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OPERATING A USER EQUIPMENT IN A RADIO ENVIRONMENT COMPRISING A PLURALITY OF RADIO CELLS OF A PLURALITY OF MOBILE COMMUNICATION NETWORKS

Abstract

A method for operating a user equipment in a radio environment includes: in a first step, a terminal equipment entity or functionality requests selection parameter information, the selection parameter information relating to or indicating whether a home public land mobile network (HPLMN)-provided enhanced selection criterion is used or applied by a mobile termination entity or functionality and/or relating to or indicating a parameter value of the HPLMN-provided enhanced selection criterion; and in a second step, the terminal equipment entity or functionality receives the selection parameter information.

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Background/Summary

[0001] CROSS-REFERENCE TO PRIOR APPLICATIONS [0002] This application is a U.S. National Phase application under 35 U.S.C. § 371 of International Application No. PCT/EP2023/072091, filed on Aug. 9, 2023, and claims benefit to European Patent Application No. EP 22189810.9, filed on Aug. 10, 2022. The International Application was published in English on Feb. 15, 2024 as WO 2024/033435 A1 under PCT Article 21 (2).

FIELD

[0003] The present invention relates to a method for operating a user equipment in a radio environment comprising a plurality of radio cells of a plurality of mobile communication networks, the user equipment measuring or detecting reception conditions regarding the plurality of radio cells, and subsequently selects and/or registers to a mobile communication network out of the plurality of mobile communication networks, wherein the user equipment has or is associated with a home public land mobile network (HPLMN), and the user equipment comprises a terminal equipment entity or functionality as well as a mobile termination entity or functionality.

[0004] Furthermore, the present invention relates to a user equipment for being operated in a radio environment comprising a plurality of radio cells of a plurality of mobile communication networks, the user equipment being configured to measure or to detect reception conditions regarding the plurality of radio cells, and being configured to subsequently select and/or register to a mobile communication network out of the plurality of mobile communication networks, wherein the user equipment has or is associated with an HPLMN and the user equipment comprises a terminal equipment entity or functionality as well as a mobile termination entity or functionality.

[0005] Additionally, the present invention relates to a system or a mobile communication network for operating a user equipment in a radio environment comprising a plurality of radio cells of a plurality of mobile communication networks, each one of these radio cells being associated, respectively, to at least one mobile communication network of the plurality of mobile communication networks, the user equipment being configured to measure or to detect reception conditions regarding the plurality of radio cells, and being configured to subsequently select and/or register to a mobile communication network out of the plurality of mobile communication networks, wherein an HPLMN is associated with the user equipment, and the user equipment comprising a terminal equipment entity or functionality as well as a mobile termination entity or functionality, wherein, regarding cell selection and/or network selection by the user equipment, an enhanced selection criterion, provided by the HPLMN, is stored in the user equipment.

[0006] Furthermore, the present invention relates to a program and to a computer-readable medium for operating a user equipment in a radio environment comprising a plurality of radio cells of a plurality of mobile communication networks according to exemplary embodiments of the present invention.

BACKGROUND

[0007] In conventional deployed mobile communication networks, a user equipment or mobile station typically experiences a radio environment (i.e. the different radio frequency signals that the

user equipment—at its current position or location—is potentially able to receive on different frequencies and/or frequency bands and/or at different points in time or time intervals or time slots) comprising a plurality of radio cells that are at least detectable and/or receivable by the respective user equipment or mobile station. One such radio cell is typically provided by a base station entity, i.e. an antenna arrangement of a specific base station entity emits radio frequency signals such that the user equipment, at its current position or location, is able to receive such radio frequency signals with a sufficient quality, typically with a sufficient signal to noise ratio. If this is the case, the radio environment of the user equipment comprises the considered radio cell. A plurality of radio cells (i.e. of base station entities) are typically part of a mobile communication network being a cellular mobile communication network. Hence, the plurality of radio cells of the radio environment of the user equipment are typically part of a plurality of mobile communication networks, typically each one of these radio cells being associated, respectively, to either one mobile communication network of the plurality of mobile communication networks or to more than one mobile communication networks of the plurality of mobile communication networks. Hence, via selecting a radio cell (out of the plurality of radio cells present or receivable of the radio environment at the considered position or location of the user equipment), the user equipment also selects a mobile communication network (that is associated to that radio cell). However, before a mobile communication network is considered as a network selection candidate (i.e. a candidate mobile communication network) at all, the user equipment needs to find a suitable radio cell of a mobile communication network or public land mobile network to camp on. The criteria for a radio cell to be considered as suitable radio cell (to camp on), is dependent on the considered network technology (or radio access technology) being defined in or via the relevant standardization documents, mostly referred to 3GPP (third generation partnership project) documents.

[0008] In conventional mobile communication networks, i.e. in networks in compliance with the conventional standards or standard documents, a number of drawbacks might occur: In bad or unfavorable radio coverage conditions (of a user equipment), the 3GPP defined order or prioritization of how mobile communication networks are being selected to obtain communication services or any service is not suitable in all relevant situations. For example, in some situations the field strength and/or quality (of the radio signal or a plurality of radio signals) of a radio cell (of the user equipment's radio environment) is not considered in the network selection process (PLMN selection process), leading to user equipments not being able to receive and/or transmit data subsequent to the initial network selection process (PLMN selection process). Such situations include cases where some user equipments may fail obtaining data services, even though the selected public land mobile network fulfilled the cell selection criteria for considering the respective mobile communication network (public land mobile network) in the network selection (or PLMN selection) process. In particular, in case that a user equipment is in or at an unfavorable position, the applicable cell selection criteria (e.g. “RX Access Lev min” criteria in GSM or the S-criterion in GSM succeeding technologies) might be barely fulfilled, conducting the user equipment to consider the respective public land mobile network for PLMN selection, but in fact due to, e.g., fading or local interference at the location of the user equipment, data transport between the network and the user equipment may fail subsequently. Such cases occur, especially regarding cellular user equipments or devices for internet-of-things or M2M (machine-to-machine) communications services, which devices are often used in a stationary manner (e.g. meters or all kinds of sensors or the like) and in case of unfavorable radio (reception) conditions, this kind of problem is likely to subsist permanently for such user equipment, leading to the situation of such a user equipment (especially if in automatic network selection mode) being stuck on a PLMN, while not being able to transmit data.

[0009] It has thus been proposed, in conventional mobile communication networks, to either apply an offset to the minimum required field strength to allow network access, or, in case of 3GPP technologies like UMTS, LTE or 5G, to apply an offset or an absolute value (threshold) in the S-

criterion or in the network selection phase to mitigate the problem. However, in such a situation the application-level control entity or functionality of the user equipment is not aware whether or not such mechanism is actually applied and/or whether an offset or an absolute value (threshold) is used and/or which exact value thereof is used.

SUMMARY

[0010] In an exemplary embodiment, the present invention provides a method for operating a user equipment in a radio environment comprising a plurality of radio cells of a plurality of mobile communication networks. Each one of the plurality of radio cells is associated, respectively, to at least one mobile communication network of the plurality of mobile communication networks. The user equipment measures or detects reception conditions regarding the plurality of radio cells, and subsequently selects and/or registers to a mobile communication network out of the plurality of mobile communication networks. The user equipment has or is associated with a home public land mobile network (HPLMN), and the user equipment comprises a terminal equipment entity or functionality as well as a mobile termination entity or functionality. Regarding cell selection and/or network selection by the user equipment, an enhanced selection criterion, provided by the HPLMN, is stored in the user equipment. Regarding cell selection by the user equipment, a radio cell of a considered radio access technology is considered to be a suitable radio cell only in case that corresponding reception conditions, as measured by the user equipment, correspond to or exceed the HPLMN-provided enhanced selection criterion regarding the considered radio access technology, and/or regarding network selection by the user equipment, only such mobile communication networks corresponding to suitable radio cells of the considered radio access technology are considered for network selection of the user equipment that have or correspond to reception conditions corresponding to or exceeding the enhanced selection criterion. The method comprises the following steps: in a first step, the terminal equipment entity or functionality requests selection parameter information, the selection parameter information relating to or indicating whether the HPLMN-provided enhanced selection criterion is used or applied by the mobile termination entity or functionality and/or relating to or indicating a parameter value of the HPLMN-provided enhanced selection criterion; and in a second step, the terminal equipment entity or functionality receives the selection parameter information.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Subject matter of the present disclosure will be described in even greater detail below based on the exemplary figures. All features described and/or illustrated herein can be used alone or combined in different combinations. The features and advantages of various embodiments will become apparent by reading the following detailed description with reference to the attached drawings, which illustrate the following:

[0012] FIG. **1** schematically illustrates a user equipment in a radio environment comprising a plurality of radio cells of a plurality of mobile communication networks.

[0013] FIG. **2** schematically illustrates a user equipment and its components in greater detail.

[0014] FIG. **3** schematically illustrates a situation of the user equipment measuring different signal strength of different radio cells.

[0015] FIG. **4** schematically illustrates an example of a communication between different parts within a user equipment in case of using an universal integrated circuit card as part of the user equipment.

DETAILED DESCRIPTION

[0016] Exemplary embodiments of the present invention provide a technically simple, effective and cost effective solution for operating a user equipment in a radio environment comprising a plurality

of radio cells of a plurality of mobile communication networks. Exemplary embodiments of the present invention further provide a corresponding user equipment, system or mobile communication network, and a corresponding program and computer-readable medium.
[0017] An exemplary embodiment of the present invention provides a method for operating a user equipment in a radio environment comprising a plurality of radio cells of a plurality of mobile communication networks, each one of these radio cells being associated, respectively, to at least one mobile communication network of the plurality of mobile communication networks, wherein the user equipment measures or detects reception conditions regarding the plurality of radio cells, and subsequently selects and/or registers to a mobile communication network out of the plurality of mobile communication networks, wherein the user equipment has or is associated with an HPLMN and the user equipment comprises a terminal equipment entity or functionality as well as a mobile termination entity or functionality, wherein, regarding cell selection and/or network selection by the user equipment, an enhanced selection criterion, provided by the HPLMN, is stored in the user equipment, [0018] wherein, regarding cell selection by the user equipment, a radio cell of a considered radio access technology is considered to be a suitable radio cell only in case that the corresponding reception conditions, as measured by the user equipment, correspond to or exceed the HPLMN-provided enhanced selection criterion regarding the considered radio access technology, and/or [0019] wherein, regarding network selection by the user equipment, only such mobile communication networks corresponding to suitable radio cells of the considered radio access technology are considered for network selection of the user equipment that have or correspond to reception conditions corresponding to or exceeding the enhanced selection criterion, wherein the method comprises the following steps: [0020] in a first step, the terminal equipment entity or functionality requests selection parameter information, the selection parameter information relating to or indicating whether the HPLMN-provided enhanced selection criterion is used or applied by the mobile termination entity or functionality and/or relating to or indicating a parameter value of the HPLMN-provided enhanced selection criterion, [0021] in a second step, the terminal equipment entity or functionality receives the selection parameter information.
[0022] It is thereby advantageously possible according to the present invention that it is not only possible to flexibly apply the HPLMN-provided enhanced selection criterion (instead of applying the conventionally used process) but also to ensure that the application-level entity or functionality of the user equipment, especially of or within the terminal equipment entity or functionality, is aware of the HPLMN-provided enhanced selection criterion and/or its application or use and/or its parameter value. Hence, it is advantageously possible, according to the present invention, to perform the network and/or cell selection in an optimized manner, especially leading to avoid problems related to the use of the conventionally used network selection process such as the ones mentioned above. Especially, a command towards the mobile termination entity or functionality is able to be generated, based on the terminal equipment entity or functionality's knowledge of the selection parameter information, e.g. by settings of the user equipment application, i.e. of the terminal equipment entity or functionality, such as events, especially periodical events or the like; afterwards, the result of such commands are able to be reported to the network or a backend application server (e.g. via application layer and/or non-access stratum (NAS) communication). Additionally, the home network (or HPLMN) or a backend application server can send a command (e.g. via application layer and/or non-access stratum communication) to the user equipment to trigger the user equipment application (as part of or within the terminal equipment entity or functionality) to retrieve the thresholds. This information can be beneficially used, in case the application (either within the terminal equipment entity or functionality or triggered by the backend application server) may manually select another network and/or radio access technology type, RAT type (e.g. a network or radio access technology which has not been selected in case the thresholds or offsets have been applied during the automatic selection); an application may want to do such a manual selection in case the automatic selection applying the threshold leads to undesired results.

Furthermore, with the knowledge (by the application of the terminal equipment entity or functionality) about whether and which offsets or thresholds have been set by the home operator (regarding the enhanced selection criterion), it is advantageously possible according to the present invention relieve troubleshooting: According to the present invention, an application executed on the user equipment, may query this (enhanced selection criterion) value(s) and report it/them towards the backend application server (e.g., running on a server in the cloud) or directly to the home operator network; hence, in case the device becomes not responsive or unavailable or suffers from coverage and connectivity problems the customer is able to contact the operator, to adjust the thresholds or offsets in order to resolve the connectivity problems.

[0023] Conventionally, cell selection criteria are used for radio cells to be considered suitable radio cells (i.e. for a user equipment to camp on), and these cell selection criteria are typically dependent on the considered network technology (or radio access technology) used, i.e. the radio access technology that both the user equipment and the radio cell are using. Typically, different generations of mobile communication systems (i.e. different radio access technologies) are considered, most often including one, all or a subset of the following: 2G, 3G, 4G and 5G technology (i.e. second generation mobile communication systems (GSM, global system for mobile communications), third generation mobile communication systems (UMTS, Universal Mobile Telecommunications System including its radio technology UTRA, UMTS Terrestrial Radio Access), fourth generation mobile communication systems (LTE, long term evolution including its radio technology E-UTRA, evolved UMTS Terrestrial Radio Access), and fifth generation mobile communication systems (5GS, 5G system including its radio technology NR, New Radio)), but further or additional or alternative radio access technologies are not excluded according to the present invention.

[0024] Once the user equipment (or, more specifically, the so-called AS, Access Stratum part of the user equipment) has read one or several PLMNs, i.e. one or several radio cells, which may belong to different mobile communication networks or public land mobile networks, the radio cells or public land mobile networks that passed the cell selection criterion (to be, respectively, applied in view of the potentially different radio access technologies) are reported to the so-called NAS, Non Access Stratum, (or NAS part of the user equipment) for the subsequent stage (or step) of network selection. Typically, this reporting includes also the information of the respective field strength values (measured by the user equipment) such as, e.g., the RSRP (Reference Signals Received Power) value. Based on the reporting (especially by the AS part of the user equipment to the NAS part of the user equipment), the actual network selection is able to take place. Conventionally, at the network selection stage, all radio cells judged (in the preceding cell selection stage) to be suitable radio cells are taken into consideration.

[0025] According to the present invention, the user equipment has or is associated with an HPLMN, and the user equipment comprises a terminal equipment entity or functionality (where typically the application-level entity or functionality is running or is located) as well as a mobile termination entity or functionality. Regarding cell selection and/or network selection by the user equipment, an enhanced selection criterion, provided by the HPLMN, is stored in the user equipment (or is, at least, able to be stored in the user equipment). According to the present invention, regarding cell selection by the user equipment, a radio cell of a considered radio access technology is considered to be a suitable radio cell only in case that the corresponding reception conditions, as measured by the user equipment, correspond to or exceed the HPLMN-provided enhanced selection criterion regarding the considered radio access technology (or, at least, cell selection as performed by the user equipment is able to performed such that—in case that the HPLMN-provided enhanced selection criterion is provided (transmitted) to the user equipment and stored therein—a radio cell of a considered radio access technology is considered to be a suitable radio cell only in case that the corresponding reception conditions, as measured by the user equipment, correspond to or exceed the HPLMN-provided enhanced selection criterion regarding

the considered radio access technology). Alternatively or cumulatively according to the present invention, regarding network selection by the user equipment, only such mobile communication networks corresponding to suitable radio cells of the considered radio access technology are considered for network selection of the user equipment that have or correspond to reception conditions corresponding to or exceeding the enhanced selection criterion (or, at least, network selection as performed by the user equipment is able to performed such that—in case that the HPLMN-provided enhanced selection criterion is provided (transmitted) to the user equipment and stored therein—only such mobile communication networks corresponding to suitable radio cells of the considered radio access technology are considered for network selection of the user equipment that have or correspond to reception conditions corresponding to or exceeding the enhanced selection criterion).

A method according to an embodiment of the present invention comprises that, in a first step, the terminal equipment entity or functionality requests selection parameter information, the selection parameter information relating to or indicating whether the HPLMN-provided enhanced selection criterion is used or applied by the mobile termination entity or functionality and/or relating to or indicating a parameter value of the HPLMN-provided enhanced selection criterion, and that, in a second step, the terminal equipment entity or functionality receives the selection parameter information.

Hence, this means that, according to the present invention, it is advantageously possible to allow an application (or an application-level entity or functionality of the terminal equipment entity or functionality) to become aware, whether an offset or threshold (i.e. a HPLMN-provided enhanced selection criterion) is set, and what the actual value of that threshold is.

[0026] According to the present invention, it is advantageously possible and preferred that the user equipment comprises, besides the terminal equipment entity or functionality and the mobile termination entity or functionality, a terminal adaptor entity or functionality, wherein the terminal adaptor entity or functionality receives, during or after the first step, the request of the selection information from the terminal equipment entity or functionality, and wherein the terminal adaptor entity or functionality transmits, during or prior to the second step, the selection information to the terminal equipment entity or functionality, wherein especially the user equipment is a machine type communication device.

[0027] It is thereby advantageously possible according to the present invention to comparatively easily implement and realize the present invention, and to provide for a comparatively large applicability, as user equipments are often having, besides both the terminal equipment entity or functionality and the mobile termination entity or functionality, also a terminal adaptor entity or functionality.

[0028] According to the present invention, it is advantageously furthermore possible and preferred that the terminal adaptor entity or functionality, transmits, during or after the first step, a further request of the selection parameter information to the mobile termination entity or functionality, and wherein the terminal adaptor entity or functionality receives, during or prior to the second step, the selection information from the mobile termination entity or functionality.

[0029] It is thereby advantageously possible according to the present invention to comparatively easily implement and realize the present invention.

[0030] According to the present invention, it is advantageously furthermore possible and preferred that an AT-command interface is used between, on the one hand, the terminal equipment entity or functionality, and, on the other hand, the terminal adaptor entity or functionality or the mobile termination entity or functionality.

[0031] It is thereby advantageously possible according to the present invention to comparatively easily implement and realize the present invention via using the AT command interface to allow an application (or an application-level entity or functionality of the terminal equipment entity or functionality) to become aware, whether an offset or threshold (i.e. a HPLMN-provided enhanced

selection criterion) is set, and what the actual value of that threshold is.
[0032] According to the present invention, it is furthermore advantageously possible and preferred that the user equipment comprises a universal integrated circuit card and/or a subscriber identity module, especially comprising a secure element or part of the user equipment, and/or
wherein the terminal equipment entity or functionality comprises an application or an application program.
[0033] It is thereby advantageously possible according to the present invention to comparatively easily implement and realize the present invention.
[0034] Furthermore, it is advantageously possible and preferred according to the present invention that the AT-command interface [0035] between the terminal equipment entity or functionality and the terminal adaptor entity or functionality, or [0036] between the terminal equipment entity or functionality and the mobile termination entity or functionality
is used by the application or application program of the terminal equipment entity or functionality, especially in order to execute settings of the application, especially events such as periodical events, or in order to execute a command of the HPLMN or of a backend application server, wherein especially the application or application program of the terminal equipment entity or functionality thereafter reports the result to the HPLMN or to a backend application server, especially via application layer and/or non-access stratum communication, NAS.
[0037] Thereby, it is advantageously possible, according to the present invention, that the application or application program of the terminal equipment entity or functionality is able to take into consideration, and especially flexibly react on, settings or configurations provided by the HPLMN and/or that the application or application program of the terminal equipment entity or functionality is able to establish, or close, a feedback loop towards either the HPLMN or a backend application server in order to be able to possible adapt settings and/or values of or regarding the HPLMN-provided enhanced selection criterion.
[0038] Furthermore, it is advantageously possible and preferred according to the present invention that the HPLMN-provided enhanced selection criterion comprises or takes into account a home-operator-controlled value being set or being able to be adjusted by the HPLMN or its operator, wherein the HPLMN-provided enhanced selection criterion is especially more restrictive compared to a cell selection criterion lacking a home-operator-controlled component, wherein especially the HPLMN-provided enhanced selection criterion is also applied during the normal cell-selection procedure once the network selection has taken place and/or wherein especially the HPLMN-provided enhanced selection criterion triggers the network selection in case the corresponding reception conditions, as measured by the user equipment do not correspond to or do not exceed the HPLMN-provided enhanced selection criterion.
[0039] It is thereby advantageously possible according to the present invention that the home operator is able to influence the network selection process of the user equipment such that it is possible to comparatively easily implement and realize the present invention.
[0040] Furthermore, it is advantageously possible and preferred according to the present invention that the HPLMN-provided enhanced selection criterion and/or the home-operator-controlled value of the HPLMN-provided enhanced selection criterion corresponds to at least one out of the following: [0041] an absolute value or, [0042] a relative value compared to the cell selection criterion lacking a home-operator-controlled component. [0043] an offset value being additionally applied compared to the cell selection criterion lacking a home-operator-controlled component
[0044] It is thereby advantageously possible according to the present invention to comparatively easily implement and realize the present invention.
[0045] Furthermore, it is advantageously possible and preferred according to the present invention that the home-operator-controlled value of the HPLMN-provided enhanced selection criterion is
[0046] stored in the user equipment, especially within or as part of the universal integrated circuit card and/or the subscriber identity module, and/or [0047] provided or transmitted to the user

equipment, especially by the HPLMN or its operator, especially via using an over-the-air transmission method, and/or [0048] provided or transmitted via NAS signaling to the user equipment by the HPLMN.
[0049] It is thereby advantageously possible according to the present invention to comparatively easily implement and realize the present invention.
[0050] Furthermore, the present invention relates to a user equipment for being operated in a radio environment comprising a plurality of radio cells of a plurality of mobile communication networks, each one of these radio cells being associated, respectively, to at least one mobile communication network of the plurality of mobile communication networks, wherein the user equipment is configured to measure or to detect reception conditions regarding the plurality of radio cells, and is configured to subsequently select and/or register to a mobile communication network out of the plurality of mobile communication networks, wherein the user equipment has or is associated with an HPLMN, and the user equipment comprises a terminal equipment entity or functionality as well as a mobile termination entity or functionality, wherein, regarding cell selection and/or network selection by the user equipment, an enhanced selection criterion, provided by the HPLMN, is stored in the user equipment, [0051] wherein, regarding cell selection by the user equipment, a radio cell of a considered radio access technology is considered to be a suitable radio cell only in case that the corresponding reception conditions, as measured by the user equipment, correspond to or exceed the HPLMN-provided enhanced selection criterion regarding the considered radio access technology, and/or [0052] wherein, regarding network selection by the user equipment, only such mobile communication networks corresponding to suitable radio cells of the considered radio access technology are considered for network selection of the user equipment that have or correspond to reception conditions corresponding to or exceeding the enhanced selection criterion, wherein the user equipment is configured such that: [0053] the terminal equipment entity or functionality requests selection parameter information, the selection parameter information relating to or indicating whether the HPLMN-provided enhanced selection criterion is used or applied by the mobile termination entity or functionality and/or relating to or indicating a parameter value of the HPLMN-provided enhanced selection criterion, and [0054] the terminal equipment entity or functionality receives the selection parameter information,
wherein especially the user equipment is a machine type communication device.
[0055] Furthermore, the present invention relates to a system or mobile communication network for operating a user equipment in a radio environment comprising a plurality of radio cells of a plurality of mobile communication networks, each one of these radio cells being associated, respectively, to at least one mobile communication network of the plurality of mobile communication networks, the user equipment being configured to measure or to detect reception conditions regarding the plurality of radio cells, and being configured to subsequently select and/or register to a mobile communication network out of the plurality of mobile communication networks, wherein an HPLMN is associated with the user equipment, and the user equipment comprising a terminal equipment entity or functionality as well as a mobile termination entity or functionality, wherein, regarding cell selection and/or network selection by the user equipment, an enhanced selection criterion, provided by the HPLMN, is stored in the user equipment, [0056] wherein, regarding cell selection by the user equipment, a radio cell of a considered radio access technology is considered to be a suitable radio cell only in case that the corresponding reception conditions, as measured by the user equipment, correspond to or exceed the HPLMN-provided enhanced selection criterion regarding the considered radio access technology, and/or [0057] wherein, regarding network selection by the user equipment, only such mobile communication networks corresponding to suitable radio cells of the considered radio access technology are considered for network selection of the user equipment that have or correspond to reception conditions corresponding to or exceeding the enhanced selection criterion,
wherein the system or mobile communication network is configured such that: [0058] the terminal

equipment entity or functionality requests selection parameter information, the selection parameter information relating to or indicating whether the HPLMN-provided enhanced selection criterion is used or applied by the mobile termination entity or functionality and/or relating to or indicating a parameter value of the HPLMN-provided enhanced selection criterion, and [0059] the terminal equipment entity or functionality receives the selection parameter information.

[0060] Additionally, the present invention relates to a program comprising a computer readable program code which, when executed on a computer and/or on a user equipment and/or on a network node of a mobile communication network, or in part on a user equipment and/or in part on network node of a mobile communication network, causes the computer and/or the user equipment and/or the network node of the mobile communication network to perform a method according to an exemplary embodiment of the present invention.

[0061] Still additionally, the present invention relates to a computer-readable medium comprising instructions which when executed on a computer and/or on a user equipment and/or on a network node of a mobile communication network, or in part on a user equipment and/or in part on network node of a mobile communication network, causes the computer and/or the user equipment and/or the network node of the mobile communication network to perform a method according to an exemplary embodiment of the present invention.

[0062] These and other characteristics, features and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, principles of the invention. The description is given for the sake of example only, without limiting the scope of the invention. The reference figures quoted below refer to the attached drawings.

[0063] The present invention will be described with respect to particular embodiments and with reference to certain drawings, but the invention is not limited thereto but only by the claims. The drawings described are only schematic and are non-limiting. In the drawings, the size of some of the elements may be exaggerated and not drawn on scale for illustrative purposes.

[0064] Where an indefinite or definite article is used when referring to a singular noun, e.g. “a”, “an”, “the”, this includes a plural of that noun unless something else is specifically stated.

[0065] Furthermore, the terms first, second, third and the like in the description and in the claims are used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described or illustrated herein.

[0066] In FIG. **1**, a user equipment **20** is schematically shown in a radio environment comprising a plurality of radio cells of a plurality of mobile communication networks. In the exemplary representation of FIG. **1**, a first radio cell **11** is associated with or related to a first mobile communication network **100**, a second radio cell **12** is associated with or related to a second mobile communication network **200**, and a third radio cell **13** is associated with or related to a third mobile communication network **300**.

[0067] Schematically, a base station entity is represented regarding each one of the three radio cells **11**, **12**, **13** that the user equipment **20** detects or “sees”: A first base station entity **111** (typically but not necessarily of the first mobile communication network **100**) generates or provides radio coverage of or regarding the first radio cell **11**, a second base station entity **112** (typically but not necessarily of the second mobile communication network **200**) generates or provides radio coverage of or regarding the second radio cell **12**, and a third base station entity **113** (typically but not necessarily of the third mobile communication network **200**) generates or provides radio coverage of or regarding the third radio cell **13**.

[0068] In FIG. **1**, the user equipment **20** is shown being located within the radio coverage area (illustrated via dashed circles) of the first radio cell **11**, the second radio cell **12**, as well as the third radio cell **13**. The user equipment **20** measures or detects reception conditions regarding the

plurality of radio cells **11**, **12**, **13**, and subsequently selects and/or registers to a mobile communication network out of the plurality of mobile communication networks **100**, **200**, **300**.

[0069] FIG. **2** shows the user equipment **20** and its components in greater detail:

According to the present invention, the user equipment **20** comprises a terminal equipment entity or functionality **21** as well as a mobile termination entity or functionality **23**. In the exemplary embodiment shown in FIG. **2**, the user equipment **20** additionally comprises a terminal adaptor entity or functionality **22**.

More generally according to the present invention, the terminal equipment entity or functionality **21** requests, in the first step, selection parameter information **521**, the selection parameter information **521** relating to or indicating whether the HPLMN-provided enhanced selection criterion **520** is used or applied by the mobile termination entity or functionality **23** and/or relating to or indicating a parameter value of the HPLMN-provided enhanced selection criterion **520**, and the terminal equipment entity or functionality **21** then receives, in a second step, the selection parameter information **521**.

In the exemplary embodiment shown in FIG. **2**, the terminal adaptor entity or functionality **22** receives, during or after the first step, the request **522** of (or regarding) the selection information from the terminal equipment entity or functionality **21** (especially triggered by a user interaction and/or an event of the application **211** of the terminal equipment entity or functionality **21**), and the terminal adaptor entity or functionality **22** transmits, during or prior to the second step, the selection parameter information **521** to the terminal equipment entity or functionality **21**.

Furthermore in the exemplary embodiment shown in FIG. **2**, the terminal adaptor entity or functionality **22**, transmits, during or after the first step, a further request **524** of the selection parameter information **521** to the mobile termination entity or functionality **23**, and the terminal adaptor entity or functionality **22** receives, during or prior to the second step, the selection parameter information **521** from the mobile termination entity or functionality **23**, especially as part of a message **523**. Between the mobile termination entity or functionality **23** (of the user equipment **20**) and the network **100** (exemplarily, in FIG. **2**, the first mobile communication network **100** is considered to be the HPLMN of the user equipment **20**; however, it would also have been possible that the second or third networks **200**, **300** play this role), a number of network messages **230** are typically exchanged.

[0070] According to an exemplary embodiment of the present invention, the request **522** (or request message **522**) corresponds to AT commands; the selection parameter information **521** corresponds to the respective responses; the further request **524** (or further request message **524**) corresponds to mobile termination control commands (typically according to a proprietary interface of the manufacturer of the terminal adaptor entity or functionality **22** and/or of the mobile termination entity or functionality **23**); the message **523** (conveying or comprising the selection parameter information **521**) corresponds to a mobile termination status message.

Hence especially, an AT-command interface (or, more generally, a terminal equipment-terminal adaptor interface) is used between, on the one hand, the terminal equipment entity or functionality **21**, and, on the other hand, the terminal adaptor entity or functionality **22** or the mobile termination entity or functionality **23**, thereby allowing an application (or an application-level entity or functionality of the terminal equipment entity or functionality **21**) to become aware, whether an offset or threshold (i.e. a HPLMN-provided enhanced selection criterion) is set, and what the actual value of that threshold is.

Especially when an AT-command interface is used, a command towards the mobile termination entity or functionality is comparatively easily able to be generated, based on the terminal equipment entity or functionality's knowledge of the selection parameter information, e.g. by settings of the user equipment application. Thereafter, the result of such commands are able to be reported to the network or a backend application server. Additionally, the home network (or HPLMN) or a backend application server can send a command (e.g. via application layer and/or

non-access stratum communication) to the user equipment to trigger the user equipment application to retrieve the thresholds using AT-commands. This information can be beneficially used, in case the application manually selects another network and/or radio access technology type.
[0071] It is preferred according to the present invention that the AT-command interface is realized either between the terminal equipment entity or functionality **21** and the terminal adaptor entity or functionality **22**, or between the terminal equipment entity or functionality **21** and the mobile termination entity or functionality **23**.
Especially, the AT-command interface is used by the application or application program of the terminal equipment entity or functionality **21**, and especially in order to execute settings of the application, especially events such as periodical events, or in order to execute a command of the HPLMN or of a backend application server; especially, the application or application program of the terminal equipment entity or functionality **21** thereafter reports the result to the HPLMN or to a backend application server, especially via application layer and/or non-access stratum communication, NAS.
[0072] According to an especially preferred embodiment of the present invention, the user equipment **20** is a machine type communication device.
Furthermore, it is preferred according to the present invention that the terminal adaptor entity or functionality **22** corresponds, e.g., to a GSM data card, e.g. equal to a DCE, data circuit terminating equipment, and the terminal equipment entity or functionality **21**, e.g. corresponds to a computer (equal to a DTE, data terminal equipment) or, in case of an internet-of-things device (or machine type communication device), it would be the actual application executed in the device.
Furthermore, the user equipment **20** comprises a universal integrated circuit card and/or a subscriber identity module, especially comprising a secure element or part of the user equipment **20**, and/or
the terminal equipment entity or functionality **21** comprises an application or an application program.
[0073] According to the present invention, a HPLMN-provided enhanced selection criterion is able to be applied by the user equipment **20** regarding cell selection and/or regarding network selection. The HPLMN-provided cell selection criterion, designated by reference sign **520**, is schematically shown in FIG. **3** which represents a situation of the user equipment **20** measuring different signal strength of the different radio cells **11**, **12**, **13**. The ordinate of the diagram shown in FIG. **3** corresponds to the signal strength **500** or an indicator thereof (such as a field strength value and/or signal quality parameter). According to mechanisms in conventionally known mobile communication networks, the user equipment **20** applies a conventionally defined cell selection criterion **510** in the cell selection stage. According to this (conventionally defined) cell selection criterion **510**, both the first radio cell **11** and the third radio cell **13** would be regarded as suitable radio cells (according to or applying the cell selection criterion **510** in the cell selection stage and/or in the network selection stage) as both radio cells **11**, **13** are schematically shown as having or providing (at the location of the user equipment **20**) a signal strength corresponding to or exceeding the (conventionally defined) cell selection criterion **510**.
According to the present invention, the HPLMN-provided enhanced selection criterion **520** is defined (i.e. somehow received, by the user equipment **20**, from the HPLMN, either initially, e.g. stored on an universal integrated circuit card, or during operation of the user equipment **20**) and taken into consideration when it comes to select a radio cell and/or a network. As the HPLMN-provided enhanced selection criterion **520** is typically more demanding or requires an increased reception signal level or quality (schematically indicated, in FIG. **3**, via the HPLMN-provided enhanced selection criterion **520** being represented above the conventionally defined cell selection criterion **510**, i.e. the HPLMN-provided enhanced selection criterion **520** is especially more restrictive compared to the conventionally defined cell selection criterion **510**), only the third radio cell **13** is considered (as it is the only one of the three radio cells represented that the corresponding

reception conditions, as measured by the user equipment **20**, correspond to or exceed the HPLMN-provided enhanced selection criterion **520** regarding the considered radio access technology), by the user equipment **20**, to be or correspond to a suitable radio cell and/or a suitable network in case that the HPLMN-provided enhanced selection criterion **520** is applied, i.e. required.
The HPLMN-provided enhanced selection criterion **520** might either correspond to a HPLMN-provided cell selection criterion being taken into consideration when it comes to select a radio cell. Alternatively or cumulatively, the HPLMN-provided enhanced selection criterion **520** might correspond to an enhanced network selection criterion taken into consideration when it comes to select a network, especially a public land mobile network, especially in the first or initial part of the network selection stage.
Both in FIG. **1** and in FIG. **3**, only radio cells and mobile communication networks **100**, **200**, **300** are shown without differentiating between different radio access technologies. However, it is to be understood that this also applies for different radio access technologies, e.g. the third radio cell **13** might exceed the HPLMN-provided enhanced selection criterion **520** only regarding one specific radio access technology, but a radio cell (not specifically represented in FIG. **1** or **3**) of another radio access technology and also provided or generated by the third base station entity **113** might not exceed the respective HPLMN-provided enhanced selection criterion **520** to be applied regarding the other radio access technology, and, perhaps, vice versa for the other radio cells **11**, **12**.
[0074] According to the present invention, the user equipment **20** typically has or is associated with a home public land mobile network, HPLMN, and wherein the enhanced selection criterion **520** comprises or takes into account a home-operator-controlled value being set or being able to be adjusted by the HPLMN or its operator, wherein the HPLMN-provided enhanced selection criterion **520** is especially more restrictive compared to a cell selection criterion **510** (or general cell selection criterion) lacking a home-operator-controlled component, wherein especially the HPLMN-provided enhanced selection criterion **520** is also applied during the normal cell-selection and/or during the network selection procedure.
[0075] FIG. **4** schematically represents an example of a communication within the user equipment **20** in case of using a universal integrated circuit card **24** as part of the user equipment **20**; i.e. FIG. **4** shows the communication between the terminal equipment entity or functionality **21**, the terminal adaptor entity or functionality **22**, the mobile termination entity or functionality **23**, and the universal integrated circuit card **24**. A double arrow between the terminal equipment entity or functionality **21** and the terminal adaptor entity or functionality **22** schematically and exemplarily indicates the AT-command interface, and another double arrow between the mobile termination entity or functionality **23** and the universal integrated circuit card **24** schematically and exemplarily indicates the mobile termination entity or functionality-universal integrated circuit card interface.
[0076] In order to allow an application (i.e. the terminal equipment entity or functionality **21**) to query the offsets or thresholds (of the enhanced selection criterion **520**) being stored and remotely maintained by the home operator on the subscriber identity module or sim card (or universal integrated circuit card), a respective command set for the “AT(-command) interface” as well as for the “MT-UICC” interface and respective procedures need to be defined. A message flow between the application (or the user) **211**, the terminal equipment entity or functionality **21**, the terminal adaptor entity or functionality **22**, the mobile termination entity or functionality **23** and the universal integrated circuit card **24** could, e.g., result in the following processing steps:
[0077] In a first processing step, the user/application **211** triggers a query (towards the terminal equipment entity or functionality **21**) in order to obtain the current enhanced selection criterion **520** status/value (done via interaction with a terminal equipment based on API/software library).
In a second processing step (**601**), the terminal equipment entity or functionality **21**, issues (towards the terminal adaptor entity or functionality **22**) the AT-Command (set) over the AT command line interface (serial interface), e.g. <AT+CURT> (“AT” as the typical start of an AT-

command sequence; “C” as typically for an interaction with ‘cellular’; “URT” corresponding to the actual command, e.g. for “User Related Threshold”); the second processing step corresponds to the first step, i.e. the terminal equipment entity or functionality **21** requesting the selection parameter information **521**.
In a third processing step, the terminal adaptor entity or functionality **22** forwards the request to the mobile termination entity or functionality **23**.
In a fourth processing step (**602**), the mobile termination entity or functionality **23** queries the universal integrated circuit card **24**.
In a fifth processing step (**603**), the universal integrated circuit card **24** responds with the current threshold, i.e. provides the selection parameter information **521** to the mobile termination entity or functionality **23**.
In a sixth processing step, the mobile termination entity or functionality **23** forwards the result, i.e. the selection parameter information **521**, to the terminal adaptor entity or functionality **22**.
In a seventh processing step (**604**), the terminal adaptor entity or functionality **22** forwards the result, i.e. the selection parameter information **521**, to the terminal equipment entity or functionality **21** in form of an AT-command result, e.g. like: <CR><LF>+CURT:(0-20,12) <CR> <LF> (Where +CURT points at the result to a query of CURT value: (0-20,12) corresponds to a value range of 0-20 and a current value of 12).
[0078] In an eighth processing step, the terminal equipment entity or functionality **21** forwards the result to the application **211** (or to the user).
[0079] While subject matter of the present disclosure has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. Any statement made herein characterizing the invention is also to be considered illustrative or exemplary and not restrictive as the invention is defined by the claims. It will be understood that changes and modifications may be made, by those of ordinary skill in the art, within the scope of the following claims, which may include any combination of features from different embodiments described above.
[0080] The terms used in the claims should be construed to have the broadest reasonable interpretation consistent with the foregoing description. For example, the use of the article “a” or “the” in introducing an element should not be interpreted as being exclusive of a plurality of elements. Likewise, the recitation of “or” should be interpreted as being inclusive, such that the recitation of “A or B” is not exclusive of “A and B,” unless it is clear from the context or the foregoing description that only one of A and B is intended. Further, the recitation of “at least one of A, B and C” should be interpreted as one or more of a group of elements consisting of A, B and C, and should not be interpreted as requiring at least one of each of the listed elements A, B and C, regardless of whether A, B and C are related as categories or otherwise. Moreover, the recitation of “A, B and/or C” or “at least one of A, B or C” should be interpreted as including any singular entity from the listed elements, e.g., A, any subset from the listed elements, e.g., A and B, or the entire list of elements A, B and C.

Claims

1. A method for operating a user equipment in a radio environment comprising a plurality of radio cells of a plurality of mobile communication networks, wherein each one of the plurality of radio cells is associated, respectively, to at least one mobile communication network of the plurality of mobile communication networks, wherein the user equipment measures reception conditions regarding the plurality of radio cells, and subsequently selects and/or registers to a mobile communication network out of the plurality of mobile communication networks, wherein the user equipment has or is associated with a home public land mobile network (HPLMN), and the user equipment comprises a terminal equipment entity or functionality as well as a mobile termination

entity or functionality, wherein an AT-command interface is used between, on the one hand, the terminal equipment entity or functionality, and, on the other hand, the mobile termination entity or functionality, wherein, regarding cell selection and/or network selection by the user equipment, an enhanced selection criterion, provided by the HPLMN, is stored in the user equipment, wherein: regarding cell selection by the user equipment, a radio cell of a considered radio access technology is considered to be a suitable radio cell only in case that corresponding reception conditions, as measured by the user equipment, correspond to or exceed the HPLMN-provided enhanced selection criterion regarding the considered radio access technology, and/or regarding network selection by the user equipment, only such mobile communication networks corresponding to suitable radio cells of the considered radio access technology are considered for network selection of the user equipment that have or correspond to reception conditions corresponding to or exceeding the enhanced selection criterion, wherein the method comprises the following steps: in a first step, the terminal equipment entity or functionality requests selection parameter information via the AT-command interface, the selection parameter information relating to or indicating whether the HPLMN-provided enhanced selection criterion is used or applied by the mobile termination entity or functionality and/or relating to or indicating a parameter value of the HPLMN-provided enhanced selection criterion; and in a second step, the terminal equipment entity or functionality receives the selection parameter information, via the AT-command interface.

2. The method according to claim 1, wherein the user equipment comprises, besides the terminal equipment entity or functionality and the mobile termination entity or functionality, a terminal adaptor entity or functionality; wherein the terminal adaptor entity or functionality receives, during or after the first step, the request of the selection parameter information from the terminal equipment entity or functionality; and wherein the terminal adaptor entity or functionality transmits, during or prior to the second step, the selection parameter information to the terminal equipment entity or functionality.

3. The method according to claim 2, wherein the terminal adaptor entity or functionality, transmits, during or after the first step, a further request of the selection parameter information to the mobile termination entity or functionality; and wherein the terminal adaptor entity or functionality receives, during or prior to the second step, the selection parameter information from the mobile termination entity or functionality.

4. (canceled)

5. The method according to claim 1, wherein the user equipment comprises a universal integrated circuit card, especially comprising a secure element of the user equipment.

6. The method according to claim 5, wherein an AT-command interface between the terminal equipment entity or functionality and the terminal adaptor entity or functionality, or between the terminal equipment entity or functionality and the mobile termination entity or functionality, is used by the application or application program of the terminal equipment entity or functionality.

7. The method according to claim 1, wherein the HPLMN-provided enhanced selection criterion comprises or takes into account a home-operator-controlled value being set or being able to be adjusted by the HPLMN or its operator.

8. The method according to claim 7, wherein the home-operator-controlled value of the HPLMN-provided enhanced selection criterion corresponds to at least one out of the following: an absolute value, a relative value relative to a cell selection criterion lacking a home-operator-controlled component, or an offset value being additionally applied relative to a cell selection criterion lacking a home-operator-controlled component

9. The method according to claim 7, wherein the home-operator-controlled value of the HPLMN-provided enhanced selection criterion is: stored in the user equipment, or provided or transmitted to the user equipment, or provided or transmitted via non-access stratum (NAS) signaling to the user equipment by the HPLMN.

10. (canceled)

11. A system for operating a user equipment in a radio environment comprising a plurality of radio cells of a plurality of mobile communication networks, wherein the system comprises: the user equipment; and the plurality of mobile communication networks; and a home public land mobile network (HPLMN); wherein each one of the plurality of radio cells is associated, respectively, to at least one mobile communication network of the plurality of mobile communication networks; wherein the user equipment is configured to: measure reception conditions regarding the plurality of radio cells, and subsequently select or register to a mobile communication network out of the plurality of mobile communication networks; wherein the HPLMN is associated with the user equipment; wherein the user equipment comprises: a terminal equipment entity or functionality; and a mobile termination entity or functionality; wherein the user equipment is configured to use an AT-command interface between, on the one hand, the terminal equipment entity or functionality, and, on the other hand, the mobile termination entity or functionality. wherein, regarding cell selection and/or network selection by the user equipment, an enhanced selection criterion, provided by the HPLMN, is stored in the user equipment; wherein: regarding cell selection by the user equipment, a radio cell of a considered radio access technology is considered to be a suitable radio cell only in case that corresponding reception conditions, as measured by the user equipment, correspond to or exceed the HPLMN-provided enhanced selection criterion regarding the considered radio access technology, and/or regarding network selection by the user equipment, only such mobile communication networks corresponding to suitable radio cells of the considered radio access technology are considered for network selection of the user equipment that have or correspond to reception conditions corresponding to or exceeding the enhanced selection criterion; wherein the terminal equipment entity or functionality is configured to: request selection parameter information via the AT-command interface, the selection parameter information relating to whether the HPLMN-provided enhanced selection criterion is used by the mobile termination entity or functionality and/or relating to a parameter value of the HPLMN-provided enhanced selection criterion; and receive the selection parameter information via the AT-command interface.

12-14 (canceled)

15. A non-transitory computer readable storage medium comprising instructions, which when executed on a computer associated with a user equipment or on a user equipment, causes the computer or the user equipment to perform the method according to claim 1.