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(71) Applicant *(for all designated States except US)*: **NOKIA CORPORATION** [FI/FI]; Keilalahdentie 4, FI-02150 Espoo (FI).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **AKSELIN, Marko Tapani** [FI/FI]; Lumilyhdyntie 3, FI-90630 Oulu (FI). **KOSKELA, Jarkko, Tuomo** [FI/FI]; Kajuuttapiha 3, FI-90500 Oulu (FI).

(74) Agent: **ESPATENT OY**; Kaivokatu 10 A, FI-00100 Helsinki (FI).

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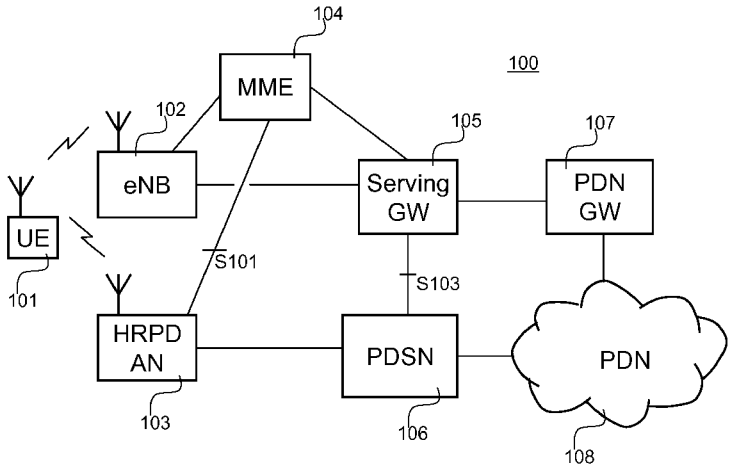


FIG 1

(57) Abstract: The invention relates to acquiring and using information related to cell changes in mobile communication networks. An exemplary method includes sending a connection request message to a network entity, receiving a connection rejection message responsive to the sending of the connection request message from the network entity, the connection rejection message comprising a reason code and a tracking area identifier, acquiring the reason code and the tracking area identifier from the connection rejection message, andstoring the tracking area identifier according to the reason code.

CELL CHANGE

FIELD OF THE INVENTION

The present invention relates in general to mobile communication and in particular, but not exclusively, to cell changes in mobile communication networks.

BACKGROUND OF THE INVENTION

Mobile communication systems have been in use for a few decades, but especially the last decade has shown an enormous growth in mobile communication usage. Today's mobile phones typically combine a communication device and a portable/mobile computer in one physical device.

Mobile communication systems have been built on a number of different standards and technologies, such as Global System for Mobile communication (GSM), and IS-95, commonly known by the name of its radio access technology, Code-Division Multiple Access (CDMA). These systems have evolved to today's mobile communication systems that provide e.g. higher data speeds. Such systems include e.g. the Universal Mobile Telecommunication System (UMTS), also known by the name of its air interface technology, Wideband Code-Division Multiple-Access (WCDMA), and CDMA2000. Development of next generation mobile communication access and core network systems, such as Long Term Evolution (LTE) and High Rate Packet Data (HRPD) are underway.

Traditionally, different mobile communication technologies and standards have been dominant in different countries, but there have been areas where e.g. access networks of different access technologies overlap. It is possible that roaming between access networks of different standards and access technologies using dual mode mobile phones becomes an important feature.

SUMMARY

It is possible that a network operator does not allow roaming to its radio access network from a radio access network using different access technology. In other words, the operator's network may be configured to reject cell change requests from mobile stations that are connected to a base station or base stations of the access network with different access technology. As a mobile station may be continuously measuring the signals transmitted by nearby base stations while looking for the best available radio signal quality, the mobile station may attempt a cell change to a forbidden base station several times, if the forbidden base station provides the best radio signal quality.

Particular embodiments of the invention aim at addressing at least some of the issues discussed above. According to a first aspect of the invention there is provided a method that comprises sending a connection request message to a network entity, receiving a connection rejection message responsive to the sending of the connection request message from the network entity, the connection rejection message comprising a reason code and a tracking area identifier, acquiring the reason code and the tracking area identifier from the connection rejection message, and storing the tracking area identifier according to the reason code.

A second aspect is represented by an apparatus comprising a communication interface configured to operate a communication connection, a memory, and a processor functionally coupled to the communication interface and to the memory, the processor being configured to send via the communication interface a connection request message to a network entity, to receive a connection rejection message responsive to the sending of the connection request message from the network entity via the communication interface, the connection rejection message comprising a reason code and a tracking area identifier, to acquire the reason code and the tracking area identifier from the connection rejection message, and to store the tracking area identifier in the memory according to the reason code.

According to a third aspect there is provided a computer program product embodied on a computer-readable medium, the computer program comprising program code operable to be executed by a processor, the program code being configured to enable, when executed, the processor to send a connection request message to a network entity, to receive a connection rejection message responsive to the sending of the connection request message from the network entity, the connection rejection message comprising a reason code and a tracking area identifier, to acquire the reason code and the tracking area identifier from the connection rejection message, and to store the tracking area identifier according to the reason code.

According to a fourth aspect there is provided a method that comprises receiving a connection request message, determining whether a connection is allowed according to the request, generating, in case the connection is not allowed, a connection rejection message, inserting in the connection rejection message a reason code and a tracking area identifier, said tracking area identifier indicating a forbidden tracking area, and sending the connection rejection message.

According to a fifth aspect there is provided an apparatus comprising a communication interface configured to operate a communication connection, and a processor functionally coupled to the communication interface, the processor being configured to receive a connection request message via the communication interface, to determine whether a connection is allowed according to the request, to generate, responsive to determining that the connection is not allowed, a connection rejection message, to insert in the connection rejection message a reason code and a tracking area identifier, said tracking area identifier indicating a forbidden tracking area, and to send the connection rejection message.

According to a sixth aspect there is provided a computer program product embodied on a computer-readable medium, the computer program comprising program code operable to be executed by a processor, the program code being configured to enable, when executed, the processor to receive a connection request message, to determine whether a connection is allowed according to the

request, to generate, responsive to determining that the connection is not allowed, a connection rejection message, to insert in the connection rejection message a reason code and a tracking area identifier, said tracking area identifier indicating a forbidden tracking area, and to send the connection rejection message.

According to a seventh aspect there is provided an apparatus comprising communication interface means for operating a communication connection, means for sending via the communication interface means a connection request message to a network entity, means for receiving a connection rejection message responsive to the sending of the connection request message from the network entity via the communication interface means, the connection rejection message comprising a reason code and a tracking area identifier, means for acquiring the reason code and the tracking area identifier from the connection rejection message, and means for storing the tracking area identifier in the memory according to the reason code.

According to the methods, apparatuses, and computer programs described hereinbefore, a connection request message may be sent to a network entity. If the requested connection is not allowed, the network entity may indicate the reason for the connection not being allowed with a reason code included in a connection rejection message. The network entity may further insert in the connection rejection message a tracking area identifier. The tracking area identifier may be extracted from the connection rejection message and stored according to the reason code.

The aspects described hereinbefore represent non-limiting examples of the invention. Various exemplary embodiments of the invention are described hereinafter in the detailed description as well as in the dependent claims appended hereto. The embodiments are described with reference to selected aspects. A person skilled in the art appreciates that any embodiment may apply to a particular aspect either alone or in combination with other embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 shows a simplified schematic picture of a system where at least one embodiment may be implemented;
Fig. 2A outlines the structure of an apparatus according to an exemplary embodiment;
Fig. 2B outlines the structure of an apparatus according to another exemplary embodiment;
Fig. 3 illustrates a method according to an exemplary embodiment;
Fig. 4A depicts a method according to another exemplary embodiment;
Fig. 4B shows a method according to yet another exemplary embodiment;
Fig. 4C shows a method according to another exemplary embodiment; and
Fig. 5 illustrates a method according to a further exemplary embodiment.

DETAILED DESCRIPTION

In the following description, like numbers denote like elements.

Fig. 1 shows a simplified schematic picture of an exemplary system 100 where at least one embodiment of the invention may be implemented. The exemplary system 100 of Fig. 1 comprises a user equipment 101, a first base station 102, a second base station 103, a mobility management entity 104, a serving gateway entity 105, a packet data serving node 106, a packet data network gateway 107, and a packet data network 108. Fig. 1 also shows two interfaces / reference points: the S101 interface between the mobile management entity 104 and the second base station 103, and the S103 interface between the serving gateway 105 and the packet data serving node 106.

The user equipment 101 may be e.g. a mobile phone, a laptop computer, a personal digital assistant, a handheld computer, a game console, or the like.

The first base station 102, the mobility management entity 104, the serving gateway 105, and the packet data network gateway 107 may belong to a mobile communication network according to a first network standard. For example, the first base station 102 may be part of an Evolved UMTS Terrestrial Radio Access Network / Long Term Evolution access network (E-UTRAN/LTE), and be denoted as evolved Node B (eNB). Similarly, the mobility management entity 104, the serving gateway 105, and the packet data network gateway 107 may form part of an evolved packet core (EPC). The EPC and the E-UTRAN may belong to an evolved packet system (EPS) network according to specifications by the 3rd Generation Partnership Project (3GPP).

The second base station 103 and the packet data serving node 106 may belong to a mobile communication network according to a second network standard. For example, the second base station 103 may belong to a High Rate Packet Data (HRPD) access network and be denoted as a High Rate Packet Data Access Node (HRPD AN). The HRPD access network and the packet data serving node 106 may be part of a HRPD system according to specifications by the 3rd Generation Partnership Project 2 (3GPP2).

The user equipment 101 may be a dual-mode equipment that is capable of transmitting and receiving signals over two interfaces, i.e. the air interface between the user equipment 101 and the first base station 102 as well as the air interface between the user equipment 101 and the second base station 103. For example, the user equipment may be able to communicate over an E-UTRAN and HRPD air interface.

The mobility management entity 104 may handle e.g. non-access stratum signaling for both control and user planes, management of tracking area lists, and selection of a serving gateway and a packet data network gateway 107 for the transfer of user data. Functions of a mobility management entity 104 are discussed further e.g. in 3GPP Technical Specification (TS) 23.401 V.8.3.0.

The serving gateway 105 and the packet data network gateway 107 may be logical gateway entities residing on a common physical network element or on separate physical network elements. The serving gateway 105 may also reside on a common physical network element with the mobility management entity 104. The serving gateway may serve as a termination point of an interface to E-UTRAN, for example as an endpoint of a data transmission path trough the E-UTRAN allocated to a user equipment, and handle e.g. packet routing and forwarding.

The packet data network gateway 107 may handle e.g. packet filtering and Internet Protocol (IP) address allocation to user equipment. Functions of a serving gateway 105 and a packet data network gateway 107 are discussed further e.g. in 3GPP Technical Specification (TS) 23.401 V.8.3.0.

The packet data serving node 103 may provide on the HRPD system side at least some of the functions provided by the mobility management entity 104, the serving gateway 105, and the packet data network gateway 107 on the EPS system side. Both the packet data network gateway 107 and the packet data serving node 103 may operate as an gateway to the packet data network 108, and enable the user equipment 101 to access the packet data network 108. The packet data network may be e.g. a network operator's IP network or the internet.

Fig. 2A outlines the structure of an apparatus 20 according to an exemplary embodiment. The apparatus 20 of Fig. 2A may represent e.g. the user equipment 101 of Fig. 1.

The apparatus 20 of Fig. 2A may comprise a communication interface module 21, a processor 22 coupled to the communication interface module 21, and a memory 24 coupled to the processor 22. The apparatus 20 further comprises a computer program 25 stored in the memory 24 and operable to be loaded to and executed in the processor 22, which enables the apparatus 20 to operate according to at least some embodiments of the invention. For example, the computer program 25 may implement a number of protocol stacks according to various communication standards The apparatus 20 may further comprise a user interface controller 23 coupled to the processor 22.

The communication interface module 21 may be e.g. a radio interface module, such as a WLAN, Bluetooth, GSM/GPRS, CDMA, WCDMA, E-UTRAN or HRPD radio module, or a wireline interface module, such as a LAN interface module. The communication interface module 21 may be integrated into the apparatus 20 or into an adapter, card or the like that may be inserted into a suitable slot or port of the apparatus 20. The communication interface module 21 may support one radio or wired interface technology or a plurality of technologies. For example, the communication interface module 21 may support E-UTRAN and HRPD air interfaces. Fig. 2A shows one communication interface module 21, but the apparatus 20 may comprise a plurality of communication interface modules 21.

The processor 22 may be e.g. a central processing unit (CPU), a microprocessor, a digital signal processor (DSP), a graphics processing unit, an application specific integrated circuit (ASIC), or the like. Fig. 2A shows one processor 22, but the apparatus 20 may comprise a plurality of processors. The apparatus 20 may e.g. comprise a baseband processor and a multimedia processor.

The memory 24 may be for example a non-volatile or a volatile memory, such as a read-only memory (ROM), a programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), a random-access memory (RAM), a flash memory, a data disk, an optical storage, a magnetic storage, a memory card, or a smart card, such as a SIM or USIM card, or the like. The apparatus 20 may comprise a plurality of memories 24. The memory 24 may be constructed as a part of the apparatus 20 or it may be inserted into a slot, port, or the like of the apparatus 20. The memory 24 may serve the sole purpose of storing data, or it may be constructed as a part of an apparatus serving other purposes, such as processing data.

The user interface controller 23 may comprise circuitry for receiving input from a user of the apparatus 20 e.g. via a keyboard, graphical user interface shown on the display of the apparatus 20, speech recognition circuitry, or an accessory device, such as a headset, and for providing output to the user via e.g. a graphical user interface or a loudspeaker.

A skilled person appreciates that in addition to the elements shown in Fig. 2A, the apparatus 20 may comprise other elements, such as microphones, displays, as well as additional circuitry such as input/output (I/O) circuitry, memory chips, application-specific integrated circuits (ASIC), processing circuitry for specific purposes such as source coding/decoding circuitry, channel coding/decoding circuitry, ciphering/deciphering circuitry, and the like.

Fig. 2B outlines the structure of an apparatus 260 according to another exemplary embodiment. The apparatus 260 may represent e.g. the mobility management entity 104 of Fig. 1.

The apparatus 260 may comprise a communication interface module 261, a processor 262 coupled to the communication interface module 261, and a memory 263 coupled to the processor 262. The apparatus may further comprise a computer program 264 stored in the memory 263 and operable to be loaded into and executed on the processor 262, which enables the apparatus 260 to operate according to at least one embodiment of the invention. For example, the computer program 264 may implement a number of protocol stacks according to various communication standards. The memory 263 may further store a table, database or the like that contains information about tracking area(s) served by the apparatus 260, and/or identification information of a network the apparatus 260 belongs to.

The communication interface module 261 may be e.g. a module that operates a wireline interface, such as a LAN or ATM interface module. The communication interface module 261 may be integrated into the apparatus 260 or into an adapter, card or the like that may be inserted into a suitable slot or port of the apparatus 260. The communication interface module 261 may support one wireline interface technology or a plurality of technologies. Fig. 2B shows one communication interface module 261, but the apparatus 260 may comprise a plurality of communication interface modules 261, possibly supporting different communication technologies.

The processor 262 may be e.g. a central processing unit (CPU), a microprocessor, a digital signal processor (DSP), a graphics processing unit, or the like. Fig. 2B shows one processor 262, but the apparatus 260 may comprise a plurality of processors.

The memory 263 may be for example a non-volatile or a volatile memory, such as a read-only memory (ROM), a programmable read-only memory (PROM), erasable programmable read-only memory (EPROM), a random-access memory (RAM), a flash memory, a data disk, an optical storage, a magnetic storage, or the like. The apparatus 260 may comprise a plurality of memories 263. The memory 263 may be constructed as a part of the apparatus 260 or it may be inserted into a slot, port, or the like of the apparatus 260. The memory 263 may serve the sole purpose of storing data, or it may be constructed as a part of an apparatus serving other purposes, such as processing data.

In addition to the elements shown in Fig. 2B, the apparatus 260 may comprise other circuitry such as input/output (I/O) circuitry, memory chips, application-specific integrated circuits (ASIC), processing circuitry for specific purposes such as source coding/decoding circuitry, channel coding/decoding circuitry, ciphering/deciphering circuitry, and the like.

Particular exemplary embodiments of the invention are described hereinafter with reference to Figs. 3, 4A, 4B, 4C, and 5 as well as to Figs. 1, 2A, and 2B, where applicable.

In step 30 of Fig. 3, a connection request message is sent to a network entity. For example, the user equipment 101 may send the connection request message to the mobility management entity 104 in a situation, where the user equipment 101 is connected to the second base station 103, and the connection is prepared to be transferred to the first base station 102.

The connection request message may be a pre-registration message, such as an attach request message defined in section 8.2.1 of 3GPP TS 24.301 V0.1.0.

The user equipment 101 may send the connection request message over an inter-network interface using a suitable tunneling. For example, the user equipment may use S101 tunneling over an S101 interface, which is adapted to e.g. transport pre-registration messages prior to a cell change event. That is, the user equipment may insert the connection request message into an S101 message, and send the S101 message to the second base station 103, which forwards the S101 message containing the connection request message to the mobility management entity 104 over the S101 interface shown in Fig. 1. S101 messages are discussed in detail e.g. in 3GPP TS 29.276 V8.0.0.

The term 'cell change' as used herein refers to an act of a user equipment migrating from a first cell to a second cell. An example of a cell change is cell reselection.

With reference to Fig. 2A, using the apparatus 20 as an example of the user equipment 101, the connection request message may be generated and sent to the mobility management entity 104 through the communication interface module 21 by the processor 22, controlled by the computer program 24.

In step 31 of Fig. 31, a connection rejection message may be received from the network entity responsive to the sending of the connection request message in step 30. The connection rejection message may comprise a reason code and a tracking area identifier. For example, the user equipment 101 of Fig. 1 may receive the connection reject message from the mobility management entity 104. The user equipment 101 may receive the connection rejection message as a content of a S101 message that the mobility management entity 104 has sent to the second base station 103 over the S101 interface shown in Fig. 1. The second base station 103 forwards the S101 message containing the connection rejection message to the user equipment 101.

The reason code may indicate why the connection request has been rejected. For example, the reason code may indicate, that the first base station 102, where the connection was to be transferred to, belongs to a tracking area that the operator of

the network has excluded from receiving connections that are transferred from an access network of another type. In other words, the reason code may indicate, that a cell change to the requested base station is forbidden. The tracking area identifier included in the connection rejection message may be used to identify the forbidden tracking area and the base stations that belong to the forbidden tracking area.

The connection rejection message may be e.g. an attach reject message defined in section 8.2.4 of 3GPP TS 24.301 V0.1.0.

With reference to Fig. 2A, using the apparatus 20 as an example of the user equipment 101, the connection rejection message may be received through the communication interface module 21 by the processor 22, controlled by the computer program 24.

In step 32 of Fig. 3, the reason code and the tracking area identifier are acquired from the connection rejection message that was received in step 31. For example, the user equipment 101 may retrieve the reason code and the tracking area identifier from the received connection rejection message.

With reference to Fig. 2A, using the apparatus 20 as an example of the user equipment 101, the connection rejection message may be temporarily stored in the memory 24 and the reason code as well as the tracking area identifier retrieved from the stored connection rejection message by the processor 22, controlled by the computer program 24.

In step 33 of Fig. 3, the tracking area identifier is stored according to the reason code. For example, if the reason code indicates, that the tracking area is forbidden, the user equipment 101 may add the tracking area identifier in a stored list of forbidden tracking areas, and use the content of the list later for identifying the same or other forbidden base stations.

With reference to Fig. 2A, using the apparatus 20 as an example of the user equipment 101, the list of forbidden tracking areas may be stored in the memory 24 and maintained by the processor 22, controlled by the computer program 24.

In step 40 of Fig. 4A, the strength of a signal that is transmitted by a base station belonging to a same mobile network as the network entity is measured. For example, the user equipment 101 may measure the strength of the signal transmitted by the first base station 102.

With reference to Fig. 2A, using the apparatus 20 as an example of the user equipment 101, the strength of the signal may be measured by the processor 22, controlled by the computer program 24.

In step 41 of Fig. 4A, it is determined whether the measured signal strength meets a predetermined criteria. For example, the measured signal strength may be compared against measurement results of signals from other base stations or a predetermined threshold value. With reference to Fig. 2A, using the apparatus 20 as an example of the user equipment 101, the determination may be made by the processor 22, controlled by the computer program 24.

In case the measured signal strength meets the predetermined criteria, for example by being stronger than the signal of the current base station, the connection request message is sent in step 42 of Fig. 4A. The connection request message may be sent by the user equipment 101 of Fig. 1 in a manner described hereinbefore. In this scenario, a decision to prepare for a cell change is made by the user equipment 101 on the basis of the measurements by the user equipment 101.

In case the measured signal strength does not meet the predetermined criteria, the process of the exemplary embodiment of Fig. 4A may continue e.g. in step 40.

In step 43 of Fig. 4B, a measurement report is generated based on the measuring of the strength of the signal transmitted by the base station belonging to the same mobile network as the network entity. For example, the measurement report may

be generated by the user equipment 101 on the basis of measuring the signal of the first base station 102.

With reference to Fig. 2A, using the apparatus 20 as an example of the user equipment 101, the measurement report may be generated by the processor 22, controlled by the computer program 24.

In step 44 of Fig. 4B, the generated measurement report is sent to a base station belonging to a mobile network other than the mobile network of the measured base station and the network entity. For example, the user equipment 101 may send the measurement report to the second base station 103, to which the user equipment 101 is currently connected.

With reference to Fig. 2A, using the apparatus 20 as an example of the user equipment 101, the measurement report may be sent via the communication interface module 21 by the processor 22, controlled by the computer program 24.

In step 45 of Fig. 4B, a connection request command is received, responsive to the sending of the measurement report, from the base station where the measurement report was sent to. For example, the user equipment 101 may receive the connection request command from the second base station 103. The connection request command may be e.g. a command instructing the user equipment to send a pre-registration message.

With reference to Fig. 2A, using the apparatus 20 as an example of the user equipment 101, the connection request command may be received via the communication interface module 21 by the processor 22, controlled by the computer program 24.

In step 46 of Fig. 4B, the connection request message is sent responsive to the receiving of the connection request command. For example, the connection request message may be sent by the user equipment 101 of Fig. 1 in a manner described hereinbefore. In this scenario, a decision to prepare for a cell change is

made e.g. by the second base station 103 on the basis of the measurement report generated by the user equipment 101.

The connection rejection message discussed hereinbefore may further comprise a network identifier, and at least one embodiment may further comprise storing the network identifier in association with the tracking area identifier. The network identifier may be stored by the user equipment in a manner described hereinbefore.

In step 400 of Fig. 4C, the strength of a signal transmitted by a second base station belonging to the same network as the network entity is measured. For example, the user equipment 101 may measure the signal transmitted by a base station belonging to the same network as, but other than the base station 102.

With reference to Fig. 2A, using the apparatus 20 as an example of the user equipment 101, the signal may be measured by the processor 22, controlled by the computer program 24.

In step 401 of Fig. 4C, it is checked whether the tracking area, which the measured second base station belongs to, corresponds to a tracking area identifier that is stored in a list of forbidden tracking areas. For example, the user equipment 101 may compare the tracking area of the measured second base station to the list of forbidden tracking areas maintained by the user equipment 101, as described hereinbefore with reference to Fig. 3.

With reference to Fig. 2A, using the apparatus 20 as an example of the user equipment 101, the list of forbidden tracking areas may be stored in the memory 24, and the comparison may be carried out by the processor 22, controlled by the computer program 24.

In step 402 of Fig. 4C, it is determined whether the strength of the measured signal of the second base station meets a predetermined criteria. For example, the measured signal strength may be compared against measurement results of

signals from other base stations or a predetermined threshold value by the user equipment 101 of Fig. 1.

With reference to Fig. 2A, using the apparatus 20 as an example of the user equipment 101, said determination may be made by the processor 22, controlled by the computer program 24.

In case the measured signal strength does not meet the predetermined criteria, the process depicted in Fig. 4C may continue in step 400. In case the measured signal strength meets the predetermined criteria, the process continues to step 403.

In step 403, the result of the comparison of the tracking area to the list of forbidden tracking areas discussed hereinbefore is determined. If the identifier of the tracking area, to which the measured second base station belongs, is in the list of forbidden tracking areas, no further actions, such as cell change attempts, are made with respect to the measured second base station, and the exemplary process depicted in Fig. 4C may continue e.g. in step 400.

In case the identifier of the tracking area, to which the measured second base station belongs, is not in the list of forbidden tracking areas, the process may continue in step 404. In said step, a cell change may be initiated to the measured second base station. For example, the user equipment 101 may initiate a cell change to the measured second base station (not shown in Fig. 1).

With reference to Fig. 2A, using the apparatus 20 as an example of the user equipment 101, the cell change may be initiated by the processor 22, controlled by the computer program 24.

The cell change initiated in step 404 may include sending of a registration update message to the network entity. For example, the user equipment 101 may send a registration update message to the mobility management entity 104, informing the mobility management entity 104 of a new cell and/or tracking area where the user equipment 101 is located after the cell change. In order to send the registration

update message, the user equipment 101 may request a radio connection to the new base station (referred to above as the measured second base station), and send the request update message via an S1 interface, i.e. an interface between the new base station and the mobility management entity 104.

In step 50 of Fig. 5, a connection request message is received. For example, the connection request message may be received by the mobility management entity 104 from the user equipment 101 of Fig. 1 in a situation, where the user equipment 101 is connected to the second base station 103, and the connection is prepared to be transferred to the first base station 102.

The connection request message may be a pre-registration message, such as an attach request message defined in section 8.2.1 of 3GPP TS 24.301 V0.1.0.

The mobility management entity 104 may receive the connection request message in an S101 message via the S101 interface shown in Fig. 1. That is, the user equipment 101 may insert the connection request message into an S101 message, and send the S101 message to the second base station 103, which forwards the S101 message containing the connection request message to the mobility management entity 104 over the S101 interface.

With reference to Fig. 2B, using the apparatus 260 as an example of the mobility management entity 104, the connection request message may be received via the communication interface module 261 by the processor 262, controlled by the computer program 264.

In steps 51 and 52 of Fig. 5, it is determined whether a connection according to the connection request message is allowed. For example, the user equipment 101 may request a cell change from the second base station 103 to the first based station 102, and the mobility management entity 104 may determine whether such cell change is allowed. The mobility management entity 104 may store a list of allowed and forbidden tracking areas and compare the tracking area of the target base station to the list of forbidden tracking areas. For example, a tracking area may be forbidden for cell changes that originate from base stations of another

network type. In other words, a cell change from a HRPD system may not be allowed to particular tracking areas of an E-UTRAN system.

With reference to Fig. 2B, using the apparatus 260 as an example of the mobility management entity 104, the determination may be made by the processor 262, controlled by the computer program 264.

If the requested connection is allowed, a connection accept message is generated in step 54 of Fig. 5. The accept message may be an attach accept message defined in section 8.2.2 of 3GPP TS 24.301 V0.1.0.

In case the requested connection is not allowed, a connection rejection message is generated in step 55 of Fig. 5. For example, the connection rejection message may be generated by the mobility management entity 104 as a result of it determining that the cell change requested by the user equipment 101 is not allowed. The connection rejection message may be an attach reject message defined in section 8.2.4 of 3GPP TS 24.301 V0.1.0.

With reference to Fig. 2B, using the apparatus 260 as an example of the mobility management entity 104, the connection rejection message may be generated by the processor 262, controlled by the computer program 264.

In step 56 of Fig. 5, a reason code and a tracking area identifier may be inserted in the connection rejection message, wherein the tracking area identifier may indicate that the requested base station belongs to a forbidden tracking area. For example, the reason code and the tracking area identifier may be inserted in the connection rejection message by the mobility management entity 104.

In case the connection rejection message is an attach reject message defined in section 8.2.4 of 3GPP TS 24.301 V0.1.0, the reason code and the tracking area identifier may be inserted into a suitable information element of the attach reject message.

With reference to Fig. 2B, using the apparatus 260 as an example of the mobility management entity 104, the reason code and the tracking area identifier may be inserted in the connection rejection message by the processor 262, controlled by the computer program 264.

In step 57 of Fig. 5, the connection rejection message, containing the reason code and the tracking area identifier indicating a forbidden tracking area, is sent to the party that requested the connection. For example, the mobility management entity 104 may send the connection rejection message to the user equipment 101. With reference to Fig. 2B, using the apparatus 260 as an example of the mobility management entity 104, the connection rejection message may be sent via the communication interface module 261 by the processor 262, controlled by the computer program 264.

As described hereinbefore, the connection request message may be received via an inter-network interface, such as an S101 interface. Similarly, the connection rejection message may be sent via the S101 interface. The connection rejection message may further comprise a network identifier described hereinbefore.

Particular embodiments of the invention may enable a user equipment to receive information about forbidden tracking areas and/or base stations, to which a cell change is not allowed. As the user equipment receives information on forbidden tracking areas and base stations, the user equipment is able to store the corresponding tracking area identifiers in a list of forbidden tracking areas. In this manner, the user equipment can keep from attempting to perform a cell change to a forbidden base station. Otherwise, the user equipment may attempt the cell change a number of times in a row.

The user equipment may use the stored information on forbidden tracking areas e.g. when making a decision on a cell change. In addition to determining whether the signal strength of a base station meets a predetermined criteria for a cell change, the user equipment is able to check prior to a cell change attempt, whether the base station belongs to a forbidden tracking area.

The foregoing description has provided by way of non-limiting examples of particular implementations and embodiments of the invention a full and informative description of the best mode presently contemplated by the inventors for carrying out the invention. It is however clear to a person skilled in the art that the invention is not restricted to details of the embodiments presented above, but that it can be implemented in other embodiments using equivalent means without deviating from the characteristics of the invention.

Furthermore, some of the features of the above-disclosed embodiments of this invention may be used to advantage without the corresponding use of other features. As such, the foregoing description shall be considered as merely illustrative of the principles of the present invention, and not in limitation thereof. Hence, the scope of the invention is only restricted by the appended patent claims.

Claims:

1. A method comprising:

sending a connection request message to a network entity;

receiving a connection rejection message responsive to the sending of the connection request message from the network entity, the connection rejection message comprising a reason code and a tracking area identifier;

acquiring the reason code and the tracking area identifier from the connection rejection message; and

storing the tracking area identifier according to the reason code.

2. A method according to claim 1, wherein the connection request message comprises a pre-registration message.

3. A method according to claim 1 or 2, wherein the method further comprises measuring a signal transmitted by a base station belonging to a same mobile network with the network entity.

4. A method according to claim 3, further comprising:

sending the connection request message in case the strength of the measured signal meets a predetermined criteria.

5. A method according to claim 3, further comprising:

generating a measurement report based on the measuring of the signal;

sending the measurement report to a second base station belonging to a mobile network other than the mobile network of the measured base station and the network entity;

receiving, responsive to the sending of the measurement report, a connection request command from the second base station; and

sending the connection request message responsive to the receiving of the connection request command.

6. A method according to any one of the preceding claims, wherein the reason code indicates that the connection request message requests connection to a forbidden tracking area, and wherein the storing of the tracking area identifier comprises storing the tracking area identifier in a list of forbidden tracking areas.

7. A method according to any one of the preceding claims, wherein the connection rejection message further comprises a network identifier, and wherein the method further comprises storing the network identifier in association with the tracking area identifier.

8. A method according to any one of the preceding claims, wherein the connection request message is sent via an inter-network interface.

9. A method according to claim 8, wherein the inter-network interface comprises an interface adapted to sending pre-registration messages prior to a cell change event.

10. A method according to any one of the preceding claims, wherein the network entity is a mobility management entity.

11. A method according to any one of claims 6 to 10, further comprising:

measuring the strength of a signal transmitted by a second base station belonging to a same mobile network with the network entity;

checking whether the tracking area of the measured second base station corresponds to a tracking area identifier stored in the list of forbidden tracking areas; and

initiating, in case the strength of the measured signal meets a predetermined criteria and the tracking area of the measured second base station is not stored in the list of forbidden tracking areas, a cell change to the measured second base station.

12. A method according to claim 11, further comprising:

sending a registration update message to the network entity via the measured second base station.

13. An apparatus comprising:

a communication interface configured to operate a communication connection;

a memory; and

a processor functionally coupled to the communication interface and to the memory, the processor being configured to:

send via the communication interface a connection request message to a network entity;

receive a connection rejection message responsive to the sending of the connection request message from the network entity via the communication interface, the connection rejection message comprising a reason code and a tracking area identifier;

acquire the reason code and the tracking area identifier from the connection rejection message; and to

store the tracking area identifier in the memory according to the reason code.

14. An apparatus according to claim 13, wherein the processor is further configured to measure a signal transmitted by a base station belonging to a same mobile network with the network entity.

15. An apparatus according to claim 14, wherein the processor is configured to send the connection request message in case the strength of the measured signal meets a predetermined criteria.

16. An apparatus according to claim 14, wherein the processor is further configured to:

generate a measurement report based on the measuring of the signal;

send the measurement report to a second base station belonging to a mobile network other than the mobile network of the first base station and the network entity;

receive a connection request command from the second base station; and to

send the connection request message responsive to the receiving of the connection request command.

17. An apparatus according to any one of claims 13 to 16, wherein the reason code indicates that the connection request message requests connection to a forbidden tracking area, and wherein the processor is configured to store the tracking area identifier in a list of forbidden tracking areas.

18. An apparatus according to any one of claims 13 to 17, wherein the connection rejection message further comprises a network identifier, and wherein the processor is further configured to store the network identifier in association with the tracking area identifier.

19. An apparatus according to any one of claims 13 to 18, wherein the processor is configured to send the connection request message via an inter-network interface.

20. An apparatus according to any one of claims 17 to 19, wherein the processor is further configured to:

measure the strength of a signal transmitted by a second base station belonging to a same mobile network with the network entity;

check whether the tracking area of the measured second base station corresponds to a tracking area identifier stored in the list of forbidden tracking areas; and to

initiate, in case the strength of the measured signal meets a predetermined criteria and the tracking area of the measured second base station is not stored in the list of forbidden tracking areas, a cell change to the measured second base station.

21. An apparatus according to claim 20, wherein the processor is further configured to send a registration update message to the network entity via the measured second base station.

22. A computer program product embodied on a computer-readable medium, the computer program comprising program code operable to be executed by a processor, the program code being configured to enable, when executed, the processor to:

send a connection request message to a network entity;

receive a connection rejection message responsive to the sending of the connection request message from the network entity, the connection rejection message comprising a reason code and a tracking area identifier;

acquire the reason code and the tracking area identifier from the connection rejection message; and to

store the tracking area identifier according to the reason code.

23. A computer program product according to claim 22, wherein the program code is further configured to enable the processor to measure a signal transmitted by a base station belonging to a same mobile network with the network entity.

24. A computer program product according to claim 23, wherein the program code is further configured to enable the processor to send the connection request message in case the strength of the measured signal meets a predetermined criteria.

25. A computer program product according to claim 23, wherein the program code is further configured to enable the processor to:

generate a measurement report based on the measuring of the signal;

send the measurement report to a second base station belonging to a mobile network other than the mobile network of the first base station and the network entity;

receive a connection request command from the second base station; and to

send the connection request message responsive to the receiving of the connection request command.

26. A computer program product according to any one of claims 22 to 25, wherein the reason code indicates that the connection request message requests connection to a forbidden tracking area, and wherein the program code is further configured to enable the processor to store the tracking area identifier in a list of forbidden tracking areas.

27. A computer program product according to any one of claims 22 to 26, wherein the connection rejection message further comprises a network identifier, and wherein the program code is further configured to enable the processor to store the network identifier in association with the tracking area identifier.

28. A computer program product according to any one of claims 22 to 26, wherein the program code is further configured to enable the processor to send the connection request message via an inter-network interface.

29. A computer program product according to any one of claims 26 to 28, wherein the program code is further configured to enable the processor to:

measure the strength of a signal transmitted by a second base station belonging to a same mobile network with the network entity;

check whether the tracking area of the measured second base station corresponds to a tracking area identifier stored in the list of forbidden tracking areas; and to

initiate, in case the strength of the measured signal meets a predetermined criteria and the tracking area of the measured second base station is not stored in the list of forbidden tracking areas, a cell change to the measured second base station.

30. A computer program product according to claim 29, wherein the program code is further configured to enable the processor to send a registration update message to the network entity via the measured second base station.

31. A method comprising:

receiving a connection request message;

determining whether a connection is allowed according to the request;

generating, in case the connection is not allowed, a connection rejection message;

inserting in the connection rejection message a reason code and a tracking area identifier, said tracking area identifier indicating a forbidden tracking area; and

sending the connection rejection message.

32. A method according to claim 31, further comprising:

receiving the connection request message via an inter-network interface.

33. A method according to claim 31 or 32, further comprising:

inserting in the connection rejection message a network identifier.

34. An apparatus comprising:

a communication interface configured to operate a communication connection; and

a processor functionally coupled to the communication interface, the processor being configured to:

receive a connection request message via the communication interface;

determine whether a connection is allowed according to the request;

generate, responsive to determining that the connection is not allowed, a connection rejection message;

insert in the connection rejection message a reason code and a tracking area identifier, said tracking area identifier indicating a forbidden tracking area; and to

send the connection rejection message.

35. A computer program product embodied on a computer-readable medium, the computer program comprising program code operable to be executed by a processor, the program code being configured to enable, when executed, the processor to:

receive a connection request message;

determine whether a connection is allowed according to the request;

generate, responsive to determining that the connection is not allowed, a connection rejection message;

insert in the connection rejection message a reason code and a tracking area identifier, said tracking area identifier indicating a forbidden tracking area; and to

send the connection rejection message.

36. An apparatus comprising:

communication interface means for operating a communication connection;

means for sending via the communication interface means a connection request message to a network entity;

means for receiving a connection rejection message responsive to the sending of the connection request message from the network entity via the communication interface means, the connection rejection message comprising a reason code and a tracking area identifier;

means for acquiring the reason code and the tracking area identifier from the connection rejection message; and

means for storing the tracking area identifier in the memory according to the reason code.

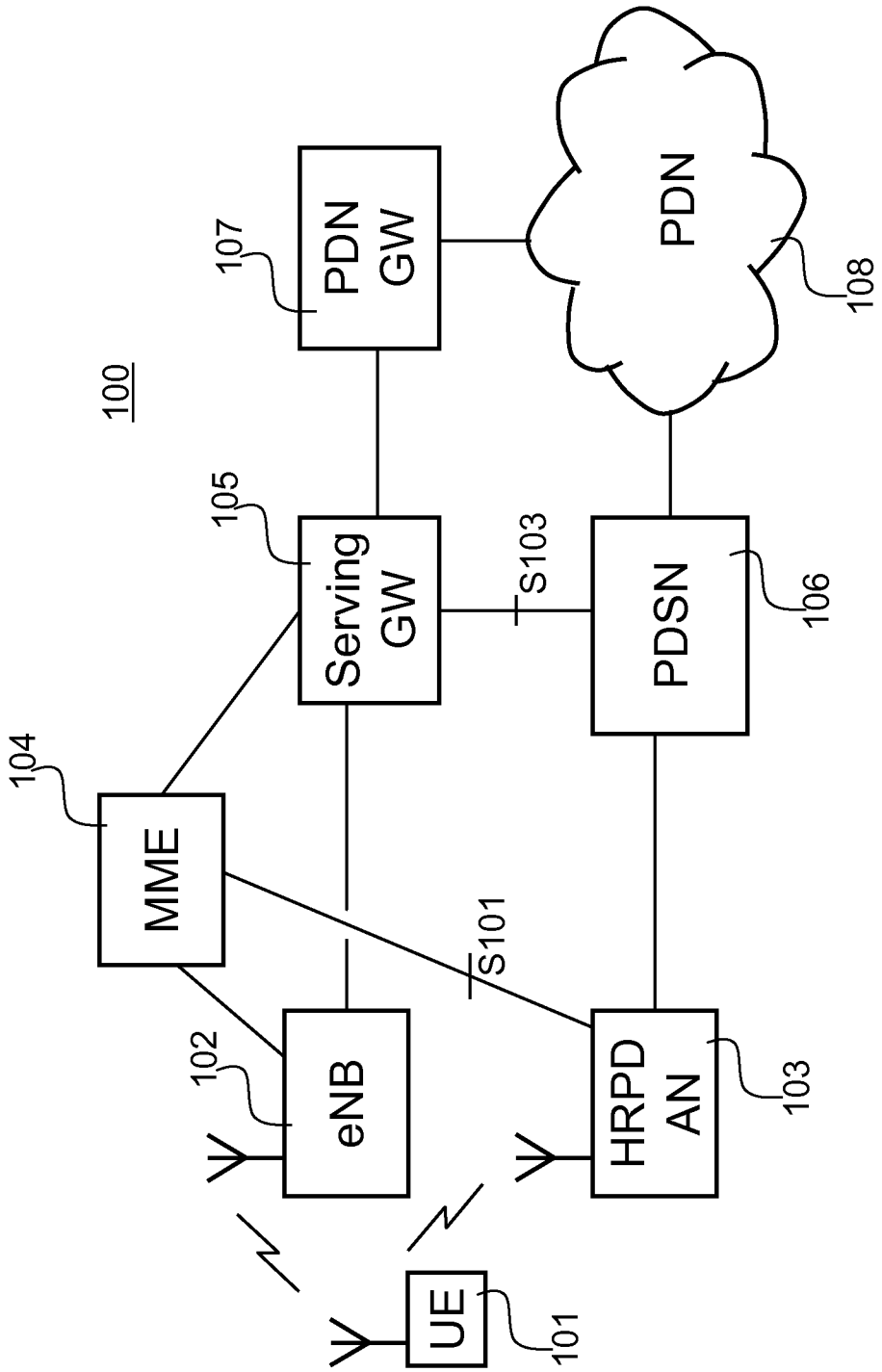

100
PDN GW
107
PDN
108
Serving GW
105
S103
PDSN
106
MME
104
S101
eNB
102
HRPD AN
103
UE
101

FIG. 1

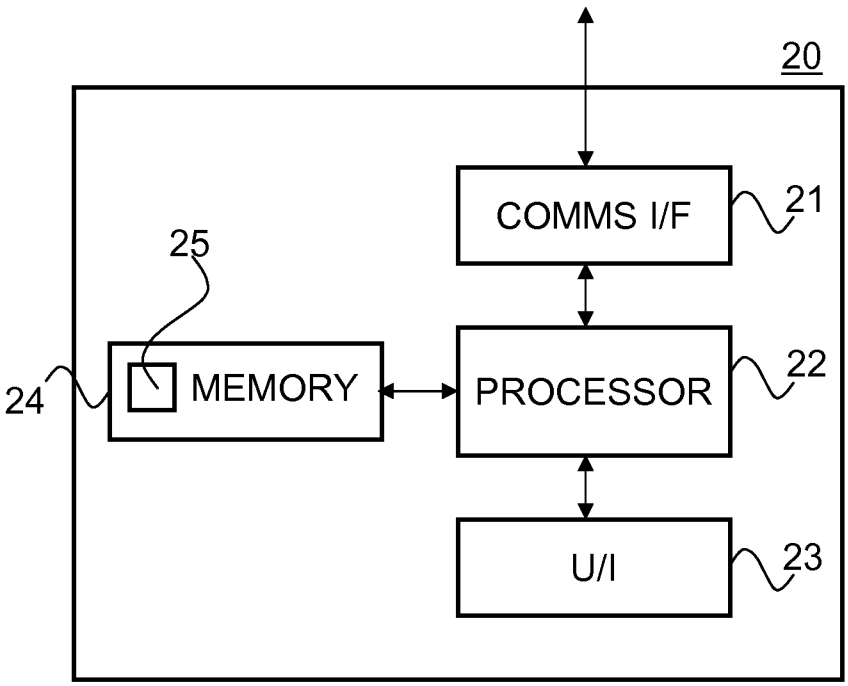

20
COMMS I/F
21
25
MEMORY
24
PROCESSOR
22
U/I
23

FIG. 2A

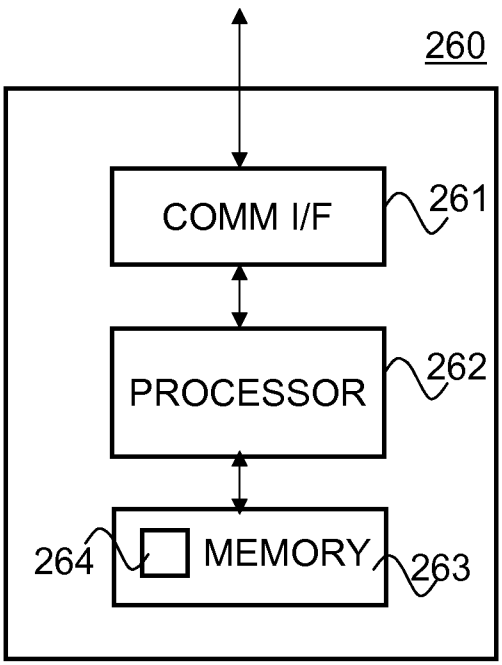

260
COMM I/F
261
PROCESSOR
262
MEMORY
264
263

FIG. 2B

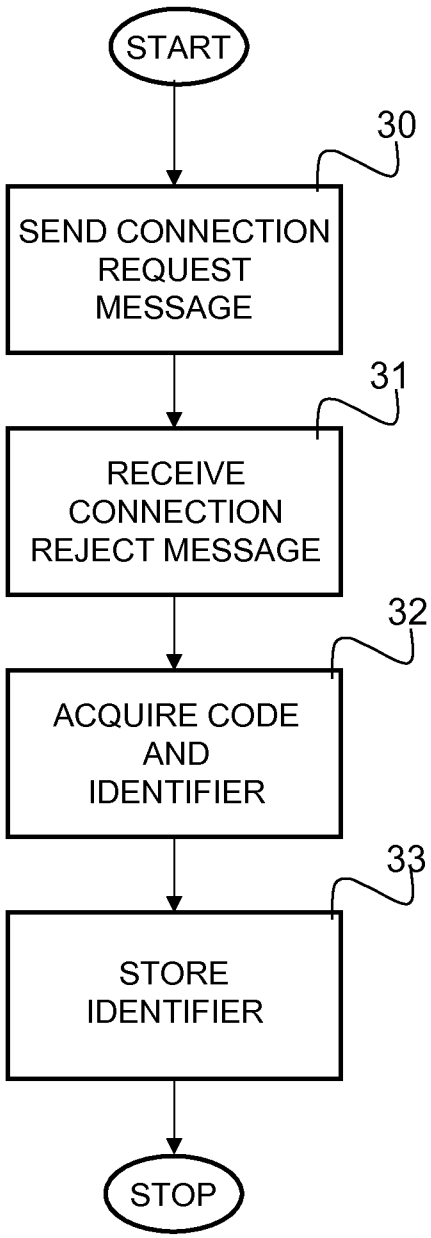

START
30
SEND CONNECTION REQUEST MESSAGE
31
RECEIVE CONNECTION REJECT MESSAGE
32
ACQUIRE CODE AND IDENTIFIER
33
STORE IDENTIFIER
STOP

FIG. 3

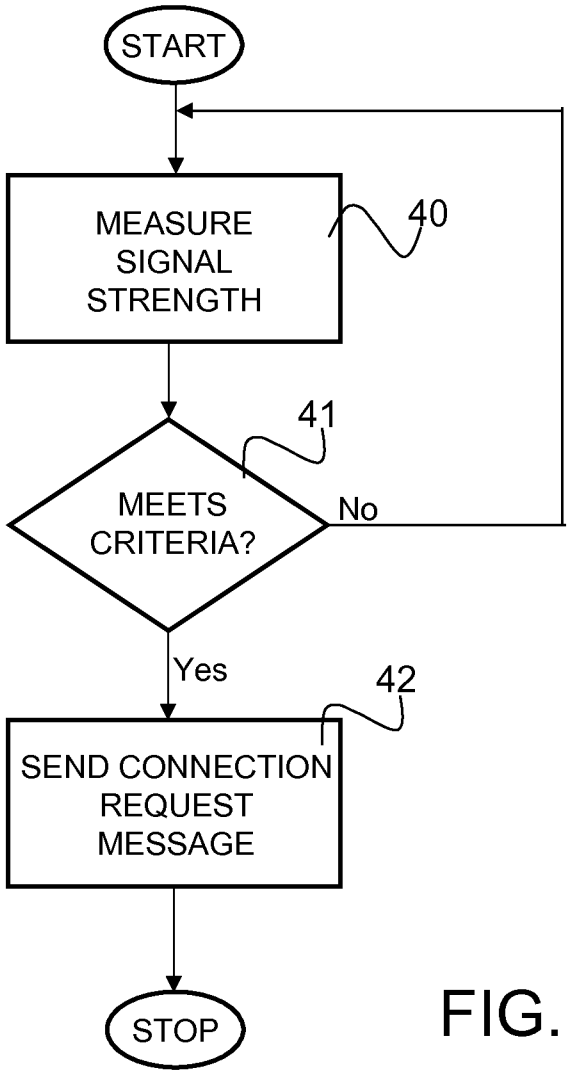

START
MEASURE SIGNAL STRENGTH
40
41
MEETS CRITERIA?
No
Yes
42
SEND CONNECTION REQUEST MESSAGE
STOP

FIG. 4A

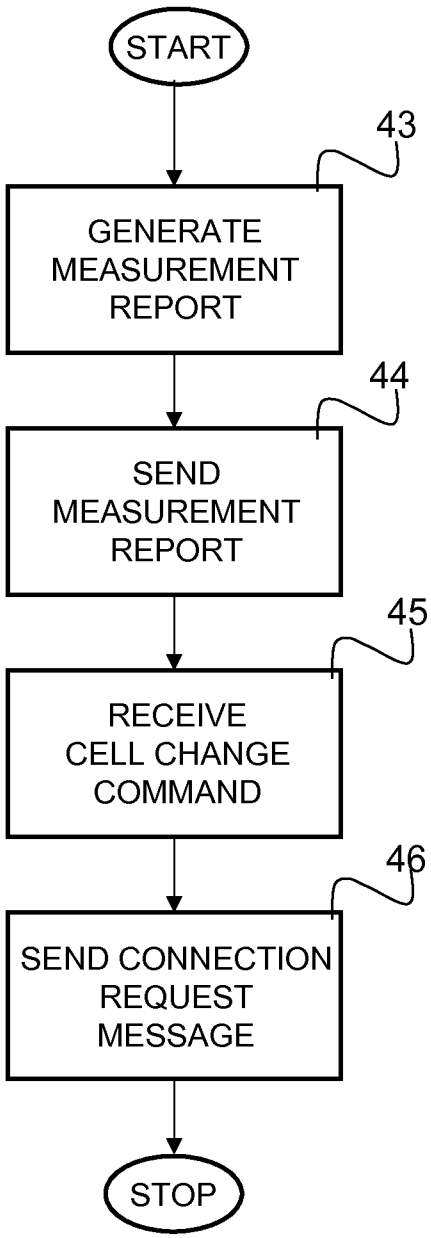

START
43
GENERATE MEASUREMENT REPORT
44
SEND MEASUREMENT REPORT
45
RECEIVE CELL CHANGE COMMAND
46
SEND CONNECTION REQUEST MESSAGE
STOP

FIG. 4B

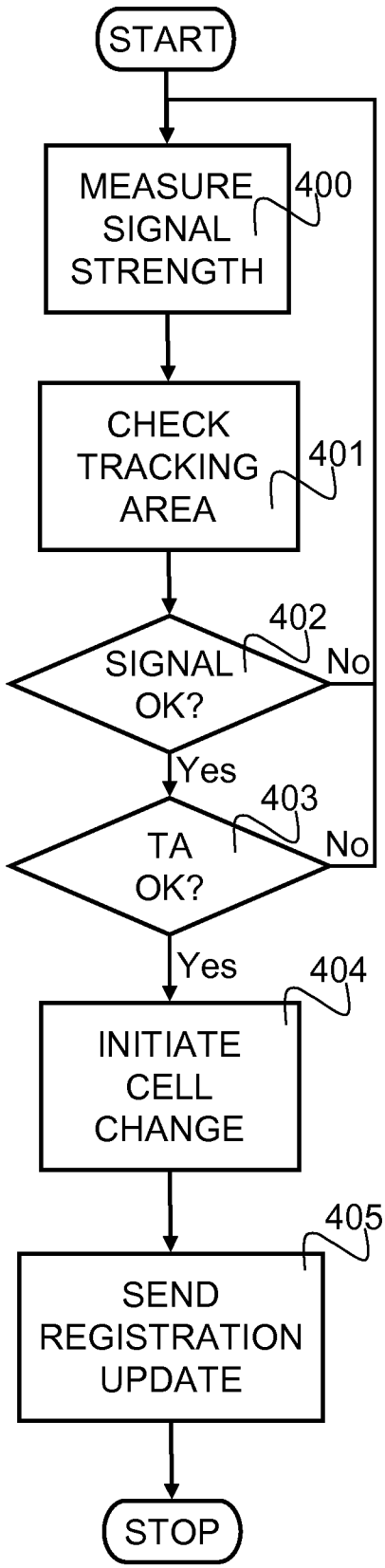

START
MEASURE SIGNAL STRENGTH
400
CHECK TRACKING AREA
401
SIGNAL OK?
402
No
Yes
TA OK?
403
No
Yes
INITIATE CELL CHANGE
404
SEND REGISTRATION UPDATE
405
STOP

FIG. 4C

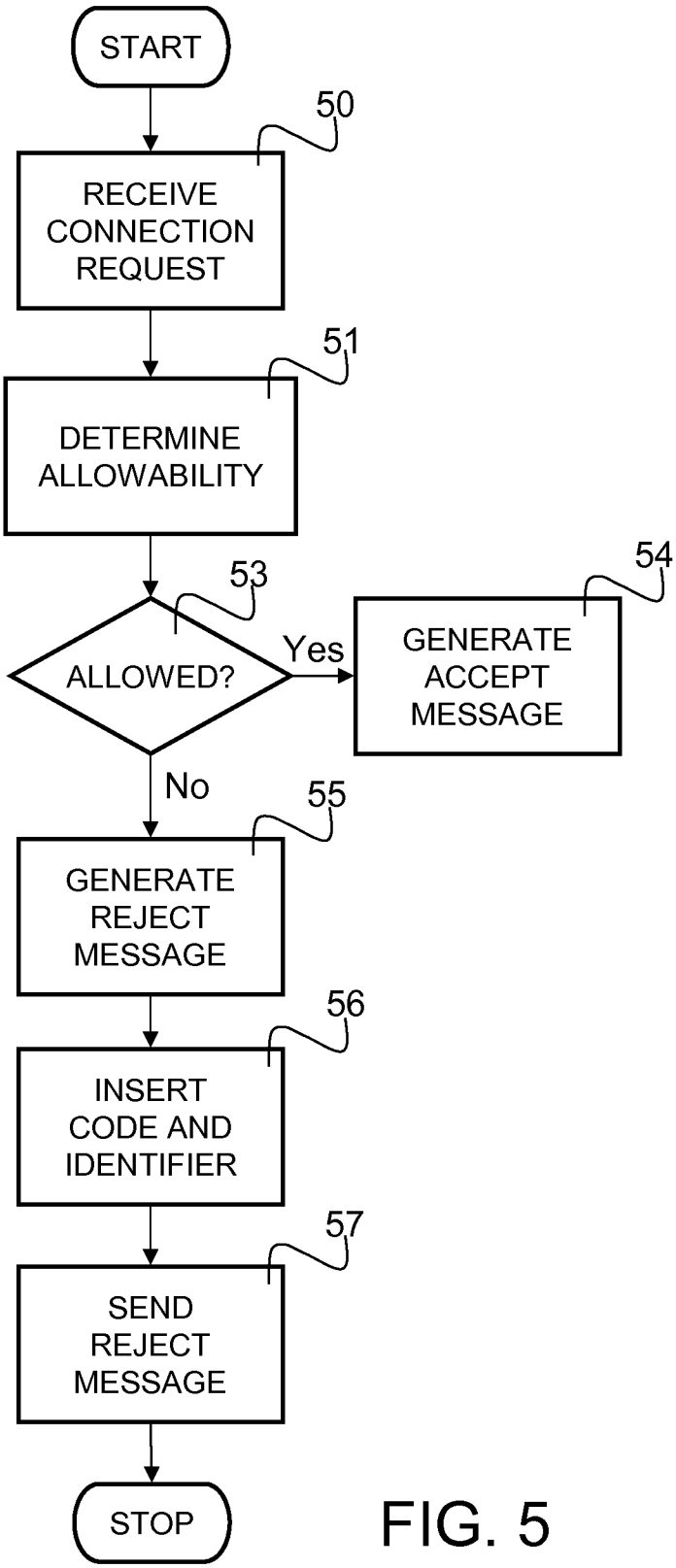

START
50
RECEIVE CONNECTION REQUEST
51
DETERMINE ALLOWABILITY
53
ALLOWED?
Yes
54
GENERATE ACCEPT MESSAGE
No
55
GENERATE REJECT MESSAGE
56
INSERT CODE AND IDENTIFIER
57
SEND REJECT MESSAGE
STOP

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2008/050610

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005288016 A1 (KUCHIBHOTLA RAVI et al.) 29 December 2005 (29.12.2005), paragraphs [0018]-[0019], [0022]-[0025]	1-36
X	3GPP TS 24.008 V8.3.0 (2008-09); 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; Mobile radio interface Layer 3 specification; Core network protocols; Stage 3 (Release 8). Paragraph 4.4.4.7.	1, 13, 22, 34, 35, 36
A	WO 2008096254 A2 (NOKIA CORP et al.) 14 August 2008 (14.08.2008)	

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

* Special categories of cited documents:

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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 June 2009 (08.06.2009)	17 June 2009 (17.06.2009)

Name and mailing address of the ISA/FI
National Board of Patents and Registration of Finland
P.O. Box 1160, FI-00101 HELSINKI, Finland
Facsimile No. +358 9 6939 5328

Authorized officer
Tapio Ikäheimo
Telephone No. +358 9 6939 500

INTERNATIONAL SEARCH REPORT

International application No.
PCT/FI2008/050610

CLASSIFICATION OF SUBJECT MATTER

Int.Cl.
H04W 48/02 (2009.01)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/FI2008/050610

Patent document cited in search report	Publication date	Patent family members(s)	Publication date
US 2005288016 A1	29/12/2005	CN 1973572 A	30/05/2007
		KR 20070030289 A	15/03/2007
		EP 1762112 A1	14/03/2007
		WO 2006007223 A1	19/01/2006
WO 2008096254 A2	14/08/2008	US 2008194235 A1	14/08/2008