, transceiver 68 operating using BluetoothTM brand wireless technology developed by the BluetoothTM Special Interest Group, a wireless universal serial bus, USB, transceiver 70 and/or the like. The BluetoothTM transceiver 68 may be

capable of operating according to low power or ultra-low power Bluetooth™ technology, for example, Wibree™, radio standards. In this regard, the apparatus 10 and, in particular, the short-range transceiver may be capable of transmitting data to and/or receiving data from electronic devices within a proximity of the apparatus, such as within 10 meters, for example. Although not shown, the apparatus may be capable of transmitting and/or receiving data from electronic devices according to various wireless networking techniques, including 6LoWpan, Wi-Fi, Wi-Fi low power, WLAN techniques such as IEEE 802.11 techniques, IEEE 802.15 techniques, IEEE 802.16 techniques, and/or the like.

[0047] The apparatus 10 may comprise memory, such as a subscriber identity module, SIM, 38, a removable user identity module, R-UIM, and/or the like, which may store information elements related to a mobile subscriber. In addition to the SIM, the apparatus may comprise other removable and/or fixed memory. The apparatus 10 may include volatile memory 40 and/or non-volatile memory 42. For example, volatile memory 40 may include Random Access Memory, RAM, including dynamic and/or static RAM, on-chip or off-chip cache memory, and/or the like. Non-volatile memory 42, which may be embedded and/or removable, may include, for example, read-only memory, flash memory, magnetic storage devices, for example, hard disks, floppy disk drives, magnetic tape, etc., optical disc drives and/or media, non-volatile random access memory, NVRAM, and/or the like. Like volatile memory 40, non-volatile memory 42 may include a cache area for temporary storage of data. At least part of the volatile and/or non-volatile memory may be embedded in processor 20. The memories may store one or more software programs, instructions, pieces of information, data, and/or the like which may be used by the apparatus for performing functions of the mobile terminal. For example, the memories may comprise an identifier, such as international mobile equipment identification, IMEI, code, capable of uniquely identifying apparatus 10.

[0048] FIGURE 4 illustrates a block diagram of an apparatus 10 such as, for example, a base station, in accordance with an example embodiment of the invention.

[0049] As shown, the apparatus 10 may include at least one antenna 12 in communication with a transmitter 14 and a receiver 16. Alternatively transmit and receive antennas may be separate. The apparatus 10 may also include a processor 20 configured to provide signals to and receive signals from the transmitter and receiver, respectively, and to control the functioning of the apparatus. Processor 20 may be configured to control the functioning of the transmitter and receiver by effecting control signaling via electrical leads to the transmitter and receiver. Likewise processor 20 may be configured to control

other elements of apparatus 10 by effecting control signaling via electrical leads connecting processor 20 to the other elements, such as for example a memory. The processor 20 may, for example, be embodied as various means including circuitry, at least one processing core, one or more microprocessors with accompanying digital signal processor(s), one or more processor(s) without an accompanying digital signal processor, one or more coprocessors, one or more multi-core processors, one or more controllers, processing circuitry, one or more computers, various other processing elements including integrated circuits such as, for example, an application specific integrated circuit, ASIC, or field programmable gate array, FPGA, or some combination thereof. A processor comprising exactly one processing core may be referred to as a single-core processor, while a processor comprising more than one processing core may be referred to as a multi-core processor. Accordingly, although illustrated in FIG. 4 as a single processor, in some embodiments the processor 20 comprises a plurality of processors or processing cores. Signals sent and received by the processor 20 may include signaling information in accordance with an air interface standard of an applicable cellular system, and/or any number of different wireline or wireless networking techniques, comprising but not limited to Wi-Fi, wireless local access network, WLAN, techniques such as Institute of Electrical and Electronics Engineers, IEEE, 802.11, 802.16, and/or the like. In addition, these signals may include speech data, user generated data, user requested data, and/or the like. In this regard, the apparatus may be capable of operating with one or more air interface standards, communication protocols, modulation types, access types, and/or the like. More particularly, the apparatus may be capable of operating in accordance with various first generation, 1G, second generation, 2G, 2.5G, third-generation, 3G, communication protocols, fourth-generation, 4G, communication protocols, Internet Protocol Multimedia Subsystem, IMS, communication protocols, for example, session initiation protocol, SIP, and/or the like. For example, the apparatus may be capable of operating in accordance with 2G wireless communication protocols IS-136, Time Division Multiple Access TDMA, Global System for Mobile communications, GSM, IS-95, Code Division Multiple Access, CDMA, and/or the like. Also, for example, the mobile terminal may be capable of operating in accordance with 2.5G wireless communication protocols General Packet Radio Service. GPRS, Enhanced Data GSM Environment, EDGE, and/or the like. Further, for example, the apparatus may be capable of operating in accordance with 3G wireless communication protocols such as Universal Mobile Telecommunications System, UMTS, Code Division Multiple Access 2000, CDMA2000, Wideband Code Division Multiple

Access, WCDMA, Time Division-Synchronous Code Division Multiple Access, TD-SCDMA, and/or the like. The apparatus may be additionally capable of operating in accordance with 3.9G wireless communication protocols such as Long Term Evolution, LTE, or Evolved Universal Terrestrial Radio Access Network, E-UTRAN, and/or the like.

5 Additionally, for example, the apparatus may be capable of operating in accordance with fourth-generation, 4G, wireless communication protocols such as LTE Advanced and/or the like as well as similar wireless communication protocols that may be developed in the future. The apparatus may comprise a wired interface I/O 64, which may be configured to enable the apparatus to communicate with other apparatuses, which may include base
10 stations, radio access network controllers and core network entities.

[0050] The apparatus 10 may include volatile memory 40 and/or non-volatile memory 42. For example, volatile memory 40 may include Random Access Memory, RAM, including dynamic and/or static RAM, on-chip or off-chip cache memory, and/or the like. Non-volatile memory 42, which may be embedded and/or removable, may
15 include, for example, read-only memory, flash memory, magnetic storage devices, for example, hard disks, floppy disk drives, magnetic tape, etc., optical disc drives and/or media, non-volatile random access memory, NVRAM, and/or the like. Like volatile memory 40, non-volatile memory 42 may include a cache area for temporary storage of data. At least part of the volatile and/or non-volatile memory may be embedded in
20 processor 20. The memories may store one or more software programs, instructions, pieces of information, data, and/or the like which may be used by the apparatus for performing functions of the mobile terminal.

[0051] FIGURE 6 is a flow diagram illustrating a method in accordance with at least some embodiments of the invention. The phases of the illustrated method may be
25 performed in mobile 110 or base station 120, for example. Phase 610 comprises determining whether a user equipment associated with a first identity is attached to a cell that is most preferable for participating in a device-to-device communication between at least two user equipments. Phase 620 comprises initiating transferring the user equipment to a cell that is more preferable for participating in the device-to-device communication
30 responsive to a determination the user equipment is not attached to a cell that is most preferable for participating in the device-to-device communication. Finally phase 630 comprises causing sending of a message to initiate the transferring

[0052] Without in any way limiting the scope, interpretation, or application of the claims appearing below, a technical effect of one or more of the example embodiments

disclosed herein is that a functioning of D2D communication is improved as latencies related to managing the D2D communication are reduced.

[0053] Embodiments of the present invention may be implemented in software, hardware, application logic or a combination of software, hardware and application logic.

5 The software, application logic and/or hardware may reside on memory 40, the control apparatus 20 or electronic components, for example. In an example embodiment, the application logic, software or an instruction set is maintained on any one of various conventional computer-readable media. In the context of this document, a “computer-readable medium” may be any media or means that can contain, store, communicate, propagate or transport the instructions for use by or in connection with an instruction execution system, apparatus, or device, such as a computer, with one example of a computer described and depicted in FIGURE 4. A computer-readable medium may comprise a computer-readable non-transitory storage medium that may be any media or means that can contain or store the instructions for use by or in connection with an instruction execution system, apparatus, or device, such as a computer. The scope of the invention comprises computer programs configured to cause methods according to embodiments of the invention to be performed.

[0054] If desired, the different functions discussed herein may be performed in a different order and/or concurrently with each other. Furthermore, if desired, one or more of the above-described functions may be optional or may be combined.

[0055] Although various aspects of the invention are set out in the independent claims, other aspects of the invention comprise other combinations of features from the described embodiments and/or the dependent claims with the features of the independent claims, and not solely the combinations explicitly set out in the claims.

25 [0056] It is also noted herein that while the above describes example embodiments of the invention, these descriptions should not be viewed in a limiting sense. Rather, there are several variations and modifications which may be made without departing from the scope of the present invention as defined in the appended claims.

WHAT IS CLAIMED IS

1. An apparatus, comprising:

at least one processor configured to determine whether a user equipment associated with a first identity is attached to a cell that is most preferable for participating in a device-to-device communication between at least two user equipments;

the at least one processor being configured to, responsive to a determination the user equipment is not attached to a cell that is most preferable for participating in the device-to-device communication, initiate transferring the user equipment to a cell that is more preferable for participating in the device-to-device communication, and

a transmitter that is caused by the at least one processor to send a message to initiate the transferring.

2. An apparatus according to claim 1, further comprising a receiver configured to receive a request to join the device-to-device communication, the request comprising the first identity;

3. An apparatus according to claim 1 or 2, wherein the device-to-device communication between at least two user equipments comprises either direct radio communication wherein radio signals transmitted by a transmitting user equipment are received by a receiving user equipment without the radio signals being re-transmitted thereinbetween, or local device to device communication wherein data is forwarded between the at least two user equipments by a base station without forwarding to other non-mobile nodes.

4. An apparatus according to any preceding claim, wherein a cell to which most of the user equipments participating in the device-to-device communication are attached to is most preferable for participating in the device-to-device communication.

5. An apparatus according to any preceding claim, wherein a cell controlled by the same base station as cells to which most of the user equipments participating in the device-to-device communication are attached to is more preferable for participating in the device-to-device communication than a cell controlled by another base station.

6. An apparatus according to any preceding claim, wherein a cell controlled by a base station that has a direct interface to a base station controlling cells to which

most of the user equipments participating in the device-to-device communication are attached to is more preferable for participating in the device-to-device communication than a cell controlled by a base station that does not have such a direct interface.

5 7. An apparatus according to claim 6, wherein the direct interface comprises a X2 interface.

8. An apparatus according to claim 6, wherein the direct interface comprises a macro base station to small base station interface in a heterogeneous radio access network.

10 9. An apparatus according to any preceding claim, wherein the apparatus comprises or is comprised in a cellular base station.

10. An apparatus according to claim 1, wherein the apparatus comprises or is comprised in a mobile communication device, the apparatus further comprising an antenna coupled to, and configured to provide signals to, the at least one processor.

15 11. A method, comprising:

determining whether a user equipment associated with a first identity is attached to a cell that is most preferable for participating in a device-to-device communication between at least two user equipments;

responsive to a determination the user equipment is not attached
20 to a cell that is most preferable for participating in the device-to-device communication, initiating transferring the user equipment to a cell that is more preferable for participating in the device-to-device communication, and causing sending of a message to initiate the transferring.

12. A method according to claim 10, further comprising receiving a request to
25 join the device-to-device communication, the request comprising the first identity;

13. A method according to claim 11 or 12, wherein the device-to-device communication between at least two user equipments comprises either direct radio communication wherein radio signals transmitted by a transmitting user equipment are received by a receiving user equipment without the radio signals being re-
30 transmitted thereinbetween, or local device to device communication wherein data is forwarded between the at least two user equipments by a base station without forwarding to other non-mobile nodes.

14. A method according to any of claims 11 - 13, wherein a cell to which most of the user equipments participating in the device-to-device communication are

attached to is most preferable for participating in the device-to-device communication.

15. A method according to any of claims 11 - 14, wherein a cell controlled by the same base station as cells to which most of the user equipments participating in the device-to-device communication are attached to is more preferable for participating in the device-to-device communication than a cell controlled by another base station.

16. A method according to any of claims 11 - 15, wherein a cell controlled by a base station that has a direct interface to a base station controlling cells to which most of the user equipments participating in the device-to-device communication are attached to is more preferable for participating in the device-to-device communication than a cell controlled by a base station that does not have such a direct interface.

17. A method according to claim 16, wherein the direct interface comprises a X2 interface.

18. A method according to claim 16, wherein the direct interface comprises a macro base station to small base station interface in a heterogeneous radio access network.

19. An apparatus, comprising:

means for determining whether a user equipment associated with a first identity is attached to a cell that is most preferable for participating in a device-to-device communication between at least two user equipments;

means for, responsive to a determination the user equipment is not attached to a cell that is most preferable for participating in the device-to-device communication, initiating transferring the user equipment to a cell that is more preferable for participating in the device-to-device communication, and

means for causing sending of a message to initiate the transferring.

20. A computer program product comprising a computer-readable medium bearing computer program code embodied therein for use with a computer, the computer program code comprising:

code for determining whether a user equipment associated with a first identity is attached to a cell that is most preferable for participating in a device-to-device communication between at least two user equipments;

code for, responsive to a determination the user equipment is not attached to a cell that is most preferable for participating in the device-to-device communication, initiating transferring the user equipment to a cell that is more preferable for participating in the device-to-device communication; and

5

code for causing sending of a message to initiate the transferring.

21. A computer program configured to cause a method according to at least one of claims 11 – 18 to be performed

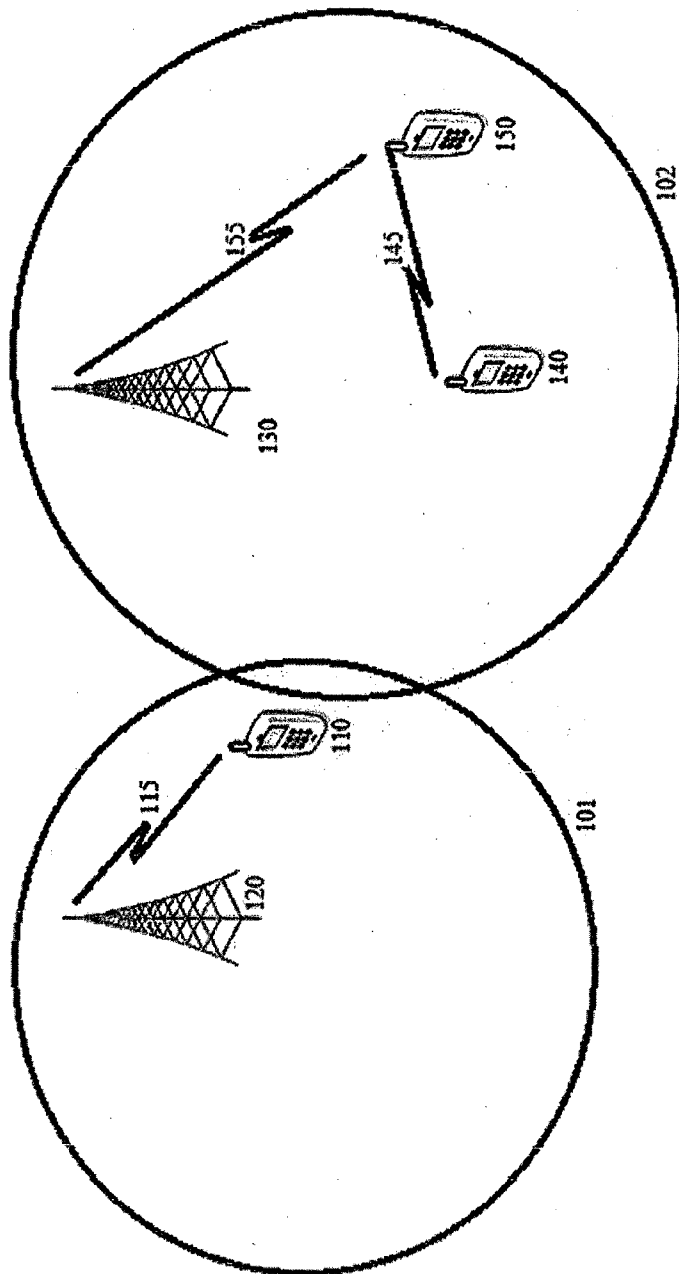


FIGURE 1

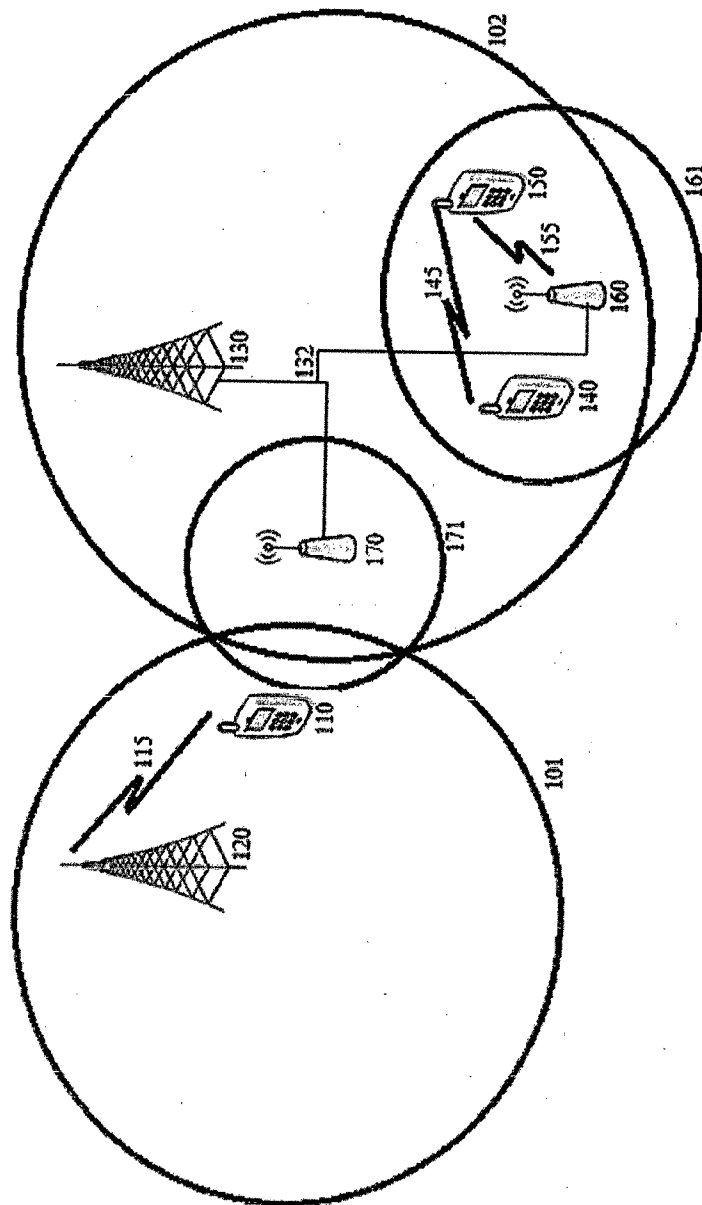


FIGURE 2

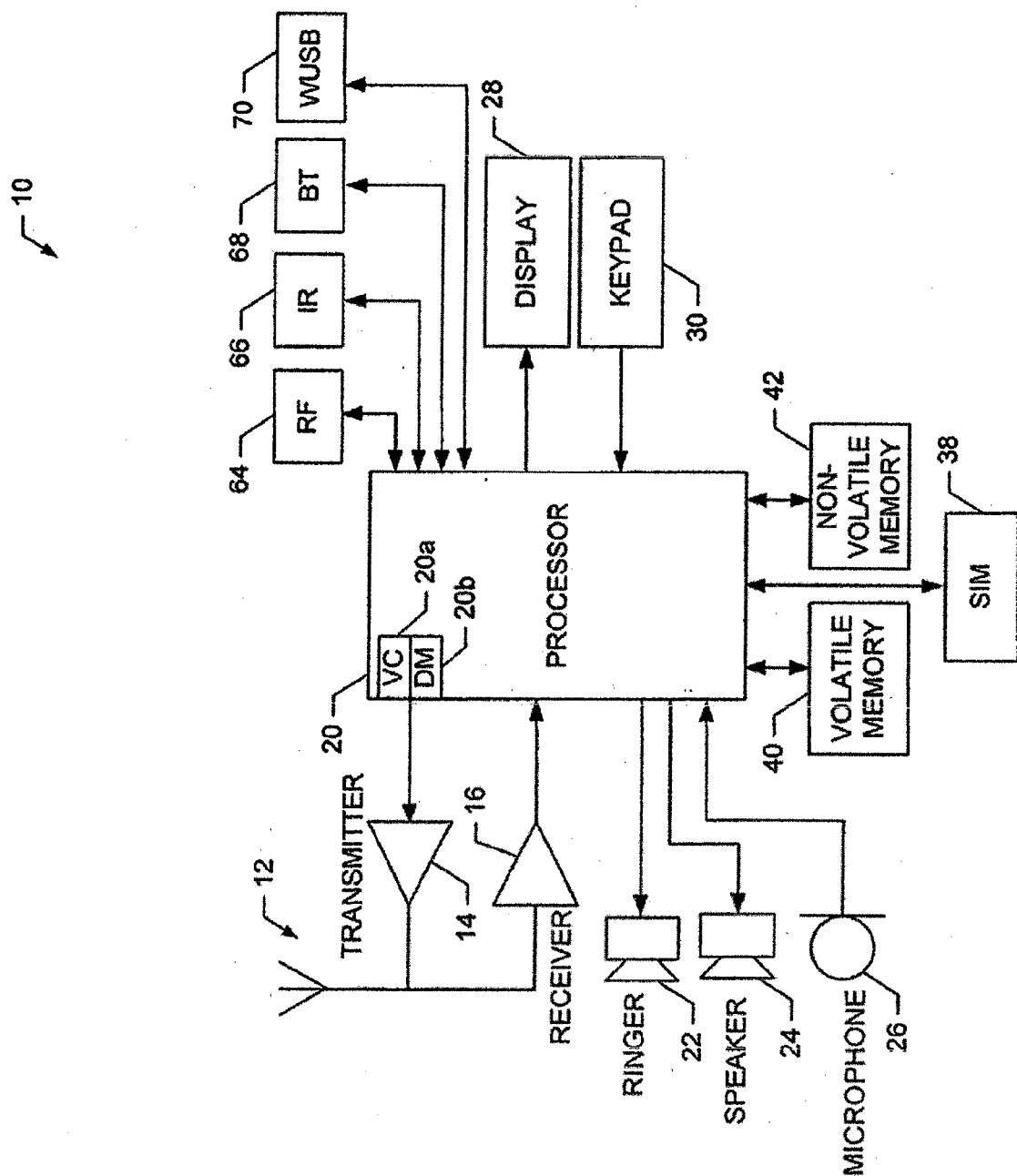


FIGURE 3

10

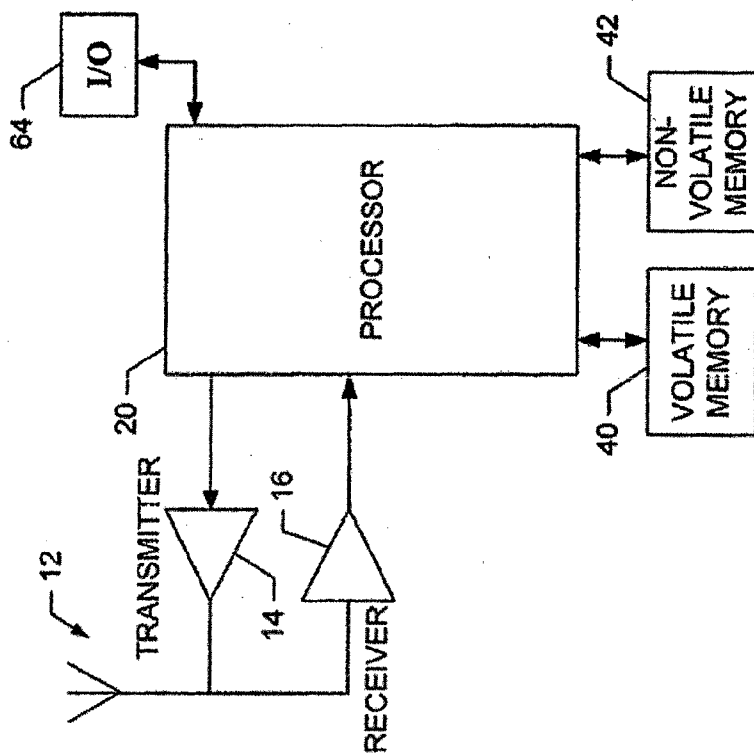


FIGURE 4

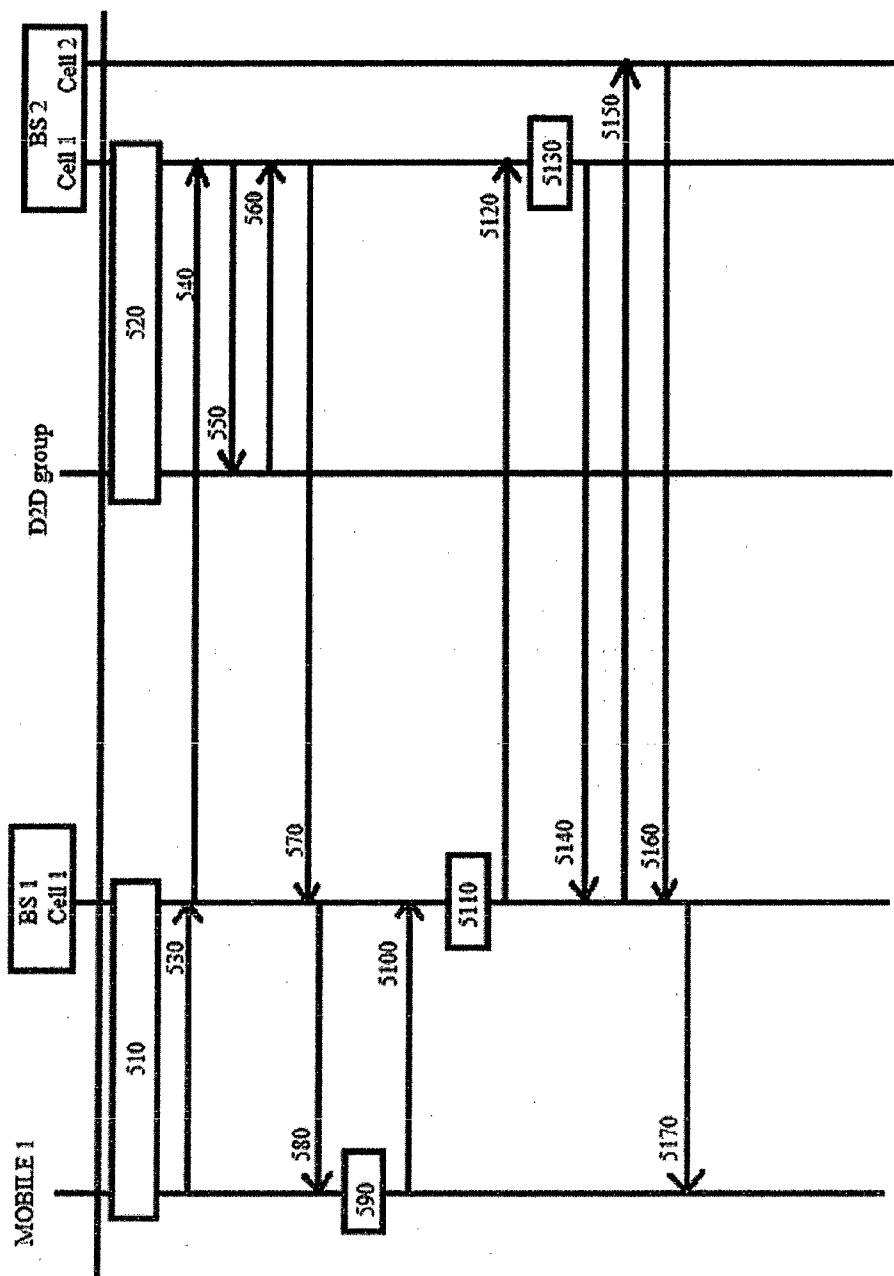


FIGURE 5

6/6

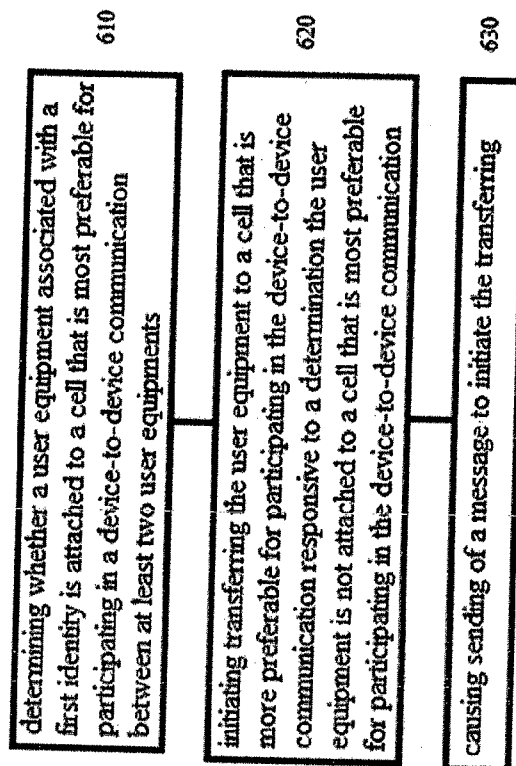


FIGURE 6

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI2013/050487

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet

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)

IPC: H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
FI, SE, NO, DK

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI, INSPEC, XPIPCOM, XPI3E, XP3GPP, XPETSI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	WO 2005053346 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]) 09 June 2005 (09.06.2005) page 6, lines 4-17	1, 11, 19, 20, 21
A	US 2007129076 A1 (CHO SUNG R [KR] et al.) 07 June 2007 (07.06.2007) abstract	1-21
A	US 2011228666 A1 (BARBIERI ALAN [US] et al.) 22 September 2011 (22.09.2011) abstract	1-21
A	WO 2011109027 A1 (NOKIA CORP [FI]) 09 September 2011 (09.09.2011) abstract	1-21



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

27 January 2014 (27.01.2014)

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI2013/050487

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INTERNATIONAL SEARCH REPORT

International application No.
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CLASSIFICATION OF SUBJECT MATTER

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H04W 36/00 (2009.01)

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H04W 48/20 (2009.01)