

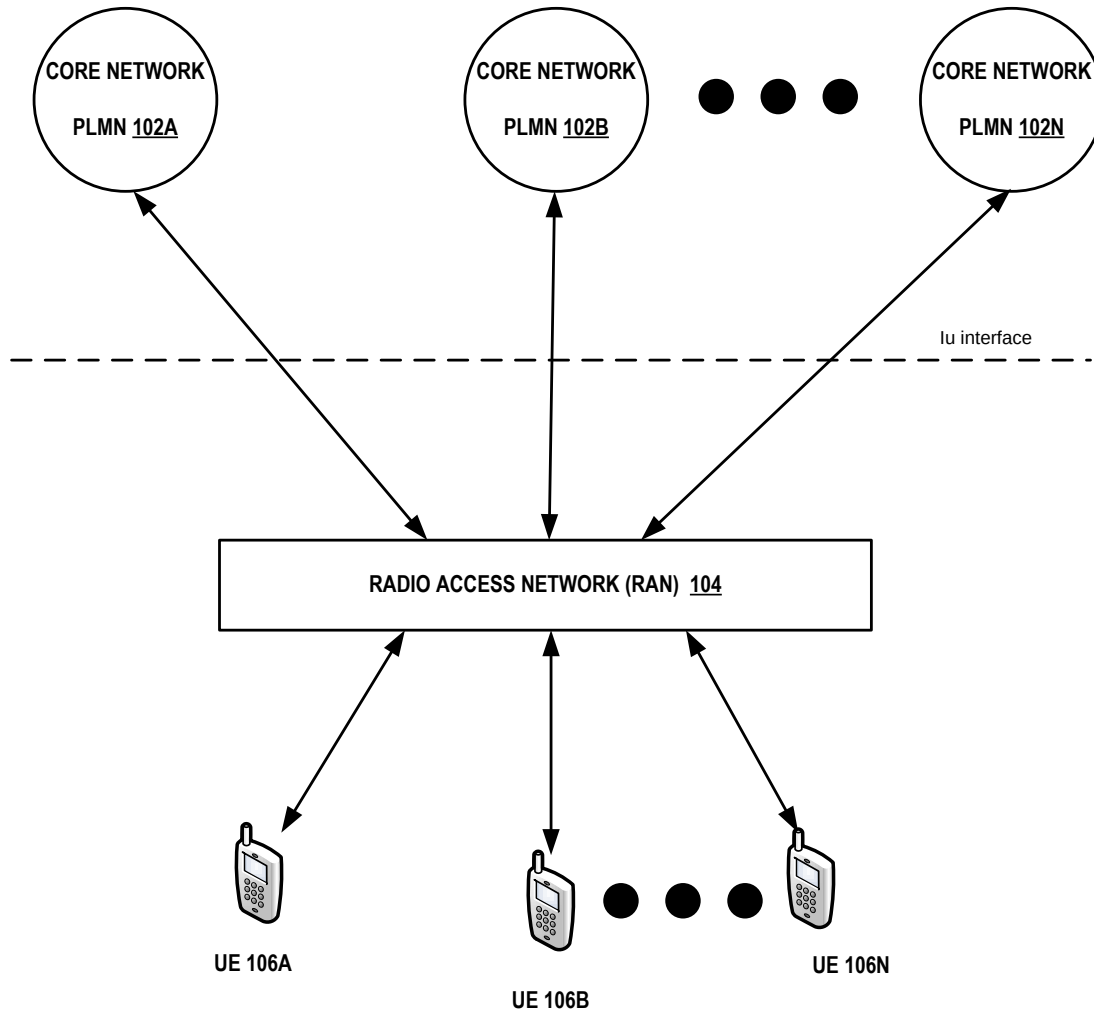
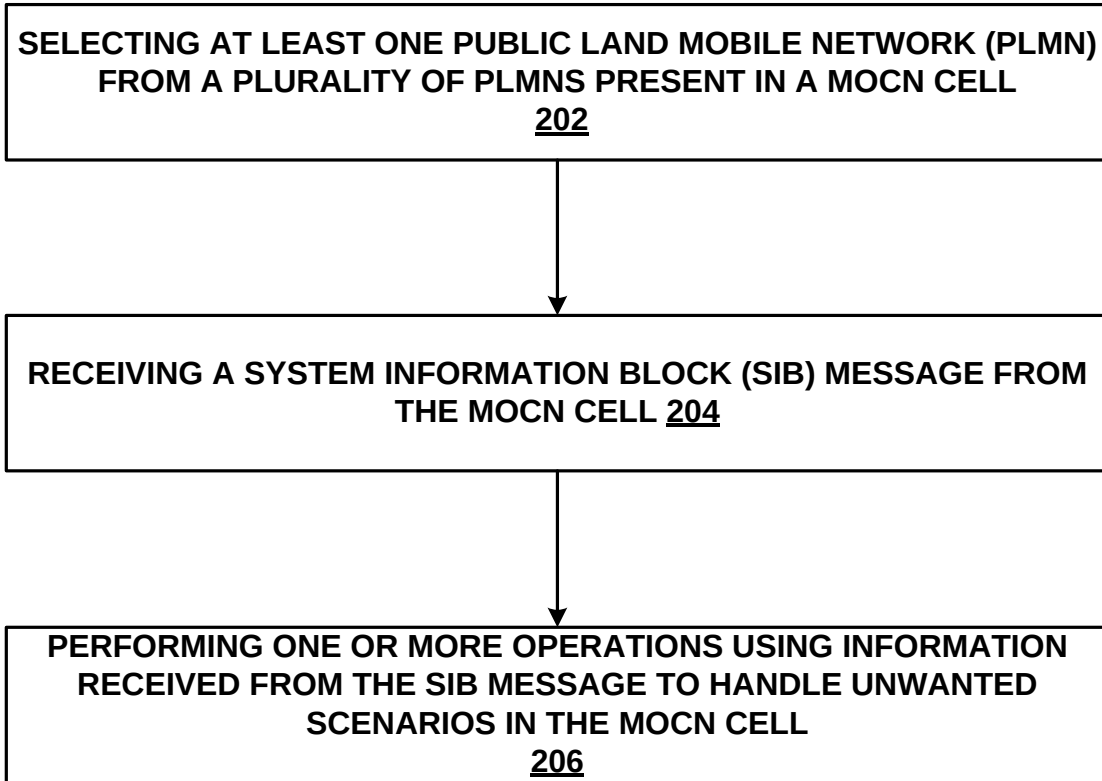


FIGURE 1

Signature

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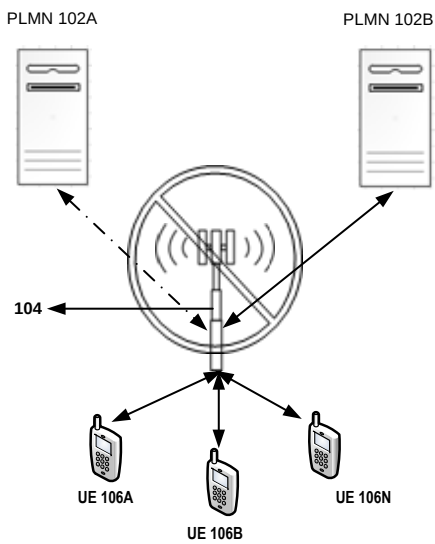


FIGURE 3A

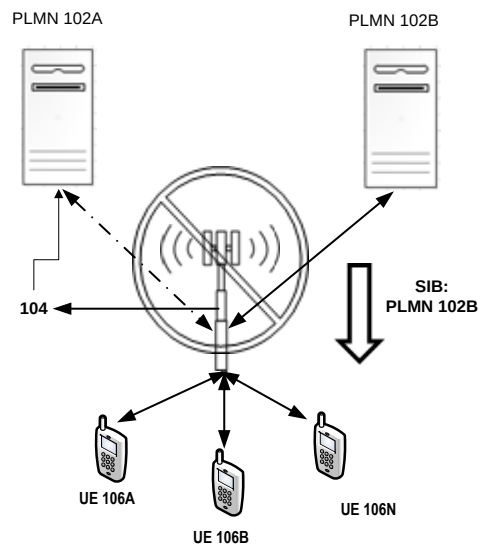


FIGURE 3B

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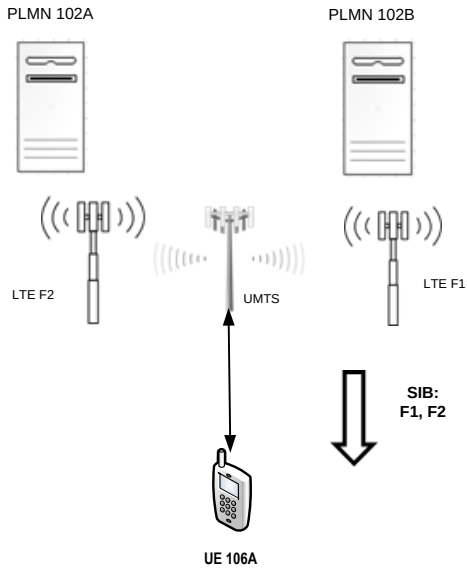


FIGURE 4A

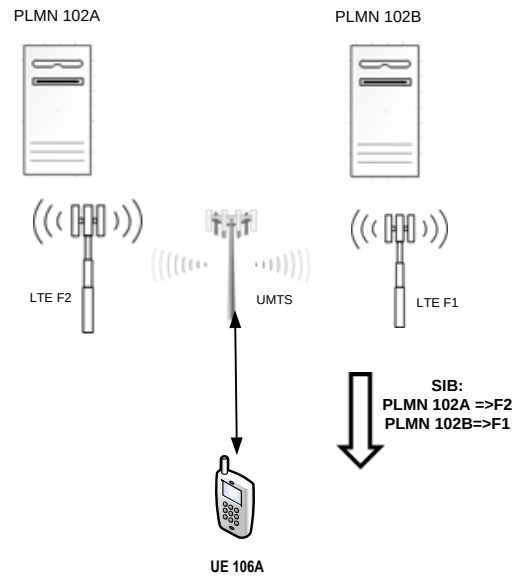


FIGURE 4B

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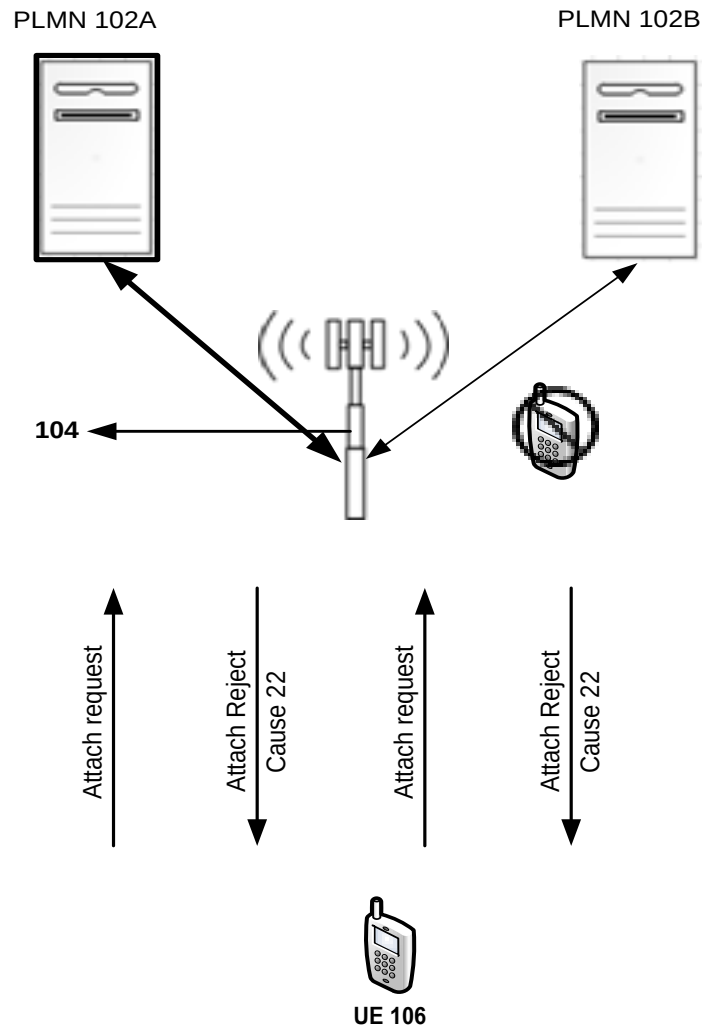


FIGURE 5

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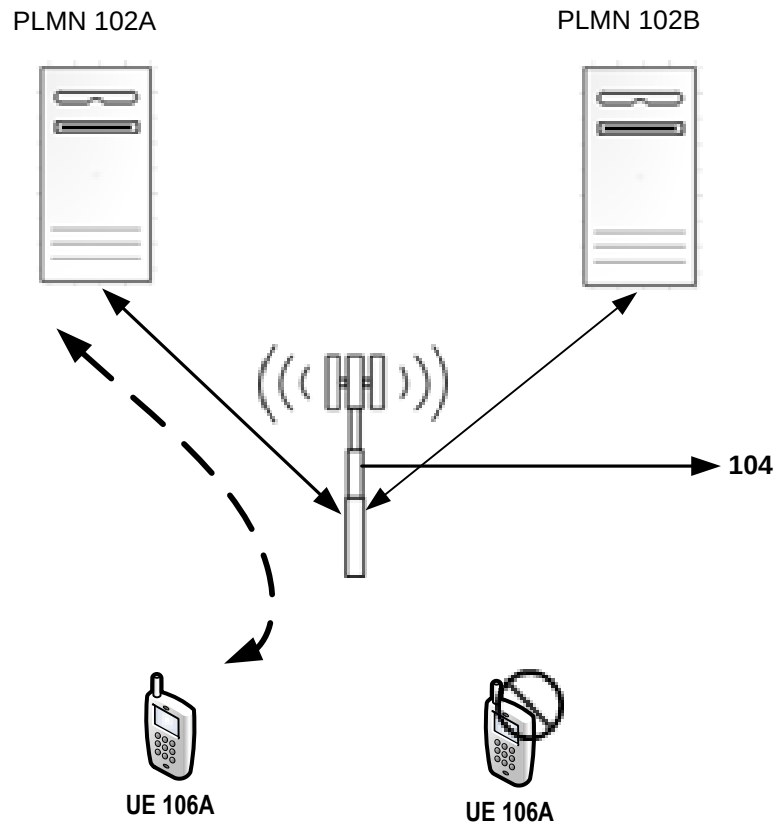


FIGURE 6

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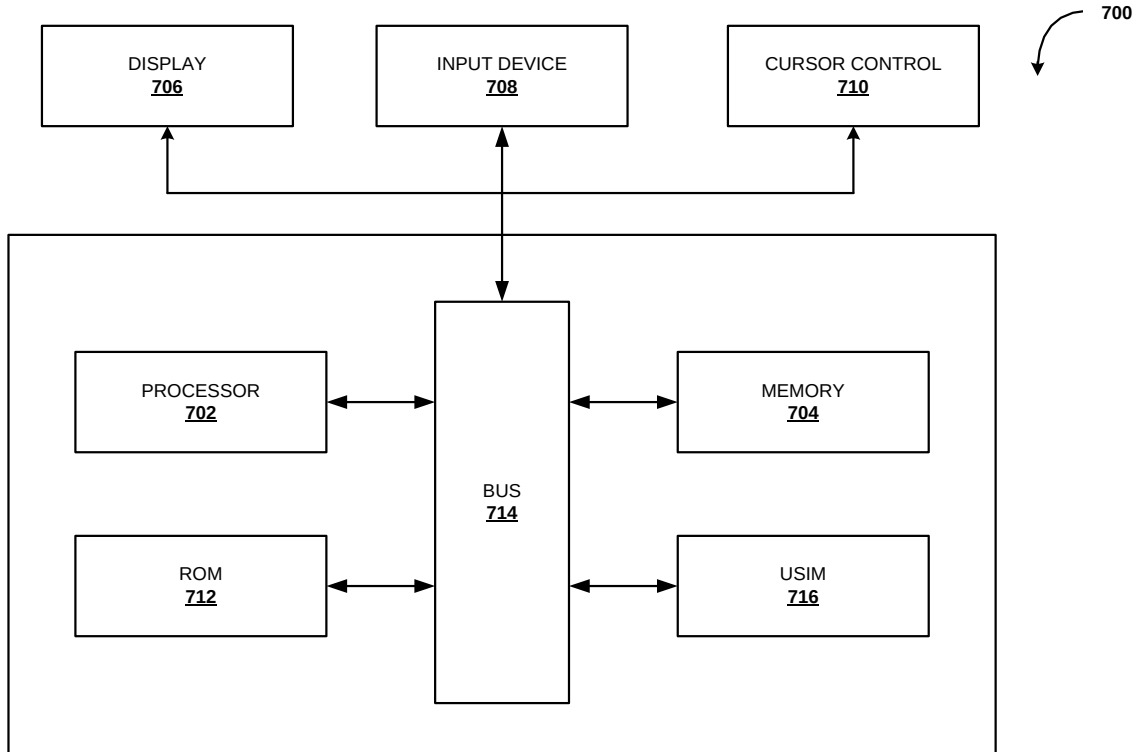


FIGURE 7

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FIELD OF THE INVENTION

The present invention relates to the field of wireless communications, and more particularly relates to a method of managing mobility and access in a Multiple Operator Core Network (MOCN).

BACKGROUND OF THE INVENTION

In wireless systems like Universal Mobile Terrestrial Systems (UMTS) and Long Term Evolution (LTE), radio access networks broadcast system information containing various control parameters to the User Equipments (UEs). Suitability of a cell, criteria to reselect to other cells, neighbor list information, and random access parameters are some of the parameters that are broadcast in a cell. The system information is numbered into different system information blocks and not all of them carry mandatory parameters. Some of the system information blocks carry information that the UE may chose to ignore. Cell barring, cell reservations, access classes, and neighbor list are also broadcasted in the system information.

In a network sharing architecture different core network operators connect to a shared radio access network. The operators do not only share the radio network elements, however may also share the radio resources themselves. **Figure 1** is a schematic diagram illustrating multiple core network (CN) nodes in a Multi-Operator Core Network (MOCN) is connected to a single radio network controller (RNC), according to the context of the invention. The CN nodes are operated by different operators.

In 3GPP and 3GPP2 wireless networks, radio access network broadcasts the neighbor cell information to the UEs. The neighbors are generally categorized as intra-frequency, inter-frequency and inter-RAT and sent in different system information blocks (SIBs). For example, SIB4 in LTE contains intra-frequency

neighbor list and intra-frequency Black cell list that can be used by the UE for measurements and reselections. SIB5 in LTE carries inter-frequency neighbor cell information. Similarly, SIB6, SIB7 and SIB8 carry inter-RAT neighbor cell information. Similarly, in UMTS and other RATs also, the neighbor cell information is categorized and broadcast in the cell.

UEs use the neighbor cell information for performing measurements, reselections etc. In the case of MOCN, the neighbor cell information is common to all the operators/public land mobile networks (PLMNs) of that cell. Also, various other parameters broadcast in the system information are common to all the PLMNs of that cell. In the current specification of 3GPP and 3GPP2 standards, many of the IEs broadcast the system information of the cell are common to all the operators/PLMNs shared by that cell. This leads to a lot of issues in the UE related to reselection, cell barring and frequency barring.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

Figure 1 is a schematic diagram illustrating Multiple Core Network (CN) nodes in a Multi-Operator Core Network (MOCN) is connected to a single Radio Network Controller (RNC), in the context of the invention.

BRIEF DESCRIPTION OF THE INVENTION

The present invention provides method of managing mobility and access in a multiple operator core network (MOCN). The invention addresses the issues that may occur in a multiple operator core network (MOCN) scenario to comply with the latest version of 3GPP and 3GPP2 standards.

Scenario 1: S1 link with one of the CNs going down

In a MOCN, consider that eNB is connected to two different PLMNs in which each PLMN is controlled by different Mobility Management Entity (MME). User equipment supports primary PLMN and successfully attaches to the MME with primary PLMN. The interface S1 Flex is enabled in the eNB. The UE decodes the broadcast system information (SI) to determine the available core network (CN). The UE then compares the broadcast system information to the information stored in the universal subscriber identity module (USIM). Radio resource control (RRC) Connection setup message indicates the selected PLMN. The UE attaches to primary PLMN (eNodeB broadcasts both Primary and Secondary PLMN in SIB1) and goes to idle mode. When the UE is in idle mode, S1 link for primary PLMN goes down (eNB broadcasts primary PLMN as reserved for operator use, and secondary PLMN as not reserved and cell as not barred).

In the above described scenario, UE is expected to reselect to the secondary PLMN. However, the UE is not able to camp on the cell for the other PLMN even though the connection with the other core network is good and the UE supports MOCN. This is because, according to the current art, when the cell status is indicated as "not barred" and "reserved for operator use" for any of the PLMNs listed, UE shall treat the cell as barred for all the PLMNs broadcast in SIB1.

According to one of the embodiments, a cell is considered as barred only for that PLMN and UE shall be able to camp on the same cell for other PLMN. Barring criteria need to be implied on a PLMN basis for a given cell instead of implying it to all the PLMNs. Although the example here is discussed specifically with respect to Long Term Evolution, the present invention is applicable for all types RATs.

Scenario 2: Radio access technology (RAT) level sharing between NWS

In a MOCN network, where UMTS network is shared with both the operators, however the LTE network is not shared, the following can occur:

1. SIB 19 in UMTS is broadcasting the inter RAT frequencies for LTE; and
2. Since the UMTS RAN is common between the operators, same SIB 19 has to carry the LTE frequencies of both the operators.

Because of this configuration, when UE is scanning for LTE cells, it has to scan the frequencies belonging to both the operators, as SIB19 does not differentiate on which frequencies belong to which operator/PLMN. This leads to unwanted frequency scan and power drain in UE.

According to one of the embodiments, in order to alleviate the above problem, neighbor frequencies (inter RAT, inter frequency) should be given per PLMN. The above example details on a case using SIB19 that neighbor list should have the information on a PLMN basis, which may include information about inter RAT, and/or inter frequency and/or intra frequency neighbors. Similar problem and solution is applicable for other RATs as well for the SIB/SI that carry neighbor list. In another embodiment, PLMN information is provided in the neighbor list.

Scenario 3: Mobility scenario

In a MOCN environment, only some cells are shared between multiple operators while the others are dedicated cells of individual operators. In an example scenario, consider Cell C1 is shared by P1, P2, P3 operators, Cell C2 is for P1 operator, Cell C3 is for P3 operator, and C2 and C3 are included as intra frequency neighbors of C1.

In this scenario, according to the current art, SIB4 in LTE contains the Intra-frequency neighbor list and the intra-frequency Black cell list. However, both these lists are common for all the PLMNs of that cell.

Because of this configuration, measurements and thereby reselections to unwanted cells may happen which lead to power drain and frequency barring. This scenario

can happen with any other 3GPP and 3GPP2 RATs as well.

According to one of the embodiments of the present invention, in order to alleviate the above problems, neighbor frequencies are given per PLMN in the case of inter-RAT and inter-frequency neighbor and neighbor cells or blacklisted cells is given per PLMN in the case of intra-frequency neighbor. For example, Intra-frequency neighbor list and intra-frequency Black cell list in SIB4 in LTE is introduced per PLMN and the list is populated accordingly. Information element namely intraFreqReselection in SIB1 in LTE shall be introduced per PLMN and used by the network to control the mobility. In the case of Inter-frequency neighbors, InterFreqCarrierFreqList per PLMN shall be introduced in SIB5 in LTE. In the case of SIB6 in LTE, CarrierFreqListUTRA-FDD per PLMN shall be introduced. NeighCellListCDMA2000 in SIB8 in LTE shall be introduced per PLMN. In SI2Quartr of GSM, E-UTRAN Not Allowed Cells shall be introduced per PLMN. Other information like Measurement control system information, Measurement control system information extension in UMTS also makes use of the neighbor list per PLMN.

Scenario 4: Core Network overloading scenario

In a MOCN environment, when the load condition on one of the CN is more and could not accept any further calls(CS/PS) CN may send attach reject such as cause 22 while the other CN is relatively free, this will lead to unnecessary signaling overhead on the E-NodeB/CN. Same scenario is applicable when one of the CN connected to the RAN is down and the CN does not intend to serve any more UEs.

According to one of the embodiments of the present invention, cell barring per PLMN shall be used by the network and the overloaded PLMN shall be indicated as barred on that cell until the congestion is cleared.

Scenario 5: Radio Access Network loading scenario

In a MOCN environment, the stakes of the different operators may not be the same. In this scenario, when the RAN is getting congested, it is possible that UEs of the highest priority operator may not be able to get service because of the congestion caused by a UE of the operator of relatively lower priority.

According to one of the embodiments of the current invention, following can be performed to achieve RAN load control and differentiation between different operators:

1. Cell barring per PLMN shall be used by the network and the lesser priority PLMNs shall be indicated as barred to avoid congestion in RAN;
2. Cell reselection offsets like "q-RxLevMinOffset" can be given per PLMN;
3. Access Class barring information can be given per PLMN basis;
4. Cell reselection thresholds/parameters for neighbor list can be given per PLMN basis;
5. RACH persistency check parameters can be given on PLMN basis; and
6. Cell Access Restriction can be given on PLMN basis.

Scenario 6: Mobility Scenario

In a MOCN environment, only some cells are shared between multiple operators while the others are dedicated cells of individual operators. In an example, consider a scenario that, Cell C1 on frequency F1 is shared by Operators P1, P2, P3, Cell C2 on frequency F1 is for operator P1, Cell C3 on frequency F2 is for operator P3, Cell C4 on frequency F2 is for operator P1, and the cells in order of the signal strength are C3, C4, C1.

In this scenario, according to current art, all the neighbors C2, C3, C4 will be added in the neighbor list of C1.

Because of this configuration, inter-frequency reselection will be triggered to C3. As C3 belongs to P3 which is not in extended PLMN list or the Home PLMN of the UE,

UE shall not consider this cell and other cells on the same frequency as candidates for reselection for a maximum of 300s according to current art. This may lead to late camping to higher priority cells or even system loss at times. This will be applicable for other 3GPP RATs as well.

According to one of the embodiments of the current invention, in order to alleviate the above problem, neighbor frequencies should be given per PLMN in the case of inter-RAT and inter-frequency neighbor and neighbor cells or blacklisted cells should be given per PLMN in the case of intra-frequency neighbor.

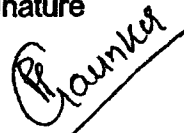
Scenario 7: Configurable Cell Barring Timer

According to the current specifications, when a cell is barred it is treated as barred for next 300 seconds. Because of this barring timer being 300 seconds, in network configuration like LTE+CDMA, UE gets stuck to CDMA for more time even though the LTE cell got better in less than 5 minutes time frame (e.g., 2 minutes). Also, this timer being 5 minutes makes it not a configurable timer.

According to one of the embodiments, barring timer is made configurable, rather than hard coding it, so that it can be adjusted from case to case.

Dated this the 3rd day of May 2013

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ABSTRACT

The present invention provides a method of managing mobility and access in a Multiple Operator Core Network (MOCN). In the MOCN, different core network (CN) operators connect to a shared radio access network. In one embodiment, the MOCN provides system information (SI) that allows user equipment (UE) to camp on a current cell to search for other public land mobile network (PLMN) if a current PLMN is not available at the UE. The MOCN further provides SI for sharing of radio access technologies between different operators and maintaining information such as neighbor list information, the Intra-frequency neighbor list and the intra-frequency Black cell list information on per PLMN basis.

Figure 1