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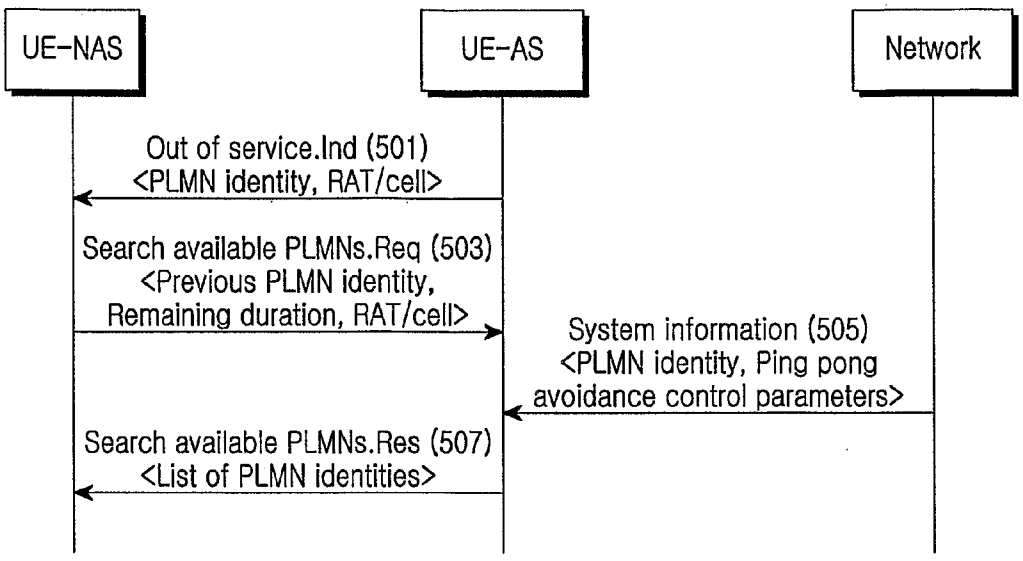
(54) **Title:** METHOD AND APPARATUS FOR NETWORK SELECTION AND/OR RE-SELECTION OF A TERMINAL IN A CELLULAR COMMUNICATION SYSTEM



(57) **Abstract:** A method of improving network selection and/or network re-selection of a mobile terminal in a cellular communications system by specifying radio quality criteria to avoid repeated change of networks.

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METHOD AND APPARATUS FOR NETWORK SELECTION AND/OR RE-SELECTION OF A TERMINAL IN A CELLULAR COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to mobile communication techniques. More particularly, but not exclusively, it relates to Public Land Mobile Network (PLMN) ping pong avoidance mechanisms.

It is applicable to both the Access Stratum (AS) and the Non Access Stratum (NAS) protocols as used in different mobile/radio access network e.g. Global System for Mobile communication (GSM), Universal Mobile Telecommunications System (UMTS). The idea is expected to be applicable from release 7 onwards.

2. Description of the Related Art

A brief description of the UMTS radio network architecture and includes background information about aspects related to PLMN selection, is provided below.

Further background information about a number of aspects related to this invention is provided by means of a number of extracts from standards.

FIG. 1 is a block diagram illustrating a configuration of a typical universal mobile telecommunications system (UMTS).

Referring to the fig.1, the typical UMTS comprises of mobile user equipments (UEs) 101, a UMTS terrestrial radio access network (UTRAN) 103 and one or more core networks (CNs) 105 as shown in the fig.1. UMTS concerns a third generation radio network using wideband code division multiple access (W-CDMA) technology.

FIG. 2 is a block diagram illustrating a configuration of the typical UTRAN as shown in the fig.1.

Referring to fig.2, the typical architecture of a the UTRAN comprises of a plurality of Node Bs 201 as base stations and a plurality of radio network controllers (RNCs) 203 as base station controllers. The Node Bs handle the actual

communication across the radio interface, covering a specific geographical area also referred to as a cell. Besides controlling the Node Bs connected to it the RNCs include functionality like the allocation of radio resources, local mobility.

An RNC connects:

to one or more core networks via the Iu interface,to a number of base stations (node B's for the case of UTRAN) via the Iub interface andpossibly to one or more other RNCs via the Iur interface.

FIG. 3 is a block diagram illustrating a configuration of the typical UMTS grouped into the Access Stratum (AS) and the Non-Access Stratum (NAS).

Referring to the fig.3, the fig.3 again shows the UMTS architecture in terms of its entities User Equipment (UE), UTRAN and Core Network. Furthermore, the respective reference points Uu (Radio Interface) and Iu (CN-UTRAN interface) are shown. Finally, the figure illustrates furthermore the high-level functional grouping into the AS 301 and the NAS 303.

The AS 301 includes the lower radio specific layers of the protocols i.e. in UMTS this includes the Radio Resource Control, the Radio Link Control and the Medium Access Control protocols as well as the Physical layer functionality. The Access Stratum offers services through the following Service Access Points (SAP) to the Non-Access Stratum (marked with circles in the figure):General Control (GC) SAPs;

Notification (Nt) SAPs; and

Dedicated Control (DC) SAPs.

The NAS 303 includes the upper radio specific layers of the protocols i.e. in UMTS this includes e.g. the Call Control (CC), the Mobility Management (MM) and the Session Management (SM) protocols.

A detailed description will now be made of detecting 'out of service' in the following two aspects:

1)UEs in Idle & _PCH 25.133 clause 4.2.2.1 specifies:

If the UE has evaluated in Nserv consecutive DRX cycles that the serving cell does not fulfil the cell selection criterion S, the UE shall initiate the measurements of all neighbour cells indicated in the measurement control system information, regardless of the measurement rules currently limiting UE measurement activities.

If the UE has not found any new suitable cell based on searches and measurements of the neighbour cells indicated in the measurement control system

information for 12 s, the UE shall initiate cell selection procedures for the selected PLMN as defined in TR 22.811, Review of Network Selection Principles, version 7.0.0 (hereinafter "reference 1")

After this 12 s period a UE in Cell:PCH or URA_PCH is considered to be "out of service area" and shall perform actions according to 25.331.

2) For UEs in CELL_FACH 25.133 clause 5.5.2.3 specifies:

The UE is "out of service area" if the UE has evaluated for 4 s that that the serving cell does not fulfil the cell selection criterion S and if the UE has not found any new suitable cell based on searches and measurements of the neighbour cells indicated in the measurement control system information during these 4 s. When the UE is "out of service area" it shall initiate cell selection procedures for the selected PLMN as defined in the reference 1. Hereinafter, an action upon detecting out of service will be described with regard to URA_PCH state, CELL_PCH state and CELL_FACH state in detail.

Regarding the actions upon detecting out of service, 25.331 specifies the following:

8.5.5.1.1 Actions following detection of "out of service" area in URA_PCH or CELL_PCH state

If the UE detects the "out of service area" and the UE is in URA_PCH or CELL_PCH state it shall perform the following actions:

1> start timer T316;

1> perform processes described in subclause 7.2.2.

8.5.5.1.2 Actions following detection of "out of service" area in CELL_FACH state

If the UE detects the "out of service area" and the UE is in CELL_FACH state it shall perform the following actions. The UE shall:

1> start timer T317 if not already running;

1> perform processes described in subclause 7.2.2.

With clause 7.2.2 specifying

1> if the UE is "out of service area":

2> perform cell selection process as specified in TS 25.331, Radio Resource Control(RRC); Protocol Specification (hereinafter "reference 2");

2> run timer T316;

2> run timer T305;

2> if the cell selection process fails to find a suitable cell after a complete scan of all RATs and all frequency bands supported by the UE, the UE shall after a minimum of TimerOutOfService time (default value 30 s) of being "out of service area":

3> indicate all available PLMNs to NAS to enable the selection of a new PLMN;

3> if an acceptable cell is found then the UE shall camp on that cell to obtain limited service as defined in the reference 2 and, perform actions according to subclause 8.5.24;

3> else if no acceptable cell is found, the UE shall continue looking for an acceptable cell as defined in the reference 2.

Hereinafter, it will be described regarding the support of PLMN selection, 25.304 specifies the following:

5.1.2.2 UTRA case

The UE shall scan all RF channels in the UTRA bands according to its capabilities to find available PLMNs. On each carrier, the UE shall search for the strongest cell and read its system information, in order to find out which PLMN the cell belongs to. If the UE can read the PLMN identity, the found PLMN shall be reported to the NAS as a high quality PLMN (but without the RSCP value), provided that the following high quality criterion is fulfilled:

1. For an FDD cell, the measured primary CPICH RSCP value shall be greater than or equal to -95 dBm.

2. For a TDD cell, the measured P-CCPCH RSCP shall be greater than or equal to -84 dBm.

Found PLMNs that do not satisfy the high quality criterion, but for which the UE has been able to read the PLMN identities are reported to the NAS together with the CPICH RSCP value for UTRA FDD cells and P-CCPCH RSCP for UTRA TDD cells.

The search for PLMNs on the rest of the carriers may be stopped on request of the NAS. The UE may optimise this search by using stored information of carrier frequencies and optionally also information on cell parameters, e.g. scrambling codes, from previously received measurement control information elements.

Once the UE has selected a PLMN, the cell selection procedure shall be performed in order to select a suitable cell of that PLMN to camp on.

Hereinafter, it will be described regarding cell selection and PLMN re-selection in detail.

Cell selection

Regarding cell selection/ cell suitability, 25.304 specifies the following:

5.2.3 Cell Selection Process

5.2.3.1 UTRA case

5.2.3.1.1 Description

The UE shall use one of the following two search procedures:

a) Initial Cell Selection

This procedure requires no prior knowledge of which RF channels are UTRA carriers. The UE shall scan all RF channels in the UTRA bands according to its capabilities to find a suitable cell of the selected PLMN. On each carrier, the UE need only search for the strongest cell. Once a suitable cell is found this cell shall be selected.

b) Stored Information Cell Selection

This procedure requires stored information of carrier frequencies and optionally also information on cell parameters, e.g. scrambling codes, from previously received measurement control information elements. Once the UE has found a suitable cell for the selected PLMN the UE shall select it. If no suitable cell of the selected PLMN is found the Initial cell selection procedure shall be started.

Table 1 to Table 3 below illustrate criteria and variable defined for cell selection.

The cell selection criterion S is fulfilled when:

Table 1

for FDD cells:	Srxlev > 0 AND Squal > 0
for TDD cells:	Srxlev > 0

Table 2

$Squal = Q_{qualmeas} - Qqualmin$
$Srxlev = Q_{rxlevmeas} - Qrxlevmin - Pcompensation$

Table 3

Squal	Cell Selection quality value (dB) Applicable only for FDD cells.
Srxlev	Cell Selection RX level value (dB)
$Q_{qualmeas}$	Measured cell quality value. The quality of the received signal expressed in CPICH E_C/N_0 (dB) for FDD cells. CPICH Ec/N0 shall be averaged as specified in [10]. Applicable only for FDD cells.
$Q_{rxlevmeas}$	Measured cell RX level value. This is received signal, CPICH RSCP for FDD cells (dBm) and P-CCPCH RSCP for TDD cells (dBm).
Qqualmin	Minimum required quality level in the cell (dB). Applicable only for FDD cells.
Qrxlevmin	Minimum required RX level in the cell (dBm)
Pcompensation	max(UE_TXPWR_MAX_RACH – P_MAX, 0) (dB)
UE_TXPWR_MAX_RACH	Maximum TX power level an UE may use when accessing the cell on RACH (read in system information) (dBm)
P_MAX	Maximum RF output power of the UE (dBm)

PLMN re-selection

Regarding (automatic) PLMN selection, 23.122 specifies the following:

4.4.3.1.1 Automatic Network Selection Mode Procedure

The MS selects and attempts registration on other PLMN/access technology combinations, if available and allowable, in the following order:

i) HPLMN (if not previously selected);

ii) each PLMN/access technology combination in the "User Controlled PLMN Selector with Access Technology" data file in the SIM (in priority order);

iii) each PLMN/access technology combination in the "Operator Controlled PLMN Selector with Access Technology" data file in the SIM (in priority order);

iv) other PLMN/access technology combinations with received high quality signal in random order;

v) other PLMN/access technology combinations in order of decreasing signal quality.

When following the above procedure the following requirements apply:

a) An MS with voice capability shall ignore PLMNs for which the MS has identified at least one GSM COMPACT.

b) In A/Gb mode or GSM COMPACT, an MS with voice capability, or an MS not supporting packet services shall not search for CPBCCH carriers.

c) In ii and iii, the MS should limit its search for the PLMN to the access technology or access technologies associated with the PLMN in the appropriate PLMN Selector with Access Technology list (User Controlled or Operator Controlled selector list). An MS using a SIM without access technology information storage (i.e. the "User Controlled PLMN Selector with Access Technology" and the "Operator Controlled PLMN Selector with Access Technology" data files are not present) shall instead use the "PLMN Selector" data file, for each PLMN in the "PLMN Selector" data file, the MS shall search for all access technologies it is capable of and shall assume GSM access technology as the highest priority radio access technology.

d) In iv and v, the MS shall search for all access technologies it is capable of, before deciding which PLMN to select.

e) In ii, and iii, a packet only MS which supports GSM COMPACT, but using a SIM without access technology information storage (i.e. the "User Controlled PLMN Selector with Access Technology" and the "Operator Controlled PLMN Selector with Access Technology" data files are not present) shall instead use the "PLMN Selector" data file, for each PLMN in the "PLMN Selector" data file, the MS shall search for all access technologies it is capable of and shall assume GSM COMPACT access technology as the lowest priority radio access technology.

f) In i, the MS shall search for all access technologies it is capable of. No priority is defined for the preferred access technology and the priority is an implementation issue, but "HPLMN Selector with Access Technology" data file on the SIM may be used to optimise the procedure.

g) In i, an MS using a SIM without access technology information storage (i.e. the "HPLMN Selector with Access Technology" data file is not

present) shall search for all access technologies it is capable of and shall assume GSM access technology as the highest priority radio access technology. A packet only MS which supports GSM COMPACT using a SIM without access technology information storage shall also assume GSM COMPACT access technology as the lowest priority radio access technology.

h) In v, the MS shall order the PLMN/access technology combinations in order of decreasing signal quality within each access technology. The order between PLMN/access technology combinations with different access technologies is an MS implementation issue.

NOTE 1: Requirements a) and b) apply also to requirement d), so a GSM voice capable MS should not search for GSM COMPACT PLMNs, even if capable of GSM COMPACT.

NOTE 2: Requirements a) and b) apply also to requirement f), so a GSM voice capable MS should not search for GSM COMPACT PLMNs, even if this is the only access technology on the "HPLMN Selector with Access Technology" data file on the SIM.

NOTE 3: High quality signal is defined in the appropriate AS specification.

If successful registration is achieved, the MS indicates the selected PLMN.

If registration cannot be achieved because no PLMNs are available and allowable, the MS indicates "no service" to the user, waits until a new PLMN is available and allowable and then repeats the procedure.

If there were one or more PLMNs which were available and allowable, but an LR failure made registration on those PLMNs unsuccessful or an entry in any of the lists "forbidden LAs for roaming", or "forbidden LAs for regional provision of service" prevented a registration attempt, the MS selects the first such PLMN again and enters a limited.

In addition, terminologies with regard to abbreviations described in this description are the following:

Abbreviations & terminology

ABS	Automatic Background Scan
LR-PLMN	Last Registered PLMN
NRP	National Roaming Partner
NSP	Network Selection Principles
OOS	Out Of Service
PPPA	PLMN Ping Pong Avoidance

PR-PLMN Previously Registered PLMN

Other abbreviations and terminologies can be found in 3GPP TS 21.905

Problem description

The following is an extract from 3GPP TR 22.811 version 7.0.0.

6.10 Ping ponging between Registration Areas

Currently the mechanisms standardised do not seem to adequately cater for the national roaming scenario nor for multi RAT (3G, WLAN, 2G etc.) environments. This, when associated with fluctuating signal condition, can lead to UE ping-ponging between 2G and 3G , causing significant signalling load on the network as well as severely affecting user experience.

The currently specified behaviour is as follows:

- If less than 12 seconds, the UE will be momentarily out of coverage but will not declare out of service (OOS), and then it will come back to the serving cell.

- If slightly more than 12 seconds, the UE will declare Out-of-service(OOS) and start scanning, but then will most likely come back to the same 3G cell.

- If longer (~30 sec) the UE may go to a national roaming partner, but after 6 minutes it is likely to come back to the same weak 3G cell upon the first background HPLMN search.

This will create instability that will affect user experience as this is a source of missed calls, failed call setups and possible denial of certain services.

Means should be reviewed to improve the effect of ping ponging between registration areas. It should be possible for allow the network to be configured by the operator so as to enable the definition of different quality criteria for leaving and coming back to a cell/PLMN.

Detailed description current UE behaviour

The currently specified UE behaviour is as follows:

When the UE is near the edge of the operators PLMN coverage area, the UE may go 'out of service'.

If the serving cell does not fulfil the cell selection criterion over at least 3 measurement periods TMeasurement_Period Intra (_FACH) or for Nserv consecutive DRX cycles (idle & _PCH).

Note 1. Network operators normally configure their network such that even cells that are quite bad will still meet the criteria for a suitable cell – they don't like mobiles to indicate 'out of service'.

During the next 4 (_FACH) or 12 s (idle & _PCH), the UE will search for another cell on the current (e)PLMN, based on the neighbouring cell list (both inter-Frequency and inter- RAT neighbours).

Cell re-selection is initiated if a suitable cell is found for the current (e)PLMN.

If no cell is found, a UE in connected mode is considered to be 'out of service'. Furthermore, the UE shall acts as defined below.

Next, the UE performs a complete scan of all RATs and all frequency bands supported by the UE in an attempts to find a suitable cell for the current (e)PLMN.

If a suitable cell is found during this complete scan, the UE does not need to perform a routing area update unless it is changing Routing Area i.e. there may not be NAS signalling involved.

Note 2. The UE does not stop T305 (5 min. or higher) and/ or T307 (5 through 50 sec) upon reporting available PLMNs.

If no suitable cell is found during this complete scan, after at least 30 s (default value of TimerOutOfService) <connected mode> the UE should indicate the available PLMNs to facilitate re-selection of another PLMN.

The UE-AS reports the available PLMNs.

UE-AS reports PLMNs for which the 'high quality criterion' is fulfilled as 'high quality PLMNs'.

UE-AS also reports other available PLMNs i.e. PLMNs for which the UE managed to read the PLMN identity on BCCH, together with a measured quality (p-CPICH RSCP in case of FDD).

Note3. When reporting available PLMNs, the UE need not verify if the cell from which it reads the PLMN identity is suitable e.g. whether or not it is barred.

The UE-NAS selects a PLMN from the available PLMNs indicated by AS, in the following order of preference:

Home PLMN

User preferred PLMN/ access technologies using 'User controlled PLMN selector with Access Technology', in order of priority.

Operator preferred PLMN/ access technologies using 'Operator controlled PLMN selector with Access Technology', in order of priority.

Other PLMNs/ access technologies, indicated as 'high quality', randomly.

Other PLMNs/ access technologies, in order of signal strength.

The UE periodically performs a background scan for available PLMNs.

As mentioned before, no constraints are specified concerning the PLMN selection meaning that in case of fluctuating radio conditions e.g. due to cell breathing, the UE may re-select a different PLMN each time.

Discussion on characteristics of desired improvement

On the issue of ping pong between registration areas (PLMNs in actual), the main perceived problem is as follows:

Upon performing the first or a subsequent background PLMN scan, the UE may move back towards the original cell/ PLMN, even though the quality of the original UMTS cell may still be quite bad – just about suitable.

When remaining at the edge of the coverage area, the UE may ping pong between the PLMNs regularly.

The main adverse effects associated with this PLMN-ping pong are the signalling load and the temporary user unavailability. (i.e. 34- 42 seconds and associated signalling delays for every ping pong).

Therefore, a need therefore exists for an apparatus and method for avoiding risk of ping pong between PLMNs.

SUMMARY OF THE INVENTION

It is, therefore, an object of an exemplary embodiment of the present invention to provide an apparatus and method for PLMN ping pong avoidance.

It is another object of an exemplary embodiment of the present invention to provide an apparatus and method for preventing the UE from reselecting the 2G NRP due to a small gap of 3G coverage, the UE should use a timer during which PLMN reselections are forbidden after a loss of 3G coverage even if the UE is in idle mode.

To achieve the above and other objects, there is provided a method for improving network selection and/or network re-selection of a mobile terminal in a

cellular communications system by specifying radio quality criteria to avoid repeated change of networks.

According to another aspect of the present invention, there is provided a mobile terminal for use in a cellular communications network, adapted to select or re-select a PLMN based on radio quality criteria for avoiding repeated change of PLMN in the process of PLMN selection.

According to another aspect of the present invention, there is provided a network element in a cellular communications network, adapted to provide radio quality criteria for a mobile terminal selecting or re-selecting a PLMN.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following detailed description when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a block diagram illustrating a configuration of a typical universal mobile telecommunications system (UMTS);

FIG. 2 is a block diagram illustrating a configuration of a typical UTRAN as shown in the fig.1;

FIG. 3 is a block diagram illustrating a configuration of the typical UMTS grouped into the Access Stratum (AS) and the Non-Access Stratum (NAS);

FIG. 4 shows an example of the use of a criteria for a scenario including OOS according to an exemplary embodiment of the present invention;

FIG. 5 is a flowchart illustrating the communications between the UE-AS, UE-NAS and a network element according to one embodiment of the present invention;

FIG. 6 is a schematic illustration of a deployment scenario according to another embodiment of the present invention.

Throughout the drawings, the same drawing reference numerals will be understood to refer to the same elements, features and structures.

DETAILED DESCRIPTION OF THE EXEMPLARY EMBODIMENTS

An exemplary embodiment of the present invention will now be described in detail with reference to the annexed drawings. The matters defined in the

description such as a detailed construction and elements are provided to assist in a comprehensive understanding of the embodiments of the invention.

Accordingly, those of ordinary skill in the art will recognize that various changes and modifications of the embodiments described herein can be made without departing from the scope and spirit of the invention. Also, in the following description, a detailed description of known functions and configurations incorporated herein has been omitted for conciseness.

Currently no mechanisms are available to avoid the ping pong between PLMNs. So far only a suggestion has been provided concerning what kind of mechanism may be desirable i.e. to introduce some kind of asymmetry i.e. to make the criteria for returning and leaving different.

Possible solutions using existing mechanisms include the following:

Increasing the background scan timer could reduce the ping pong upon ABS, but that would harm moving UEs.

No mechanism is specified at AS level, which is partly due to the fact that after the PLMN re-selection the UE performs cell selection rather than re-selection i.e. the cell re-selection hysteresis/ offsets do not apply. Furthermore, UE-AS reports all PLMNs of which it managed to read the PLMN identity as available.

No mechanism is currently available at NAS level either. It is important to note that when selecting PLMNs, HPLN as well as User and Operator preference take precedence above the radio quality reported by AS i.e. UE-NAS shall select the highest priority PLMN even though the radio quality may be quite bad (just found to e suitable by AS).

Some further discussion/ assumptions on what the desired improvement may/ should give:

It seems operators prefer to avoid the signalling load & bad user experience, even though this implies that it will make it harder/ take longer for the UE to return to the operator's PLMN.

The problem only concerns a stationary UEs since this slow kind of ping pong is rather unlikely for UEs that are moving.

It does not seem unlikely that a stationary UE at one time detects out of service while at a following background scan the UE is able to read system information and report it as an available PLMN.

The mechanism should at least avoid the PLMN ping pong at 'PLMN re-selection' i.e. upon every background scan since that scenario suffers from most of the adverse effects.

It would be beneficial if the mechanism could also address the case of the direct return to the cell/ PLMN in which the out of service was triggered i.e. upon the initial full scan upon detecting OOS.

Since the NSP workshop of 25th Jan 2006 in Amsterdam, operator '3' prepared a further detailed proposal which can be characterised as follows:

For further details are described in R2-060586 Network Selection and Ping Pong Effect, 3.

Separate sets of operator controllable hysteresis parameters are proposed for each of the two scenario's.

An temporary offset for the Ec/No criterium (0 to 10 dB with a 0.5 or 1 dB step).

An temporary offset for the RSCP criterium (as above)

A duration specifying how long the offsets are to be applied (Tens of seconds/ tens of minutes).

The UE acquires the parameters from the candidate cell, which broadcasts these possibly cell specific parameters as part of cell selection parameters (SIB3).

The UE shall consider a cell of the RPLMN (upon OOS)/ higher priority PLMN (upon ABS) suitable only if it meets the Scriteria after applying the concerned temporary hysteresis offset to each of the quality criteria. Correspondingly, UE-AS may report to NAS fewer available PLMNs than PLMNs found suitable according to the original criteria.

Our understanding according to the present invention about the proposed use of the above parameters is as follows:

When detecting OOS from a cell broadcasting PPPA-control parameters, the UE starts applying the temporary discouragement towards the concerned cell. At the same time, the UE starts an 'OOS-discouraged PLMN' timer. The UE stops applying the temporary discouragement towards a cell of the 'OOS-discouraged PLMN' when the timer exceeds the value broadcast by the concerned cell. The UE also stops applying the temporary discouragement towards the 'OOS-discouraged PLMN' when re-entering 'in service area'.

Upon entering a VPLMN, the UE starts an 'ABS-discouraged PLMN' timer. When detecting a cell of a higher priority PLMN broadcasting PPPA-

control parameters, the UE applies the temporary discouragement as long as the timer exceeds the value broadcast by the concerned cell. When re-selecting another PLMN, the UE restarts the 'ABS-discouraged PLMN' timer.

Furthermore, it is important to note that in order to avoid that the UE needs to record the PR-PLMN, the PPPA-mechanism is proposed to apply to a PLMN regardless of whether the UE was previously registered on it.

Hereinafter, ping pong avoidance mechanisms according the present invention are described in detail.

This can be achieved in different ways:

1) Quality level approach: Different quality levels i.e. by specifying that the UE should only move back if the quality level is sufficiently high e.g. offset higher than the criteria for leaving the cell/ considering out of service.

2) Quality duration approach: Different quality durations i.e. by specifying that the UE should only move back if the conditions for returning last longer than for leaving/ detecting out of service e.g. by using a scaling factor for the timer (e.g. similar to what we have for Treselection).

At first glance, a timer based mechanism has the disadvantage that it could further increase the duration of the 'unavailability period'.

Although we do not wish to exclude the 'Quality duration' approach, the following sections are primarily focussed on the 'Quality offset' approach. However, the some of the principles discussed may also be applied for the 'Quality duration' approach also.

A PLMN ping pong avoidance mechanism can either utilise a quality level, a quality duration based criterion.

As a further option, the ping pong avoidance could, irrespective of which mechanism is used, be temporary meaning that ping pong avoidance is limited to a specific duration. For a UE that is stationary, a timer based mechanism is most suitable for limiting the duration while for UEs that are (starting) to move, a mechanism based on the movement of the UE could be used e.g. the number of cell re-selections, the distance moved since the UE was registered on the previous PLMN (e.g. in case the UE).

The PLMN ping pong avoidance could, irrespective of which mechanism is used, be temporary. This could be done by means of a timer based mechanism and/ or in combination with a mechanism related to the UE movement e.g. the

number of cell re-selections or the distance moved since the UE was registered on the previous PLMN.

One possible realisation of the mechanisms described in the previous is given, purely as an example. This concerns a mechanism with 'Temporary barring', which could work as follows. The UE would mark the cell/ PLMN which previously triggered 'out of service' as barred for a limited duration i.e. the UE should not re-select the PLMN for a given, possibly configurable duration or a number of re-selections, unless the measured quality exceeds a certain quality level e.g. the 'high quality condition'.

Alternatively to the temporary PLMN ping pong avoidance mechanism discussed above, a permanent mechanism can be used. The following considerations lead to the thought that a permanent mechanism may in fact result in a better solution than use of a temporary mechanism:

When the UE stops applying the temporary offset, it is likely to move back to the previous PLMN. Hence, a timer based temporary mechanism may cause the UE to ping pong with a frequency corresponding with the duration of the temporary offset.

As mentioned before, in order to simplify UE implementation, the PPPA-mechanism is proposed to apply to a PLMN regardless of whether the UE was previously registered on it. This implies that the UE does not need to record the PR-PLMN.

In order to avoid that the UE indicates 'out of service', the S-criterion is typically set to a rather low value i.e. a value that does not guarantee that the UE is able to properly communicate with the network. This, together with the fact that the selection of PLMNs is not primarily based on radio link quality means that the UE may select a PLMN for which the radio link quality is quite poor. In such a case, it may be desirable to allow the UE to select a lower priority PLMNs that is able to offer a proper level service.

The above suggests that a permanent discouragement mechanism is not just beneficial for avoiding ping pong between PLMN, but more generally in order to have a means to the UE's improve service availability. Permanent mechanism is used in the following to denote a mechanism that is not applied in a temporary manner.

UE application rules for a permanent mechanism

The UE would apply the permanent discouragement upon every PLMN re-selection, possibly including the manual ones i.e. UE-AS only indicates PLMNs as available after considering the permanent discouragement threshold, broadcast by the concerned cell.

The UE would not apply the parameters upon initial PLMN selection, to avoid excessive delays in case only single PLMN is found. In case the UE can only detect a single PLMN which is only available if the discouragement is not applied, the mechanism would otherwise imply that the UE has to try all frequencies and RATs before deciding not to apply the discouragement (see exception condition, previous IPR)

In line with the original IPR, the UE should not apply the permanent discouragement either if the 'previous PLMN' is the only PLMN the UE finds suitable according to the original criteria.

Further related ideas

Like the newly defined criteria for 'entering a PLMN', also criteria for 'leaving a PLMN' could be defined. The rationale is that, to ensure a proper service provisioning, one would like the UE to leave earlier than defined by the current 'cell suitability criteria'. The 'cell suitability criteria' would remain unaltered and continue to define the criteria for indicating 'out of service' on the display of the mobile.

Possible realisations/ examples

In this section some further suggestions are provided concerning the use of three separate criteria, merely as examples:

One quality criterion for leaving a PLMN i.e. if the quality is below this threshold, the UE is allowed to leave the current PLMN.

One quality criterion for entering a PLMN i.e. the UE should only enter a PLMN if the quality is above this threshold.One quality criterion for displaying 'out of service' i.e. for not considering any of the available PLMNs as suitable.

FIG. 4 shows an example of the use of the above criteria for a scenario including OOS according to an exemplary embodiment of the present invention.The scenario illustrated in the Fig. 4 can be describe in terms of a number of events, marked as Tn in the figure:

T0 When the quality of the current cell drops below S_{LEAVE} 403 UE-AS starts a Timer-A (4s when in CELL_FACH, 12s otherwise). UE-AS continues cell re-selection for the registered (e)PLMN

T1 Timer-A, started at T0 expires, indicating that the quality of the current cell has been below S_{LEAVE} 403 long enough to detect OOS. The UE-AS starts Timer-B. The UE has not left the registered PLMN as yet, but from now on UE-AS applies cell selection for the registered (e)PLMN

T2 The quality of the current cell exceeds S_{LEAVE} 403, upon which UE-AS stops Timer-B and resumes normal service for the registered (e)PLMN

T3 As T0

T4 As T1

T5 Timer-B, started at T4 expires, indicating that the quality of the current cell has been below S_{LEAVE} 403 long enough to 'leave' the PLMN. From now on the UE-AS applies cell selection for any PLMN

T6 The quality of the current cell drops below $S_{No\ service}$ 405upon which the UE starts to display 'no service'. The UE-AS continues cell selection for any PLMN

T7 The quality of the single PLMN that UE-AS is able to detect current cell exceeds $S_{No\ service}$ 405 upon which the UE stops to display 'no service' and resumes normal service for the concerned PLMN i.e. UE-AS reports the PLMN as available, UE-NAS initiates registration upon which the concerned PLMN becomes the registered PLMN

Alternative

T8 The quality of one of the PLMNs that the UE was able to detect exceeds S_{Entry} 401 upon which the UE stops to display 'no service' and resumes normal service for the concerned PLMN, as for T7

Timer-B, as described in the previous, could be made operator configurable in order to introduce a more flexible 'leaving condition'

One could wonder if the UE should apply cell selection rather than cell – reselection while Timer-B, as in the example above is running. Table 4 below shows the main differences between cell selection and cell re-selection.

Table 4

Aspect	Cell re-selection	Cell selection
Frequencies & RATs to search for	Frequencies & RATs broadcast by the	Any frequency and RAT

neighbouring cells	currently selected cell	
Cell acceptance condition	Target cell is better than serving cell with an amount & duration depending on operator controllable cell re-selection parameters e.g. an offset better for at least a given period	Target cell only has to meet cell suitability criteria

The above table shows that with cell selection, the UE accepts an alternative frequency/RAT earlier/at a higher quality level.

Some possible reasons about why this approach may have been selected for the current specification:

Due to the lowness of the S-criteria, it is likely the UE is unable to reach the broadcast channel correctly. Hence, the cell re-selection parameter values that the UE previously read from the broadcast channel may not be up to date anymore.

The UE may have moved away from the cell in which it read the broadcast information. The set of neighbours broadcast by the original cell may not be appropriate for the area the UE has moved to.

The new 'leave condition' may corresponds with a certain likelihood that the UE is able to receive the broadcast and paging channels, as well to transmit the initial access message. The arguments indicated above are assumed to still apply, although maybe to a lesser extend. Another consideration could be that from a UE implementation perspective it would be easier to apply cell selection criteria when searching all frequencies and RATs i.e. this may be more similar to the UE implementation for other scenario's.

Since the UE may be able to receive the broadcast channel, although it may take a little longer, we do not wish to exclude the option to apply cell re-selection either:

While the UE operates Timer-B, it either applies cell selection or cell re-selection for the registered (e)PLMN.

The proposed solution addresses the basic root of problem rather than finding a solution around some adverse characteristics.

Compared to the temporary solution, the proposed mechanism results in a simpler solution i.e. avoiding the complexities of start and stop conditions of a temporary mechanism.

Radio quality parameters

The characteristics of the mechanism to prevent ping ponging may depend on where the function is implemented. One main factor is the nature of the available radio quality information, which differs between protocol layers e.g. UE-AS has more detailed information available than UE-NAS.

UE-NAS only has limited radio quality information available i.e. upon performing a full scan, UE-AS indicates which of the available PLMNs are high quality and for the other (low quality) PLMNs it provides a single measured quality e.g. the CPICH RSCP value in case of FDD. The UE-AS however, typically has more quality information available e.g. for FDD it also applies the Ec/No measurement.

Another aspect is that UE-AS is aware about the parameters/ criteria for making a cell suitable i.e. the criteria for 'leaving the PLMN'.

The availability of more detailed radio quality information enable the UE-AS is able to make a better judgement about the quality of a radio link than UE-NAS. For UMTS FDD, additional use of the Ec/No quality measures will result in decisions taking the uplink interference/ quality better into account.

The PLMN ping pong avoidance mechanism can utilise more than one condition e.g. to reflect both uplink and downlink quality conditions.

Knowledge of the parameters/ criteria for making a cell suitable means that in UE-AS it is easy to introduce a return condition that is relative to the condition for leaving.

The PLMN ping pong avoidance mechanism could either be implemented in AS or in NAS.

The PLMN ping pong avoidance mechanism can either utilise relative or absolute quality conditions.

A PLMN may include access networks using more than one radio access technology (RATs) e.g. GSM, UMTS, LTE. In each radio access technology different measurement quantities may be used to indicate the quality of the radio connection. More general, each radio technologies may have quite different characteristics. This means that the quality avoidance control parameters e.g.

those related to the quality level, as used in different radio access technologies may need to be different. Thus, it is desirable that the PLMN ping pong avoidance mechanism allows the use of different control parameters for different radio technologies in order to accommodate PLMNs including of multiple ratio access technologies.

The PLMN ping pong avoidance mechanism allows the use of different control parameters for different radio technologies in order to accommodate PLMNs including of multiple ratio access technologies.

Control/ signalling aspects

It is considered that the network that the UE should re-enter/ return to should provide the control information, since that is the appropriate network to indicate that it allows the UE to stay longer in another PLMN (so as to avoid excessive signalling & bad user experience). If the control parameters were provided in the currently registered PLMN, it would be easy to misuse the control parameters in an attempt to keep the UEs in the current PLMN, although that is not preferred by the use & nor by its home PLMN operator.

The PLMN ping pong avoidance control parameters should be provided by the radio access network the UE should avoid to return to i.e. the previously registered PLMN.

The parameters to control the PLMN ping pong avoidance could be provided to the UE in different ways:

The UE acquires the parameters when it was previously registered on the PLMN and stores them for later use i.e. when this PLMN has become the previous PLMN. The UE could e.g. apply a variable 'previous PLMN' to store this information.

The UE acquires the parameters from the PLMN at the time it attempts to return to the PLMN.

It seems there is a general desire to avoid that the UE is required to store information concerning a PLMN other than the one the UE is currently registered on. Apparently, this desire especially applies for the UE-AS. Furthermore, it should be noted that when the UE attempts to return to a PLMN i.e. when indicating the available PLMNs to the UE-NAS it has to acquire certain information broadcasted by the concerned cell. Hence, it may not be a significant burden to also acquire further information like the concerned control parameters

at that same time. Considering that, it seems the approach in which the control parameters are acquired from the PLMN at the time it attempts to return to the PLMN is preferable. Nevertheless, the other approach need not be excluded.

The UE may acquire the PLMN ping pong avoidance control parameters either when it was previously registered on the PLMN (in which case it needs to store them for later use) or it may acquire them when attempting to return to the concerned PLMN.

The PLMN ping pong avoidance control parameters are assumed to be broadcast. In case the UE acquires the parameters from the PLMN at the time it attempts to return to the PLMN, it would be beneficial to signal these parameters together with the PLMN identity which the UE anyhow has to read at that time.

The PLMN ping pong avoidance control parameters may be broadcast and may be signalled together with the PLMN identity.

In the case of UMTS, the PLMN identity(ies) is signalled in the Master Information Block (MIB). This system information block has an area scope of 'cell' meaning that the information is valid only in the cell in which it is read. It is assumed that the need for PLMN ping pong avoidance may differ from cell to cell e.g. because the deployment conditions are different in different areas. Hence, it seems desirable to be able to set the control parameters differently in each cell – in other words area scope of 'cell' seems appropriate.

Note This approach does not apply for the case the UE acquires the PLMN ping pong avoidance control parameters when previously registered on the PLMN. This is because the UE may attempt to return to a different cell than the one in which the control parameters were read.

It should be possible to configure different PLMN ping pong avoidance control parameters in each cell – in UMTS/ RRC this implies the parameters should have area scope set to 'cell'.

The drawbacks of the PLMN ping pong are considered to be more severe when the UE is in connected mode as compared to when the UE is in idle mode. Although the signalling overhead would be the same in both cases, the user is considered to be more susceptible to 'temporary unavailability' when in connected mode – which should normally correspond with a higher level of activity. As a result, there may be some interest in configuring different parameters for idle and connected mode UEs.

It should be possible to configure different PLMN ping pong avoidance control parameters for idle and connected mode UEs.

The Master information block is transmitted frequently. Hence, addition of new parameters is only acceptable if there is good justification. Also in general adding parameters to system information messages should be done with care considering the relative cost of broadcasting transmission mechanism. Hence, it may be desirable to perform some signalling optimisation. One possibility would be to, when a quality criterion considering both Ec/No and RSCP quality measures is introduced, to anyhow to signal a single 'Quality offset' parameter. This single parameter could possibly indicate the offset values to be used for each measurement quantity by means of a mapping table e.g. as shown below Table 5.

Table 5

Quality offset value	Ec/No offset	RSCP offset
0	1	2
1	2	4
2	4	8
..		

Possible realisations/ examples

In the previous we have provided a number of proposals that may be combined to construct a complete mechanism. In this section we provide an outline of such a complete mechanism, merely as an example. This example applies the following proposals:

A PLMN ping pong avoidance mechanism utilising:

A temporary quality level based condition.

The temporary nature is realised by means of a timer e.g. TimerPPA.

Utilising an a relative quality condition.

The PLMN ping pong avoidance control parameters are provided by the radio access network the UE should avoid to return to i.e. the previously registered PLMN as follows.

The UE acquires the parameters at the time it attempts to return to the PLMN i.e. during the full scan performed by the UE (meaning that the control parameters need not be stored by the UE).

The control parameters may be specific to the cell (and hence implicitly also to the radio access technology).

In the case of UMTS, the control parameters could be included in the Master Information Block.

The mechanism is primarily implemented in UE-AS with some support by UE-NAS in order to avoid that the UE-AS needs to store information concerning a PLMN the UE is currently not registered on.

FIG. 5 is a flowchart illustrating the communications between the UE-AS, UE-NAS and a network element according to one embodiment of the present invention.In step 501, UE-AS reports to UE-NAS that it is going out of service on a PLMN (i.e. a suitable cell is not even found after a full scan).

The UE-NAS stores information to avoid ping pong to this PLMN e.g. it may store the PLMN identity, possibly with a 'ping pong avoidance flag'. Possibly this information could be stored with other information in UE-NAS e.g. the forbidden PLMNs information.

In step 503, when UE-NAS requests the UE to indicate the available PLMNs, UE-NAS provides the PLMN identity of the PLMN the UE should avoid to return to.

In step 505, when UE-AS performs a full scan and finds PLMNs with the concerned PLMN identity or one equivalent to that, the UE acquires the ping pong avoidance control parameters from the concerned cell (Network).

In step 507, the UE-AS reports the concerned PLMN as one of the available PLMNs unless the ping pong avoidance conditions are met:

The quality is below the required level e.g. either the Ec/No or the CPICH RSCP is less than offset higher than the criteria for making the cell suitable, the duration is also below the required value i.e. TimerPPA has not expired.

The above example is illustrated by a sequence diagram illustrating a possible interaction between UE-AS & UE-NAS. It should be noted that the application of the PPA duration constraint could either be implemented in UE-NAS or in UE-AS.

In the above example, UE-NAS maintains a ping pong avoidance flag which is set upon receiving an 'out of service' indication from UE-AS. The example also shows that the 'out of service' indication could not only include the identity of the previous PLMN, but also information about the radio access technology or the actual cell in which the out of service condition was triggered.

This additional information could be used to introduce a more specific ping pong avoidance flag i.e. to avoid ping pong not to the entire PLMN but only to the same cell or the same RAT.

The ping pong avoidance mechanism could either be generic i.e. avoiding return to the entire previous PLMN or it could be more specific i.e. avoiding return to a specific part of the PLMN e.g. the previous RAT, the previous cell.

Final remarks

In the previous section an example of a possible realisation of a ping pong avoidance mechanism was provided. In this section we briefly evaluate how this example mechanism addresses a number of specific situations.

FIG. 6 is a schematic illustration of a deployment scenario according to another embodiment of the present invention.

The Fig. 6 illustrates a possible network deployment scenario in an area in which UMTS and GSM cells are deployed. In the Fig. 6, different colours indicate different PLMN identities.

Furthermore, a UE on PLMN B may be configured with an equivalent PLMN i.e. PLMN identity A. Let's now consider the scenario in which the UE detects out of service while in cell A and somehow not manage to find a suitable cell for the (e)PLMN, so it moves to cell b i.e. performs PLMN re-selection to PLMN C.

The ping pong avoidance mechanism would now be able to avoid the UE ping pongs between cell a and cell b. However, due to the use of a different PLMN identity the mechanism does not prevent that the UE moves to cell c. In case the cell re-selection configuration is such that the UE is stimulated to move back to cell a, we may still have a problem. However, this is considered to be an unlikely scenario since normally in a deployment situation like the above, the UE should re-select to cell c even before detecting out of service in cell a. Hence, it seems that no specific handling is needed to accommodate the case equivalent PLMNs are configured.

In the previous we indicated that it would be an advantage if the mechanism can avoid the immediate return to the cell/ PLMN in which the out of service was triggered i.e. upon the initial full scan upon detecting OOS. The example mechanism described in the previous section should be able to address

the immediate return, irrespective if UE-NAS is involved in triggering the initial full scan performed.

A final question is what the UE should do in the following case:

the ping pong avoidance conditions are met for the 'previous PLMN' i.e. due to these conditions the UE should not report the previous PLMN as an available PLMN, the UE is unable to find any other PLMNs it can report to UE-AS as available PLMN.

In this case the ping pong avoidance conditions only have adverse effect and hence our proposal is that in this case the conditions should not be applied. The ping pong avoidance criterion should not be applied if the 'previous PLMN' is the only PLMN the UE detects.

WHAT IS CLAIMED IS:

1. A method of improving network selection and/or network re-selection of a mobile terminal in a cellular communications system by specifying radio quality criteria to avoid repeated change of networks.

2. A method according to claim 1, wherein the networks are public land mobile networks (PLMNs).

3. A method according to claim 1 or 2, wherein the radio quality criteria are specified in order to avoid repeated change of radio access technology in the process of PLMN selection and/or re-selection.

4. A method according to claim 1, 2 or 3, wherein a first and a second radio quality criterion to avoid repeated change of networks.

5. A method according to claim 4, wherein the first and second quality criterion are used permanently.

6. A method according to claim 4 or 5, wherein the first quality criterion is used for initial network selection.

7. A method according to claim 4, 5 or 6, wherein the second quality criterion is used for a following network selection and/or network re-selection.

8. A method according to any of claims 4 to 7, wherein a third quality criterion is used.

9. A method according to claim 8, wherein the mobile terminal starts the process of cell selection, network selection and/or network re-selection if the radio quality of the current cell falls below the third quality criterion.

10. A method according to claim 8 or 9, wherein cell selection is performed after the radio quality of the current cell falls below the third quality criterion for a first time period.

11. A method according to claim 8, 9 or 10, wherein network selection is performed after the radio quality of the current cell falls below the third quality criterion for a second time period.

12. A method according to claim 8, 9 or 10, wherein network re-selection is performed after the radio quality of the current cell falls below the third quality criterion for a second time period.

13. A method according to any of claims 8 to 12, wherein the second time period is configurable.

14. A method according to any of claims 8 to 13, wherein the mobile terminal starts the process of cell selection, network selection and/or network re-selection for the registered networks if the radio quality of the current cell falls below the third quality criterion.

15. A method according to any of claims 1 to 4, wherein said radio quality criteria comprises a predefined quality duration.

16. A method according to any of claims 1 to 4, wherein said radio quality criteria comprises temporarily barring a PLMN or part of a PLMN for selection.

17. A method according to any of claims 1 to 4, wherein said radio quality criteria is applied for a predetermined time interval.

18. A method according to any preceding claim, wherein a timer based mechanism is used.

19. A method according to any preceding claim, wherein a mechanism based on the movement of the mobile terminal is used.

20. A method according to any preceding claim, wherein a mechanism for selecting and/or reselecting a PLMN according to said radio quality criteria is mainly implemented in the access stratum layer.

21. A method according to any preceding claim, wherein a mechanism for selecting and/or reselecting a PLMN according to said radio quality criteria is mainly implemented in the non-access stratum layer.

22. A method according to any preceding claim, wherein said radio quality criteria comprises a relative quality condition.

23. A method according to claim 22, wherein a mechanism for selecting and/or re-selecting a PLMN according to said radio quality criteria is implemented in the access stratum layer.

24. A method according to any preceding claim, wherein said radio quality criteria comprises an absolute quality condition.

25. A method according to claim 24, wherein a mechanism for selecting and/or re-selecting a PLMN according to said radio quality criteria is implemented in the non-access stratum layer.

26. A method according to any preceding claim, wherein said radio quality criteria is used at PLMN re-selection.

27. A method according to any preceding claim, wherein said radio quality criteria is used for PLMN selection after the mobile terminal is considered out-of-service.

28. A method according to any preceding claim, wherein at least one of said radio quality criteria comprises more than one conditions.

29. A method according to claim 28, wherein said conditions specify the uplink and/or downlink radio quality.

30. A method according to claim 28 or 29, wherein said conditions are specific to the different radio access technologies.

31. A method according to any preceding claim, wherein said radio quality criteria are specified by a set of control parameters.

32. A method according to claim 31, wherein the control parameters are provided by a PLMN the mobile terminal is not currently registered with.

33. A method according to claim 31 or 32, wherein the control parameters are provided by a PLMN the mobile terminal was previously registered with.

34. A method according to claims 31, 32 or 33, wherein the control parameters are acquired at registration with said PLMN.

35. A method according to claim 34, wherein the parameters are stored for future use.

36. A method according to claims 31, 32 or 33, wherein the parameters are acquired at the time the mobile terminal attempts to re-select the PLMN.

37. A method according to any of claims 31 to 36, wherein a network element transmits said control parameters to the mobile terminal.

38. A method according to claim 36 or 37, wherein said set of parameters are transmitted to the mobile terminal with the PLMN identity.

39. A method according to any of claims 31 to 38, wherein the control parameters are cell specific.

40. A method according to any of claims 31 to 39, wherein the control parameters are specific to the UE mode.

41. A method according to any preceding claim, wherein a predefined quality level is used as radio quality criterion.

42. A mobile terminal for use in a cellular communications network, adapted to select or re-select a PLMN based on radio quality criteria for avoiding repeated change of PLMN in the process of PLMN selection.

43. A network element in a cellular communications network, adapted to provide radio quality criteria for a mobile terminal selecting or re-selecting a PLMN.

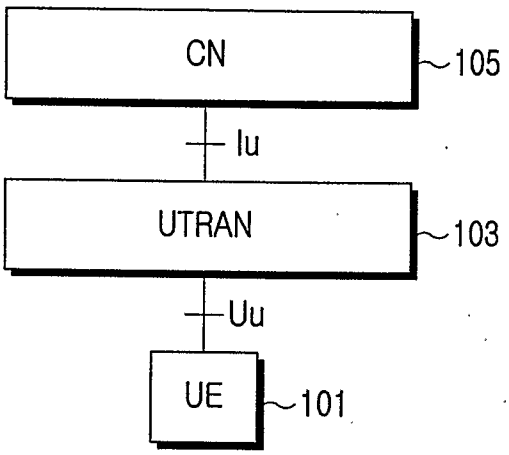

FIG.1

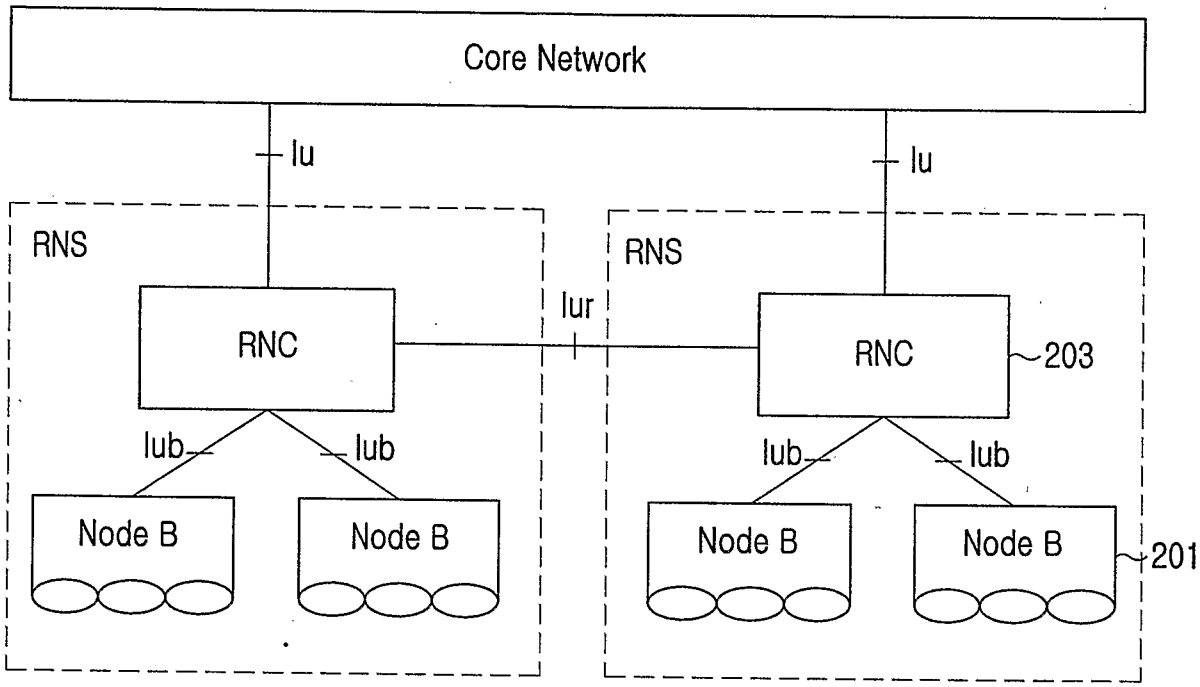
Core Network
Iu
Iu
RNS
RNS
RNC
Iur
RNC
203
Iub
Iub
Iub
Iub
Node B
Node B
Node B
Node B
201

FIG.2

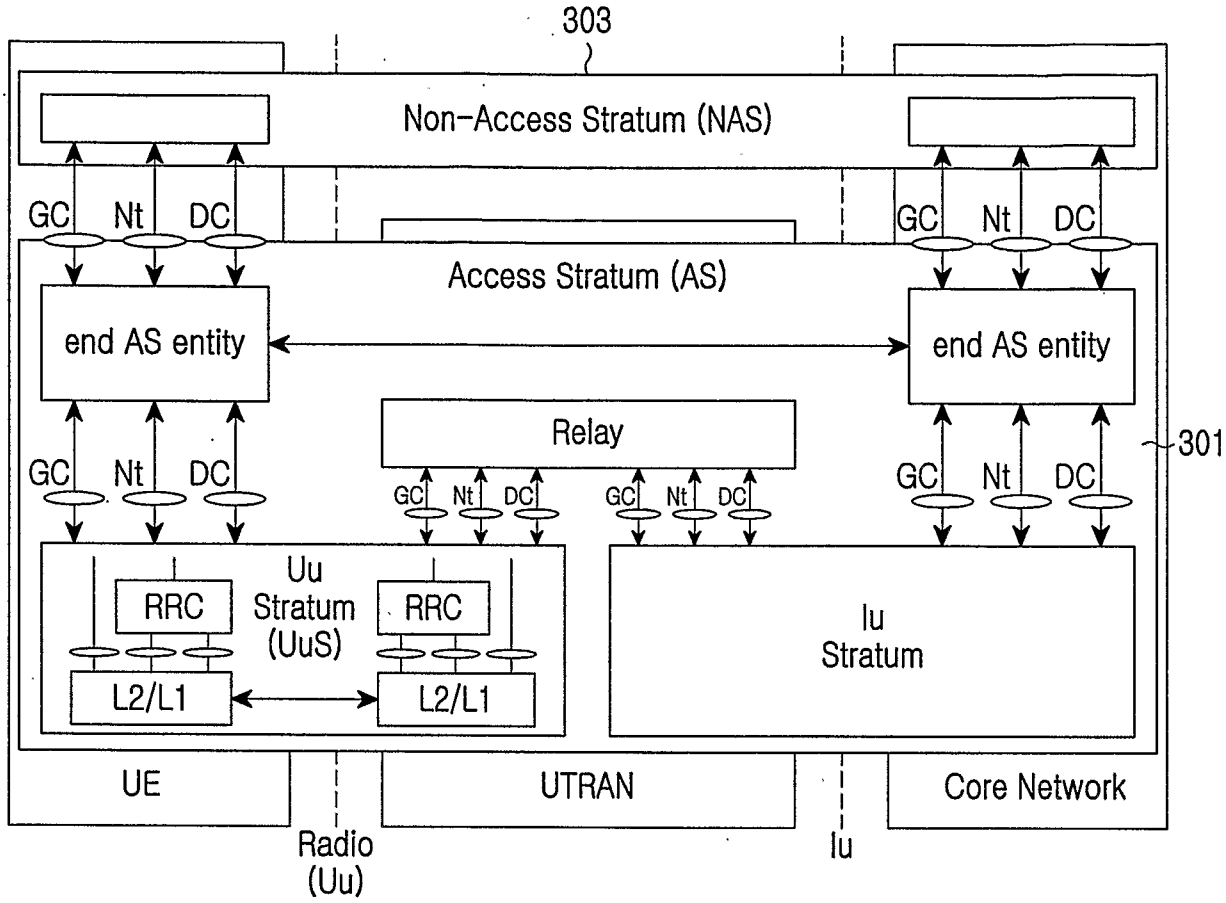
303
Non-Access Stratum (NAS)
GC
Nt
DC
Access Stratum (AS)
end AS entity
Relay
301
Uu
Stratum
(UuS)
RRC
L2/L1
Iu
Stratum
UE
UTRAN
Core Network
Radio
(Uu)
Iu

FIG.3

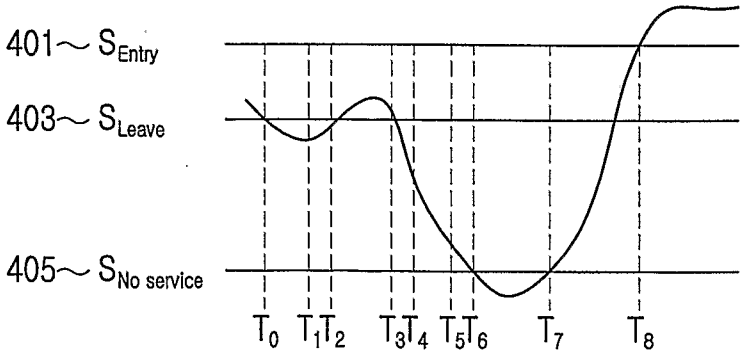
401~ S Entry
403~ S Leave
405~ S No service
T0 T1T2 T3T4 T5T6 T7 T8

FIG.4

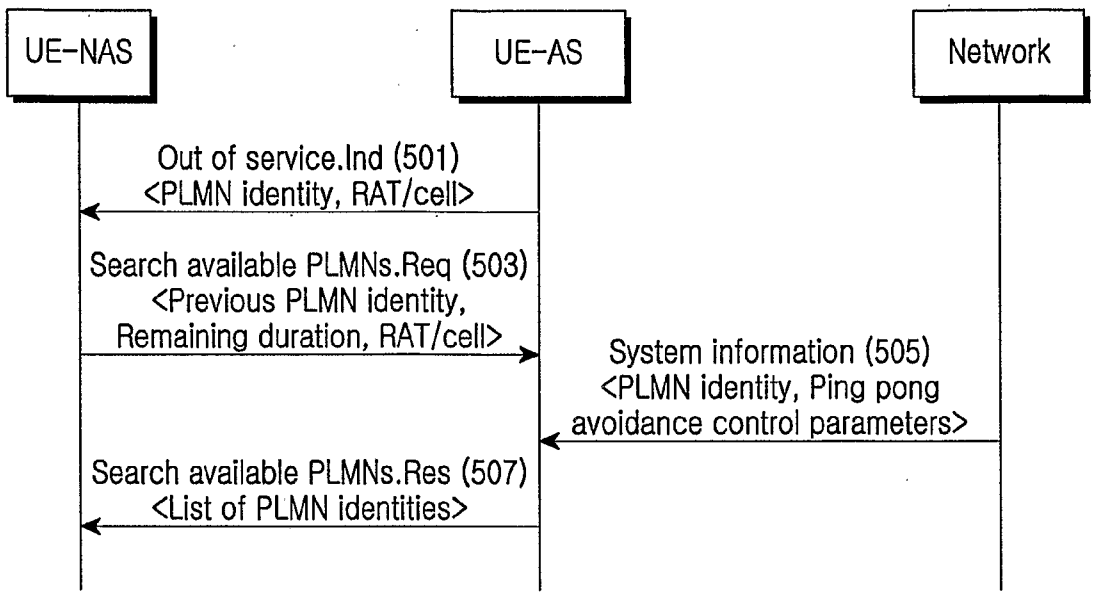
UE-NAS
UE-AS
Network
Out of service.Ind (501)
<PLMN identity, RAT/cell>
Search available PLMNs.Req (503)
<Previous PLMN identity,
Remaining duration, RAT/cell>
System information (505)
<PLMN identity, Ping pong
avoidance control parameters>
Search available PLMNs.Res (507)
<List of PLMN identities>

FIG.5

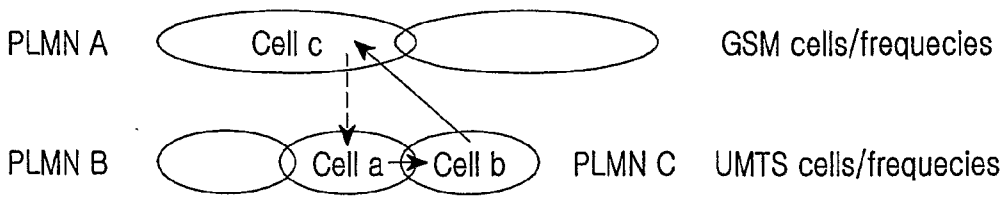
PLMN A
Cell c
GSM cells/frequecies
PLMN B
Cell a
Cell b
PLMN C
UMTS cells/frequecies

FIG.6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2007/000420

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 4 to 41
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required addtional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2007/000420

A. CLASSIFICATION OF SUBJECT MATTER

H04B 7/26(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC8 H04B 7/26, H04Q 7/00, 7/22, H04L 12/28

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

KOREAN UTILITY MODELS AND APPLICATIONS FOR UTILITY MODELS SINCE 1975
JAPANESE UTILITY MODELS AND APPLICATIONS FOR UTILITY MODELS SINCE 1975

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

eKIPASS, DELPHION, ESPACENET & Keywords : UMTS, PLMN, select, reselect, radio quality and similar terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,625,132 B1 (BOETTGER et al.) 23 September 2003 * abstract, col. 8 line 51 - col. 10 line 43, figures 4-5 *	1-3, 42, 43
X A	US 2003-69037 A1 (KIYOMOTO et al.) 10 April 2003 * abstract, paragraphs [0043]-[0063], figure 3 *	1-3, 42 43
A	JP2005-252493 A2 (NEC CORP.) 15 September 2005 * abstract, figure 1 *	1-3, 42, 43
A	JP2003-273922 A2 (MATSUSHITA ELECTRIC IND CO., LTD.) 26 September 2003 * abstract, figure 2 *	1-3, 42, 43

☐ 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 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 MAY 2007 (08.05.2007)	**08 MAY 2007 (08.05.2007)**
Name and mailing address of the ISA/KR Korean Intellectual Property Office 920 Dunsan-dong, Seo-gu, Daejeon 302-701, Republic of Korea Facsimile No. 82-42-472-7140	Authorized officer KIM, Sang Woo Telephone No. 82-42-481-8324

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2007/000420

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