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Contents

Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

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Introduction

Network sharing is a way for operators to share the heavy deployment costs for mobile networks, especially in the roll-out phase. In the current mobile telephony marketplace, functionality that enables various forms of network sharing is becoming more and more important. These aspects have not really been addressed in 3G systems, although there has been functionality that supports a very basic type of network sharing since the Release 5 versions of the 3GPP specifications.

To cope with 3GPP pre-Release 6 UEs, this specification describes extra functionality for MSCs, SGSNs, BSCs and RNCs in order to provide network sharing functionality to "non-supporting UEs".

In this Release of the specifications, all UTRAN and E-UTRAN capable UEs are required to support these network sharing requirements. Hence the E-UTRAN and MMEs (which were introduced in 3GPP Release 8) do not need functionality to handle "non-supporting UEs".

Scenarios and user requirements are described in TR 22.951 [1], while the current document presents the stage 2 details and descriptions of how these requirements are supported in a 3GPP UTRAN and/or E-UTRAN based network.

1 Scope

The present document covers the details of Network Sharing for UTRAN and E-UTRAN. It shows how several core network operators can share one radio access network and details the impacts on the network architecture. All UEs shall comply with existing requirements, among them PLMN selection and system information reception. The present document defines requirements for network-sharing supporting UEs.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1]   3GPP TR 22.951: "Service Aspects and Requirements for Network Sharing".

[2]   3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[3]   3GPP TS 25.331: "RRC Protocol Specification".

[4]   3GPP TS 23.122: "NAS Functions related to Mobile Station (MS) in idle mode".

[5]   3GPP TS 32.250: "Telecommunication management; Charging management; Circuit Switched (CS) domain charging".

[6]   3GPP TS 32.251: "Telecommunication management; Charging management; Packet Switched (PS) domain charging".

[7]   3GPP TS 24.008: "Mobile radio interface Layer 3 specification; Core network protocols; Stage 3".

[8]   3GPP TS 23.236: "Intra-domain connection of Radio Access Network (RAN) nodes to multiple Core Network (CN) nodes".

[9]   3GPP TS 23.401: "Technical Specification Group Services and System Aspects; GPRS enhancements for E-UTRAN access".

[10]   3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access (E-UTRAN); Overall description; Stage 2".

[11]   3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification".

[12]   3GPP TS 24.301: "Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3".

[13]   3GPP TS 25.413: "UTRAN Iu interface, Radio Access Network Application Part (RANAP) signalling".

[14]   3GPP TS 36.413: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definition below apply. Terms and definitions not defined below can be found in TR 21.905 [2].

Conventional network: A PLMN consisting of radio access network and core network, by which only one serving operator provides services to its subscriber. Subscribers of other operators may receive services by national or international roaming.

Common PLMN: The PLMN-id indicated in the system broadcast information as defined for conventional networks, which non-supporting UEs understand as the serving operator.

Core network operator: An operator that provides services to subscribers as one of multiple serving operators that share at least a radio access network. Each core network operator may provide services to subscriber of other operators by national or international roaming.

Gateway Core Network: A network sharing configuration in which parts of the core network (MSCs/SGSNs/MMEs) are also shared.

Multi-Operator Core Network: A network-sharing configuration in which only the RAN is shared.

Non-supporting UE: A UE that does not support network sharing in the sense that it ignores the additional broadcast system information that is specific for network sharing. In other specifications, the term "network sharing non-supporting UE" may be used.

Supporting UE: A UE that supports network sharing in the sense that it is able to select a core network operator as the serving operator within a shared network. In other specifications, the term "network sharing supporting UE" may be used.

3.2 Void

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [2] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [2].

BSC	Base Station Controller
CN	Core Network
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
eNodeB	E-UTRAN NodeB
GUTI	Globally Unique Temporary Identity
GWCN	Gateway Core Network
HLR	Home Location Register
MCC	Mobile Country Code
MME	Mobility Management Entity
MNC	Mobile Network Code
MOCN	Multi-Operator Core Network
MSC	Mobile Switching Centre
PLMN	Public Land Mobile Network
RNC	Radio Network Controller
SGSN	Serving GPRS Support Node
TMSI	Temporary Mobile Subscriber Identity
UE	User Equipment
UTRAN	Universal Terrestrial Radio Access Network

VLR   Visitor Location Register

4   General Description

4.1   Overview

A network sharing architecture shall allow different core network operators to connect to a shared radio access network. The operators do not only share the radio network elements, but may also share the radio resources themselves. In addition to this shared radio access network the operators may or may not have additional dedicated radio access networks, like for example, 2G radio access networks. There are two identified architectures to be supported by network sharing. They are shown in the figures below.

In both architectures, the radio access network is shared. Figure 1 below shows reference architecture for network sharing in which also MSCs and SGSNs are shared. This configuration will be referred to as a Gateway Core Network (GWCN) configuration.
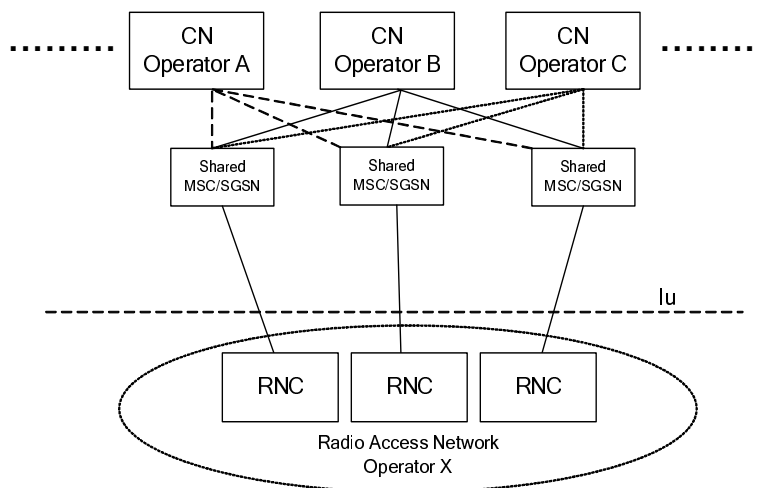
**Figure 1: A Gateway Core Network (GWCN) configuration for network sharing.
Besides shared radio access network nodes, the core network operators also
share core network nodes**

Figure 2 below shows the reference architecture for network sharing in which only the radio access network is shared, the Multi-Operator Core Network (MOCN) configuration.
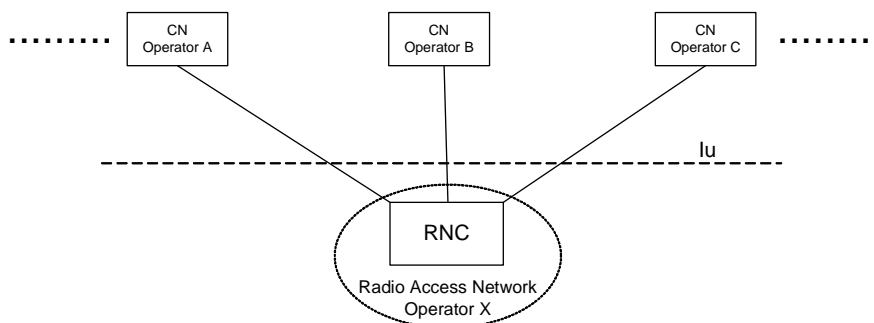
**Figure 2: A Multi-Operator Core Network (MOCN) in which multiple CN nodes are
connected to the same RNC and the CN nodes are operated by different operators**

The UE behaviour in both of these configurations shall be the same. No information concerning the configuration of a shared network shall be indicated to the UE.

For the Evolved Packet System, only the PS domain of the above figures is relevant. For E-UTRAN access Figures 1 and 2 both apply but with the MME replacing the SGSN, the eNodeB replacing the RNC, and the S1 reference point replacing the Iu interface.

4.2 Core Network Operator and Network Selection

Network sharing is an agreement between operators and shall be transparent to the user. This implies that a supporting UE needs to be able to discriminate between core network operators available in a shared radio access network and that these operators can be handled in the same way as operators in non-shared networks.

4.2.1 Core network operator identity

A core network operator is identified by a PLMN-id (MCC+MNC).

4.2.2 Broadcast system information for network sharing

Each cell in shared radio access network shall in the broadcast system information include information concerning available core network operators in the shared network. The available core network operators shall be the same for all cells of a Location Area in a shared UTRAN network. The available core network operators shall be the same for all cells of a Tracking Area in a shared E-UTRAN network. A supporting UE decodes the broadcast system information and takes the information concerning available core network operators into account in network and cell (re-)selection procedures. Broadcast system information is specified in TS 25.331 [3] for UTRAN and TS 36.331 [11] for E-UTRAN.

4.2.3 Network selection in a shared network

4.2.3.1 Behaviour of supporting UEs

A supporting UE decodes the broadcast system information to determine available core network operators in the shared network. The UE regards both the core network operators indicated in the broadcast system information and conventional networks as individual networks. The core network operators together with all conventional networks are candidate PLMNs for the PLMN selection procedure that shall be performed by the UE as specified in TS 23.122 [4].

In UTRAN, non-supporting UEs use the broadcast "common PLMN-id" in their PLMN (re)selection processes. For UTRAN, a supporting UE shall use the PLMN-ids that are broadcast in the Multiple PLMN ID List information element.

For E-UTRAN, the UE uses all of the broadcast PLMN-ids in its PLMN (re) selection processes.

4.2.3.2 Behaviour of non-supporting UEs

Non-supporting UEs ignore the broadcast system information that is relevant for network sharing. The common PLMN together with all conventional networks are candidate PLMNs for the PLMN selection procedure that shall be performed by the UE as specified in TS 23.122 [4].

4.2.4 Assignment of core network operator and core network node

When a UE performs an initial access to a shared network, one of available CN operators shall be selected to serve the UE. For non-supporting UEs, the shared network selects an operator from the available CN operators. For supporting UEs, the selection of core network operator by the UE shall be respected by the network. Supporting UEs inform the RNC/eNodeB of the network identity of the chosen core network operator.

In a UTRAN GWCN configuration, the RNC relays the chosen network identity to the shared core network node. In E-UTRAN GWCN, the eNodeB always relays the chosen network identity to the shared MME.

In a MOCN configuration, the RAN routes the UE's initial access to the shared network to one of the available CN nodes. Supporting UEs shall inform the RAN of the chosen core network operator so that the RAN can route correctly.

For non-supporting UEs the shared network selects an operator from the available CN operators. A redirection to another CN operator may be required for non-supporting UEs until an operator is found that can serve the UE. Redirection is described in clause 7.1.4.

After initial access to the shared network the UE does not change to another available CN operator as long as the selected CN operator is available to serve the UE's location. Only the network selection procedures specified in TS 23.122 [4] may cause a reselection of another available CN operator. . Also the network does not move the UE to another available CN operator, e.g. by handover, as long as the selected CN operator is available to serve the UE's location. Furthermore the UE does not change to another CN node as long as the selected CN node is available to serve the UE's location.

In UTRAN, when the network signals location/routing area identities to supporting UEs, e.g. in location updating accept messages, these identities shall contain the chosen core network operator identity. For non-supporting UTRAN UEs, they shall contain the common PLMN. The UE stores the received LAI/RAI on the SIM/USIM, as already specified in TS 24.008 [7].

In E-UTRAN, the chosen core network operator identity is included in the GUTI in e.g. the Attach Accept message. The UE shall store the received GUTI on the USIM according to the rules specified in TS 24.301 [12].

4.2.5 PS and CS domain registration coordination in UTRAN

In conventional networks, the same CN operator always serves the UE in CS and PS domains. In a shared network, supporting UEs shall behave as UEs in conventional networks with respect to registration with CS and PS domains. For non-supporting UEs, the Gs interface may be configured to guarantee that the same CN operator serves the subscriber in CS and PS domains.

Alternatively, in networks not using Gs the RNC may for non-supporting UE's coordinate that the CS and PS registrations for a given subscriber are always sent to the same CN operator. In that case RNC based coordination of PS and CS domain registration is configured in CN nodes and RNC. When a CN node receives a registration from a subscriber with a non-supporting UE having a P-TMSI/TMSI not belonging to the pool, and no IMSI is provided by RNC, it returns a Reroute Command message to the RNC (according to clause 7.1.4 "Non-supporting UEs in a MOCN configuration") with an indication that it is for coordination purposes. The coordination is done in the RNC (without memorising IMSI information for IDLE mode UEs), e.g. uses a fixed split of IMSI ranges or IMSI hash table between operators. The coordination may result in that the registration is sent back to the same CN node or CN operator again.

A network should not be configured to use RNC coordination when Gs interface is in use.

4.2.5a PS and CS domain registration coordination in E-UTRAN

When multiple core network operators share the E-UTRAN using a GWCN configuration, separate MSCs may still be used for the CS Fall Back functionality. In this case the MME uses the 'selected network' information received from the E-UTRAN to select an MSC from the already selected operator.

4.2.6 Attach/detach handling

To attach to the same core network operator from which it detached, a UE uses information stored in the UE (e.g. on the SIM/USIM) when the UE was detached. For a supporting UE in a shared network, the stored information indicates the core network operator it detached from (as specified in clause 4.2.4). This information enables a supporting UE to attach to the same core network operator from which it detached. For non-supporting UEs in a shared network, the stored information indicates the common PLMN.

4.3 Network Name Display for Supporting UEs

A supporting UE shows the name of the PLMN-id it has registered with. In case of a shared network, it is the PLMN-id of the chosen core network operator. The name stored in the UE for the PLMN-id is displayed except when the network indicates to the UE a name to be displayed, as already specified for non-supporting UEs.

4.4 HPLMN Support

The use of a shared VLR/SGSN/MME shall not result in service restrictions, e.g. roaming restrictions. Since a HSS derives whether the subscriber roams in H- or V-PLMN from the VLR/SGSN/MME identifier, a shared VLR/SGSN/MME in a GWCN shall be allocated a separate identifier from each operator sharing that CN node, i.e. a shared VLR/SGSN/MME has multiple identifiers. The VLR/SGSN/MME identifier of a user's serving CN operator is used in signalling with the HSS.

5 Functional description

The new behaviours of network nodes needed in order to describe network sharing are described.

5.1 UE functions

A supporting UE selects the core network operator and provides the PLMN-id of this operator to the network for routing purposes.

5.2 RNC functions

Network sharing information, i.e. available core network operators in the shared network, shall be transmitted in broadcast system information. If system information is transmitted to a supporting UE in dedicated signalling, the RNC shall indicate the PLMN-id of the core network operator towards which the UE already has a signalling connection (if a PLMN-id is included in the signalling). If the UE is non-supporting, the RNC shall indicate the common PLMN (if a PLMN-id identity is included in the signalling)

The RNC shall indicate the selected core network operator to the CN for supporting UEs when transferring initial layer 3 signalling. The selected CN operator is (i) indicated by the UE in RRC signalling or (ii) known implicitly from an already existing signalling connection. For non-supporting UEs, the RNC shall not indicate any selected core network operator to the CN.

In case of relocation to a GWCN or a MOCN in UTRAN or E-UTRAN:

- the source RNC determines a core network operator to be used in the target network based on available shared networks access control information, current PLMN in use, or similar information present in the node, the source RNC shall at relocation indicate that selected core network operator to the source core network node as part of the TAI/RAI sent in the Relocation required message. The selected target core network operator should be the same as the one in use. This is accomplished by not changing the serving PLMN if the PLMN in use is supported in the target cell. If the PLMN in use is not supported in the target cell the RNC selects the target PLMN based on either (i) pre-configured information in the RNC, or (ii) the SNA (Shared Network Area) Access Information IE (see TS 25.413 [13]) provided by the SGSN.

5.2a eNodeB functions

Network sharing information, i.e. available core network operators in the shared network, shall be transmitted in broadcast system information.

The eNodeB shall indicate the selected core network operator when transferring initial layer 3 signalling. The eNodeB uses the selected core network information (provided by the UE at RRC establishment, or, provided by the MME/source eNodeB at S1/X2 handover) to select target cells for future handovers appropriately.

In case of handover to a GWCN or a MOCN:

- the source eNodeB determines a core network operator to be used in the target network based on current PLMN in use, or other information present in the eNodeB, the source eNodeB shall at handover indicate that selected core network operator to the MME as part of the TAI/RAI sent in the HO required message. The selected target core network operator should be the same as the one in use. This is accomplished by not changing the serving PLMN if the PLMN in use is supported in the target cell. If the PLMN in use is not supported in the target cell

the eNB selects the target PLMN based on either (i) pre-configured information in the eNB, or (ii) the Equivalent PLMNs list (see TS 36.413[14]) provided by the MME.

- the target eNodeB uses the selected core network information to select target cells for future handovers appropriately.

5.2b   BSC functions

For Inter-RAT handover to a GWCN or a MOCN from GERAN:

- the source BSC determines a core network operator to be used in the target network based on current PLMN in use, or other information present in the BSC, the source BSC shall at handover indicate that selected core network operator to the source core network node as part of the TAI/RAI sent in the PS handover required message. The selected target core network operator should be the same as the one in use. This is accomplished by not changing the serving PLMN if the PLMN in use is supported in the target cell. If the PLMN in use is not supported in the target cell the BSC selects the target PLMN based on pre-configured information in the BSC.

5.3   MSC functions

When a UE accesses an MSC the first time, i.e. when there is no VLR entry for this UE, the MSC verifies whether the UE belongs to one of the operators sharing the MSC or their roaming partners. For that purposes the MSC derives the IMSI from another MSC/VLR or from the UE. The MSC determines a serving CN operator unless the old MSC/VLR or the UE have indicated a core network operator. The MSC/VLR shall also store the identity of the serving core network operator.

In case of a MOCN configuration, an MSC may not able to provide service to the UE. The UE may then have to be redirected to a MSC of another core network operator. The MSC/VLR that finally serves the UE assigns a NRI to the UE. This will allow the RAN to route any subsequent UE accesses the to the serving MSC/VLR.

For supporting UEs, i.e. when a selected core network operator has been indicated to the MSC by the RNC, the MSC indicates the selected core network operator PLMN-id in the LAI signalled to the UE in dedicated signalling.

For sharing scenarios with both E-UTRAN and GERAN/UTRAN access, where the network also applies idle-mode signalling reduction (see TS 23.401 [9]), the contents of the SNA Access Information IE (see TS 25.413 [13]) provided by the MSC to the RNC for a specific UE guides the target PLMN selection if the UE's registered PLMN is not available in the target cell. The SNA Access Information IE should be configured such that for any target cell there is only one PLMN-ID that can be selected for the cell.

Also, for the above scenario, in the routing areas and tracking areas between which ISR may be activated the "equivalent PLMNs" list provided by the SGSN, MSC and MME to a UE (see TS 23.008 [7]) should result in a single consistent "equivalent PLMNs" list stored by the UE. The single "equivalent PLMNs" list applies to all the UE's registered routing areas, location areas and tracking areas.

In case of relocation to a GWCN or a MOCN:

- There is no functionality in the source MSC to select a target core network operator or to modify the target core network operator selected by the RNC.

- If the source MSC has the capability to indicate the core network operator selected by the source RNC to the target MSC, the source MSC shall forward the selected core network operator chosen by the source RNC to the target MSC, which relays this information unchanged to the target RNC so that the appropriate PLMN-id can be signalled to the UE in dedicated system information signalling, as described in clause 5.2.

5.4   SGSN functions

When a UE accesses an SGSN the first time, i.e. when the UE is not yet known by the SGSN, the SGSN verifies whether the UE belongs to one of the operators sharing the SGSN or their roaming partners. For that purpose the SGSN retrieves the IMSI from another SGSN/MME or from the UE. The SGSN determines a serving core network operator unless the old SGSN or the UE have indicated a core network operator. The SGSN shall store the identity of the serving core network operator.

In case of a MOCN configuration, a SGSN may not able to provide service to the UE. The UE may then have to be redirected to a SGSN of another core network operator. The SGSN that finally serves the UE assigns a NRI to the UE. This will allow the RAN to route any subsequent UE accesses to the serving SGSN.

For supporting UEs, i.e. when a selected core network operator has been indicated to the SGSN by the RNC/BSC, the SGSN indicates the selected core network operator PLMN-id in the LAI/RAI signalled to the UE in dedicated signalling.

For sharing scenarios with both E-UTRAN and GERAN/UTRAN access, where the network also applies idle-mode signalling reduction (see TS 23.401 [9]), the contents of the SNA Access Information IE (see TS 25.413 [13]) provided by the SGSN to the RNC for a specific UE guides the target PLMN selection if the UE's registered PLMN is not available in the target cell. The SNA Access Information IE should be configured such that for any target cell there is only one PLMN-ID that can be selected for the cell.

Also, for the above scenario, in the routing areas and tracking areas between which ISR may be activated the "equivalent PLMNs" list provided by the SGSN, MSC and MME to a UE (see TS 23.008 [7]) should result in a single consistent "equivalent PLMNs" list stored by the UE. The single "equivalent PLMNs" list applies to all the UE's registered routing areas, location areas and tracking areas.

At relocation/handover to a GWCN or a MOCN:

- There is no functionality in the source SGSN to select a target core network operator or to modify the target core network operator selected by the RNC/BSC. Instead, the source SGSN uses the selected PLMN received from the RNC/BSC to determine the target core network operator. The source SGSN shall forward the selected core network operator chosen by the source RNC/BSC to the target SGSN/MME.

- The target SGSN indicates the selected core network operator chosen by the source RNC/BSC/eNodeB to the target RNC so that the appropriate PLMN-id can be signalled to the UE in dedicated system information signalling, as described in clause 5.2.

5.5 MME functions

When a UE accesses an MME for the first time, i.e. when the UE is not yet known by the MME, the MME verifies whether the UE is permitted to access the selected PLMN. For that purpose the MME retrieves the IMSI from another MME/SGSN or from the UE. The MME shall store the identity of the selected core network operator.

The MME indicates the selected core network operator PLMN-id to the UE in the GUTI.

For sharing scenarios with both E-UTRAN and GERAN/UTRAN access, where the network also applies idle-mode signalling reduction (see TS 23.401 [9]), the PLMN IDs included in the equivalent PLMN list (as defined in TS 24.008[7]) provided by the MME to the eNB guides the target PLMN selection if the UE's registered PLMN is not available in the target cell. The equivalent PLMN list should be configured such that for any target cell there is only one PLMN-ID that can be selected for the cell.

Also, for the above scenario, in the routing areas and tracking areas between which ISR may be activated the "equivalent PLMNs" list provided by the SGSN, MSC and MME to a UE (see TS 23.008 [7]) should result in a single consistent "equivalent PLMNs" list stored by the UE. The single "equivalent PLMNs" list applies to all the UE's registered routing areas, location areas and tracking areas.

At handover/relocation to a GWCN or a MOCN:

- The source MME uses the TAI/RAI information supplied by the eNodeB to select the target MME/SGSN. There is no additional functionality in the source MME to select a target core network operator or to modify the target core network operator selected by the eNodeB. Instead, the source MME uses the selected PLMN received from the eNodeB to determine the target core network operator. The source MME shall forward the selected target core network operator chosen by the source eNodeB to the target MME/SGSN.

- The target MME indicates the selected target core network operator chosen by the source eNodeB/RNC/BSC to the target eNodeB so that the eNodeB can select target cells for future handovers appropriately. Subsequent Tracking Area Update signalling is used to update the UE about any change of core network operator.

6 Charging and accounting aspects

To support inter-operator accounting in a shared network, it shall be possible to distinguish the share of usage of the shared core network node(s) between the sharing partners. The identity of the core network operator is included in the CDR types as specified in TS 32.250 [5] (CS) and TS 32.251 [6] (GPRS)/EPS.

7 Example signalling flows

7.1 Network selection

Signalling flows for manual and automatic network selection in a shared network architecture for successful and unsuccessful registration attempts are presented.

7.1.2 Non-supporting UEs in a GWCN configuration

This example shows network selection for a non-supporting UE towards the PS domain in a shared UTRAN network.

Figure 3: Network selection for a non-supporting UE in a shared UTRAN network

1. The UE reads the broadcast system information in the shared RAN.

2. A non-supporting UE cannot decode the shared network information in the broadcast system information. The common PLMN is the only candidate to be considered together with other PLMNs for network selection.

3. The UE performs network selection among available PLMNs.

4. The UE sends an ATTACH REQUEST message to the network.

5. The shared SGSN determines whether the UE is allowed to attach.

6. The shared SGSN sends the appropriate ACCEPT/REJECT message back to the UE.

7.1.3 Supporting UEs in a GWCN configuration

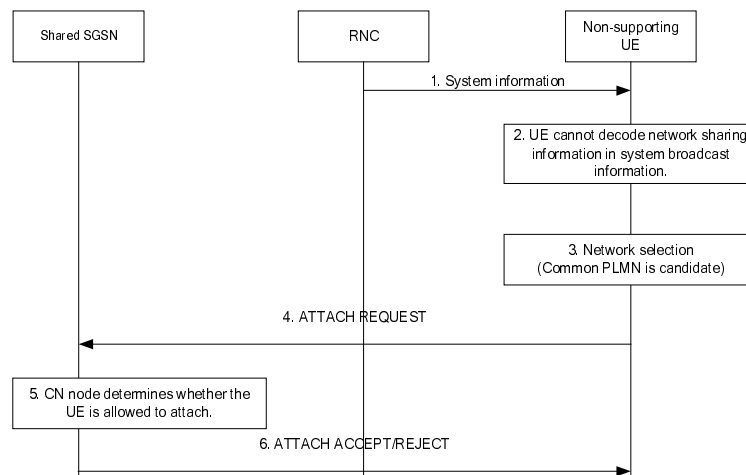This example shows network selection for a supporting UE towards the PS domain in a shared UTRAN network.
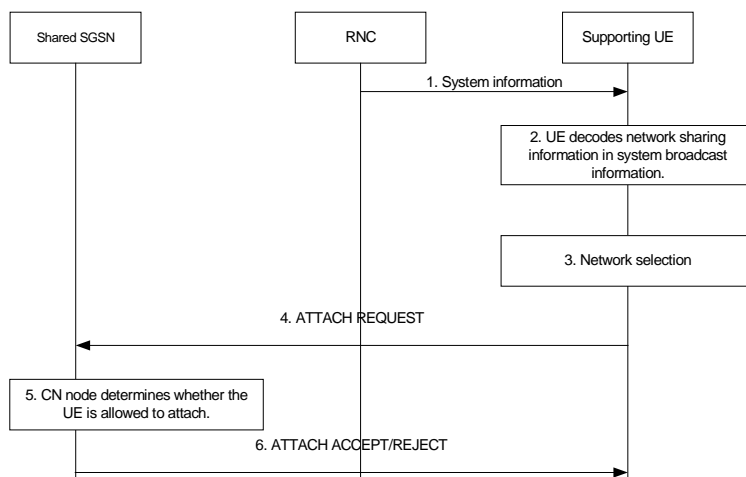
Figure 4: Network selection for a supporting UE in a shared UTRAN network

1. The UE reads the broadcast system information in the shared RAN.

2. A supporting UE decodes the shared network information and supplies the available core network operator PLMN-ids as candidates to the PLMN selection procedure. Only PLMNs in the Multiple PLMN ID List are candidates for network selection.

3. The UE performs network selection among available PLMNs.

4. The UE sends an ATTACH REQUEST message to the network indicating the chosen core network operator.

5. The shared SGSN determines whether the UE is allowed to attach.

6. The shared SGSN sends the appropriate ACCEPT/REJECT message back to the UE.

7.1.4 Non-supporting UEs in a MOCN configuration

An example of an information flow for redirection in UTRAN is shown below.

In this example an attach request from a non-supporting UE is directed to three different CN operators. The first rejects since it has no roaming agreement with the subscribers Home PLMN. The second rejects because of a roaming restriction found in HLR. The third CN operator accepts and completes the attach request. The different "MSC/SGSNs" in the example below shall be seen as different CN operators. One specific CN operator may also have several pooled MSCs/SGSNs connected to the RNC if Iu-flex is used.
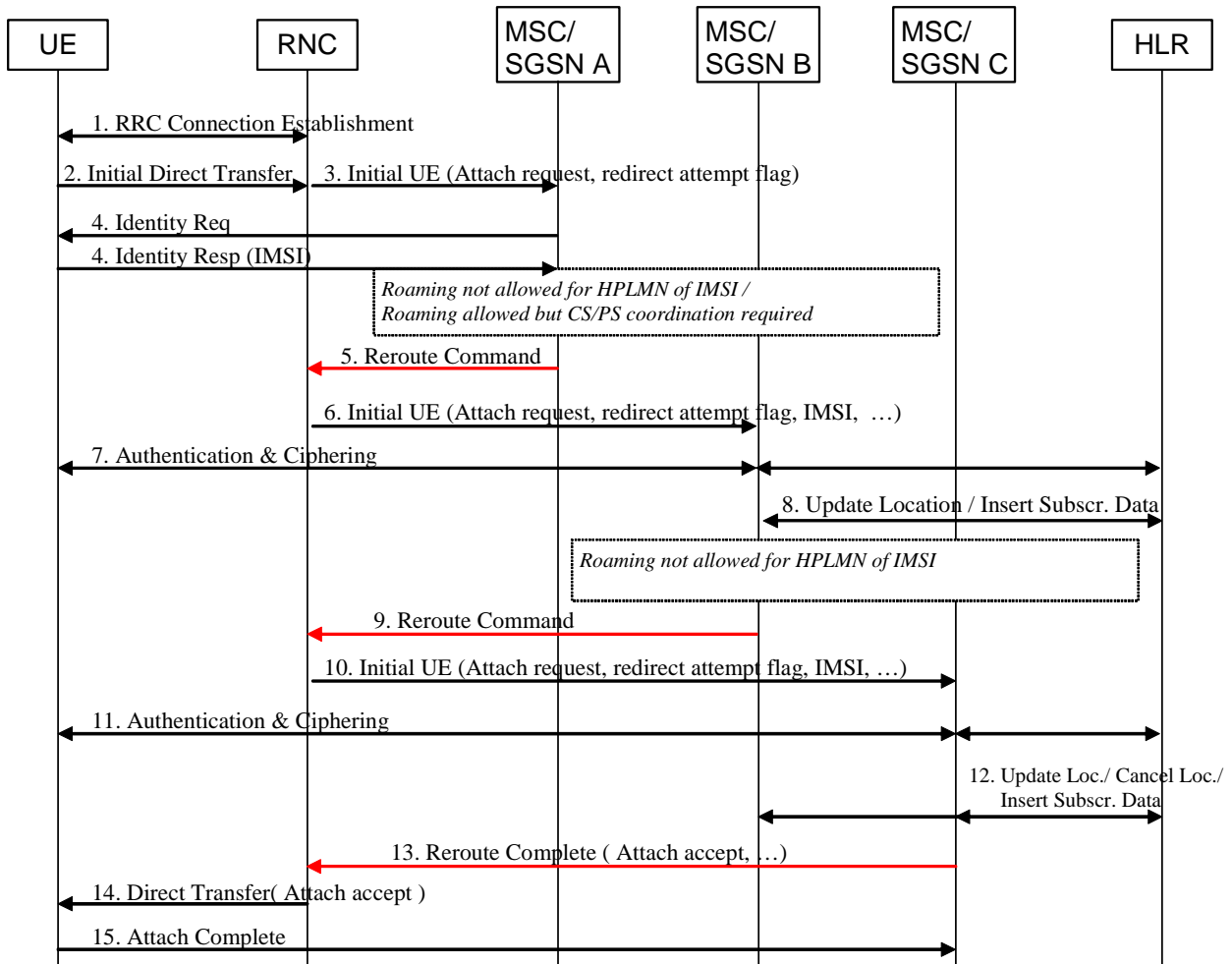
Figure 5: Information flow for redirection in UTRAN

1) The RRC connection is established.

2) RNC receives an Initial Direct Transfer from an UE. The RNC is configured to work in a Shared RAN MOCN, and therefore it forwards the NAS message in an Initial UE with an additional *redirect attempt flag* set. The flag indicates that the MSC/SGSN shall respond to the attach request with a *Reroute Command* or *Reroute Complete* message. Selection of CN node is based on NRI (valid or invalid) if present in IDNNS or by random selection. A *redirect attempt flag* could also simply be the fact that the Initial UE message does not include any selected PLMN-ID (later RAN3 decision), which a supporting UE would include. Redirect is never done for supporting UEs.

3) The MSC/SGSN receives the Initial UE with the *redirect attempt flag* set. It then knows it shall answer with a *Reroute Command* or *Reroute Complete* message. Those new messages might also be extensions to the Direct Transfer message (later RAN3 decision).

4) The MSC/SGSN needs the IMSI of the UE. It is retrieved either from old MSC / old SGSN or from the UE as in this example. By comparing the IMSI with the roaming agreements of the CN operator, the MSC/SGSN discovers that roaming is not allowed or that roaming is allowed but CS/PS coordination required. Attach procedure is aborted.

5) A message is sent back to the RNC with two NAS messages, the attach reject message and the original attach request message received from the UE (alternatively the original NAS message may be stored in the RNC). The IMSI is also included in the message, plus a reject cause code to the RNC. The message should be a new RANAP message, *Reroute Command.* It might also be an extended Direct Transfer message (later RAN3 decision).

The signalling connection between RNC and MSC/SGSN A is released. The RNC selects a MSC/SGSN in the next step. The already tried MSC/SGSNs is stored in the RNC during the redirect procedure so that the same node is not selected twice.

6) The RNC sends a new Initial UE to the next selected MSC/SGSN with the original NAS attach request message (in case of CS/PS coordination the Initial UE may also be sent back to the first MSC/SGSN depending on the outcome of the coordination). Redirect attempt flag is set and IMSI shall also be included to avoid a second IMSI retrieval from UE or old MSC/SGSN and to indicate that PS/CS domain coordination has been done in RNC (if enabled in RNC). The MSC/SGSN receiving the message starts its attach procedure.

7) MSC/SGSN B does in general support roaming for the HPLMN of the IMSI and hence authentication is done and RAN ciphering is established.

8) MSC/SGSN B updates the HLR and receives subscriber data from HLR.

9) The subscription data do not allow roaming (e.g. regional or 3G). MSC/SGSN B sends a Reroute Command message including the attach reject message, a reject cause code, the original attach request message (alternatively stored in the RNC), and the N(SD) (for MSC only). IMSI is included in Reroute Command message only if it was not included in the Initial UE received by the MSC/SGSN.

   The signalling connection between the RNC and the MSC/SGSN B is released. The RNC then selects a new MSC/SGSN as in step 5.

10) The MSC/SGSN C receives an Initial UE (with the original NAS attach request message) with the redirect attempt flag is set, an IMSI, and N(SD) (if MSC). The MSC/SGSN C starts the attach procedure and uses provided information (IMSI and N(SD)).

11) MSC/SGSN C does in general support roaming for the HPLMN of the IMSI and hence authentication is done and RAN ciphering is established.

12) MSC/SGSN C updates the HLR and receives subscriber data from HLR. Subscriber data allows roaming, and the MSC/SGSN C completes the attach procedure. This includes the assignment of a new TMSI/P-TMSI with an NRI that can be used by RNC to route subsequent signalling between UE and correct MSC/SGSN (Iu-flex functionality). The Update Location sent to HLR also triggers a Cancel Location sent to the MSC/SGSN B.

13) A *Reroute Complete* message with the NAS Attach accept message is sent to RNC. By usage of a specific Reroute Complete message, the RNC knows that the redirect is finished and can both forward the NAS message to the UE and clean up any stored redirect data (it is a later RAN3 decision if an extension to the Direct Transfer message shall be used instead of a new message).

14) The Attach Accept is forwarded to the UE. The UE stores the TMSI/P-TMSI with the Iu-flex NRI to be used for future signalling, even after power off. This is existing functionality.

15) UE responds with an Attach Complete message.

If the RNC finds no more MSC/SGSN to redirect to after receiving a Reroute Command message, e.g. step 5 or step 9, it compares the cause code with cause codes from other Reroute Command messages it has earlier received for this UE. A cause code ranking is done and the "softest" cause code is chosen and the corresponding saved NAS attach reject message is returned to the UE.

Each CN node that receives an Initial UE, shall run its own authentication procedure. This may in some rare situations cause the UE to be authenticated more than once, however the trust-model used is that one CN operator shall not trust an authentication done by another CN operator. This will of course not be an optimal usage of radio resources, but given the rare occurrence of this, the increased signalling should not be of any significance.

During the redirect procedure the RNC keeps a timer, which corresponds to the UE timer of releasing the RR connection (20 seconds). If the RNC when receiving a Reroute Command message finds that there is not sufficient time for another redirect, further redirect attempts are stopped (for this attach request message). The UE will repeat its attach request four times (each time waiting 15 seconds before it re-establishes the RR connection for another try).

7.1.5   Supporting UEs in a MOCN configuration

Supporting UEs can make use of the additional information in the broadcast system information. The UTRAN signalling flow is shown in the figure below.
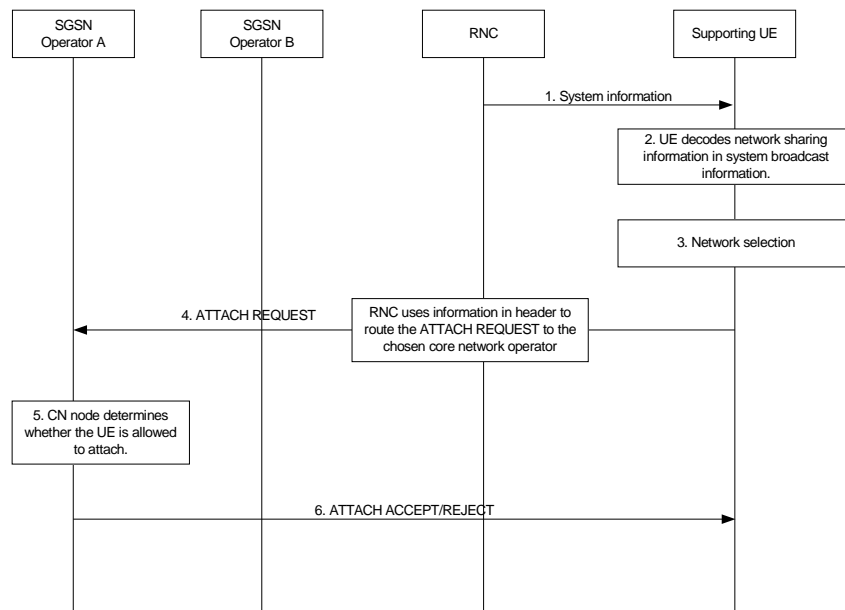
Figure 6: Network selection by a supporting UE in a UTRAN MOCN

1. The UE reads the broadcast system information in the shared RAN.

2. A supporting UE decodes the shared network information and supplies the available core network operator PLMN-ids as candidates to the PLMN selection procedure. Only PLMNs in the Multiple PLMN ID List are candidates for network selection.

3. The UE performs network selection among available PLMNs.

4. The UE sends an ATTACH REQUEST message to the network. It also indicates to the RNC the chosen core network operator. The RNC uses the routing information to determine which core network operator the message should be routed to and the ATTACH REQUEST message is sent to the core network operator chosen by the UE.

5. The core network determines whether the UE is allowed to attach to the network.

6. The shared core network node sends the appropriate ACCEPT/REJECT message back to the UE. In case of an ATTACH ACCEPT message, the core network assigns the UE an appropriate TMSI/P-TMSI so that this identity can be used for any further rerouting of messages by the RNC.

Annex A (informative):
Network Resource Indicator (NRI) allocation examples

This annex contains examples for NRI co-ordination in shared networks.

A.1 NRI in shared UTRAN networks

The Network Resource Identifier (NRI) is specified in Rel-5 for Intra Domain Connection of RAN Nodes to Multiple CN nodes (see TS 23.236 [8]). NRI is part of the temporary identity TMSI (CS domain) or P-TMSI (PS domain), which is assigned by the serving CN node to the MS.

Within the shared network NRIs has to be coordinated between the operators at least due to following reasons:

- to avoid redirection when the non-supporting UE performs LA/RA update.

- to guarantee that correct UE answers to paging (TMSI/P-TMSI shall be unique within shared network).

- to guarantee that a non-supporting UE in visited PLMN will not change network due LA/RA update or Detach/Attach function.

NRI coordination is also required between the shared network and the dedicated networks of the sharing partners:

- to guarantee that non-supporting UE in visited PLMN remain registered in the same operators network when the UE moves from dedicated network to a shared network.

- to avoid redirection when the non-supporting UE in home PLMN performs LA/RA update from dedicated network to a shared network.

In figure A.1 below operators A, B and C have both shared and dedicated networks, operator D has only dedicated network and operator E only shared network.

Figure A.1: Shared and Dedicated network example
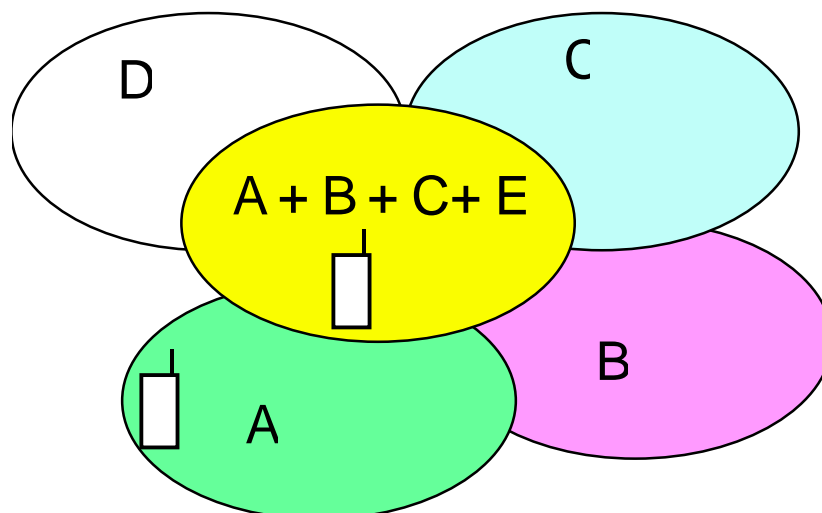
In the above, one or more of the operators in the shared network may deploy Iu-Flex between that shared radio access network and their core networks. Additionally, operators may deploy Iu-Flex within their dedicated core networks. For non-supporting UEs, NRI coordination is needed not only within the shared network, but also between the shared network and the dedicated networks.

A.2 Alternatives for NRI split in UTRAN

Sharing operators need to coordinate the used NRI, following alternatives are considered:

1) even split of NRI space, 1…3 most significant bits of NRI is used to identify the CN operator.

2) individual NRI values used to identify the CN operator.

Alternative 1; even split of NRI space

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CS/PS		'VLR-restart'						CN operator ID		Non shared NRI for CN operator internal use.																					

A calculation for the possible number of subscribers in this scenario is:

- With max 4 sharing CN operators, two most significant bits of NRI is required to identify the CN operator.

- 3 bits are used for the restart counter.

- 5 bits of NRI allows 32 independent NRI values for each CN operator.

- This leaves 20 bits for every MSC that is 1 M non-purged TMSI.

The following aspects need to be considered for this solution:

- If more bits are needed for the restart counter or CN operator ID, each additional bit reduces the available TMSI space half.

- The basic configuration allows 32 M TMSI values for each CN operator, a lot of TMSI values are wasted if some sharing partners have substantially less subscribers than others.

- It may not be feasible in large networks that use Iu-Flex for load balancing (see Annex A, network configuration examples in TS 23.236 [8]).

- The number of NRI bits used for CN operator ID may need to be fixed in the initial planning. Otherwise configuration of all existing nodes must be changed when new partners join the shared network.

Alternative 2; individual NRI values used to identify the CN operator

This could be considered in the case where a network is shared between one big and many small CN operators.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CS/PS		'VLR-restart'						Shared NRI space																							

- The biggest CN operator who needs more pool areas and TMSI space takes NRI values 32…63, [1xxxxx], this means 32M TMSI values when 4 bit is used for restart counter.

- Rest of shared NRI space is allocated to other CN operators in blocks of 4M TMSI values like NRI = 28 - 31 [0111xx], 24 - 27 [0110xx] …. 0 – 3 [000xx]. Initially gaps can be left between allocated NRI range that can be used for expansion.

Following aspects need to be considered for this solution:

- If more bits are needed for the restart counter or NRI, each additional bit reduces the available TMSI space half.

- The initial planning of NRI length should take into account the pool area configurations of all sharing operators.

TMSI per LA:

Taking the example configurations mentioned above but changing the TMSI allocation per LA would result in an increase of the addressing space, then the same TMSI value can be used multiple times in the same VLR. More considerations with this TMSI per LA approach can be found in TS 23.236 [8].

Annex B (informative): Change History

Change history								
Date	TSG #	TSG Doc.	CR	Rev	Cat	Subject/Comment	Old	New
2007-06	-	-	-	-	-	Update to Rel-7 version (MCC)	6.6.0	7.0.0
2008-12	SP-42	SP-080817	0015	2	C	Update for the Evolved Packet System	7.0.0	8.0.0
2009-03	SP-43	SP-090113	0016	5	F	Netshare cleanup	8.0.0	8.1.0
2009-09	SP-45	SP-090609	0017	-	F	Remove ambiguity regarding the UE handling of the Common PLMN ID	8.1.0	9.0.0
2009-12	SP-46	SP-090795	0018	-	F	UE selecting network in shared network	9.0.0	9.1.0
2010-03	SP-47	SP-100130	0020	4	A	Network sharing deployment requirements to solve the Kasme derivation issue	9.1.0	9.2.0
2010-03	SP-47	SP-100138	0022	2	A	Handover during the network sharing case	9.1.0	9.2.0

History

Document history		
V9.1.0	January 2010	Publication
V9.2.0	March 2010	Publication