ETSI TS 123 251 V7.0.0 (2007-06)

Technical Specification

Universal Mobile Telecommunications System (UMTS);
Network sharing;
Architecture and functional description
(3GPP TS 23.251 version 7.0.0 Release 7)

Reference

RTS/TSGS-0223251v700

Keywords

UMTS

ETSI

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Contents

Foreword

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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 is functionality that supports a very basic type of network sharing in the current specifications within 3GPP.

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 network.

1 Scope

The present document covers the details of Network Sharing. 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 additional 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.
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[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".

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 (MSC/SGSNs) 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 following abbreviations apply:

CN	Core Network
GWCN	Gateway Core Network
HLR	Home Location Register
MCC	Mobile Country Code
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
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.

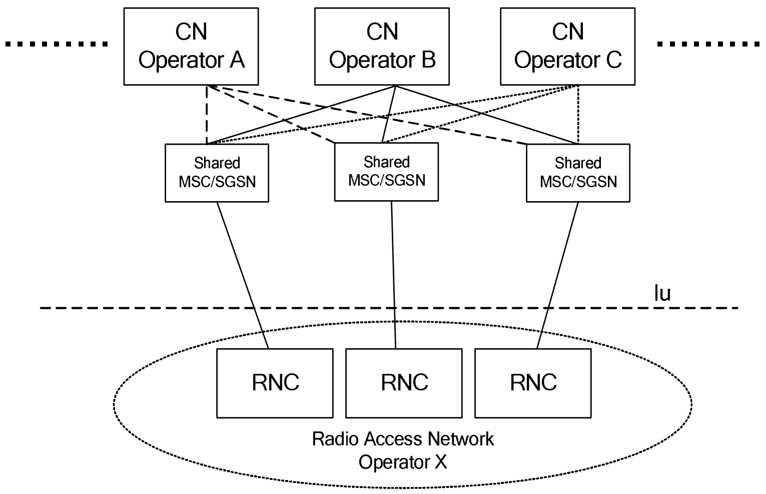

Figure 1: A Gateway Core Network (GWCN) configuration for network sharing. Besides shared radio access network nodes, the core network operators also share core network nodes

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.

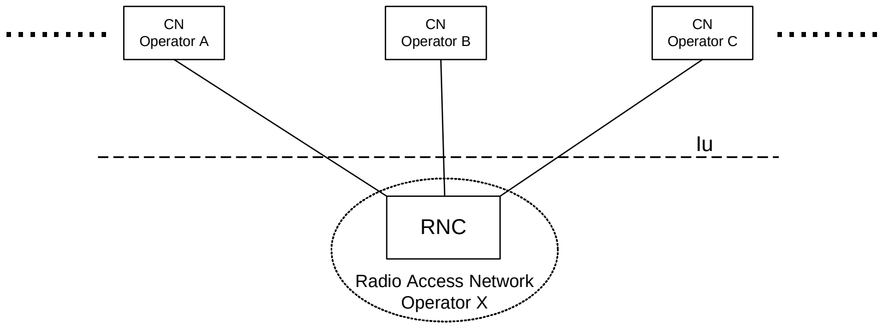

Figure 2: A Multi-Operator Core Network (MOCN) in which multiple CN nodes are connected to the same RNC and the CN nodes are operated by different operators

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.

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 the shared network. A supporting UE decodes this information and take 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].

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]. A supporting UE shall not consider the common PLMN as a candidate for network selection.

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 of the network of the identity of the chosen core network operator. In a GWCN configuration, the RNC relays this information to the shared core network node.

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 subclause 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. 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.

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 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].

4.2.5 PS and CS domain registration coordination

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 subclause 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.

4.2.6 Attach/detach handling

To attach to the same core network operator from which it detached, a UE uses information stored on the SIM/USIM. For a supporting UE in a shared network, the stored information indicates the core network operator it detached from (as specified in subclause 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 shall not result in service restrictions, e.g. roaming restrictions. Since a HLR derives whether the subscriber roams in H- or V-PLMN from the VLR/SGSN number, a shared VLR/SGSN in a GWCN shall be allocated one specific number from each supported HPLMN, i.e. a shared VLR/SGSN has multiple numbers. The VLR/SGSN number of a user's serving CN operator is used in signalling with the HLR.

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:

If the source RNC can determine 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 target core network node.

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.

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 subclause 5.2.
- If the source RNC did not have the capability to determine a core network operator, the target MSC selects a core network operator and indicates it to the Target RNC.

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 purposes the SGSN derives the IMSI from another SGSN 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 also 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 the to the serving SGSN.

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

In case of relocation 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. The source SGSN shall forward the selected core network operator chosen by the source RNC to the target SGSN.
- The target SGSN indicates the selected core network operator chosen by the source RNC to the target RNC so that the appropriate PLMN-id can be signalled to the UE in dedicated system information signalling, as described in subclause 5.2.

- If the source RNC did not have the capability to determine a target core network operator, the target SGSN selects a core network operator and indicates it to the Target RNC.

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).

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 network.

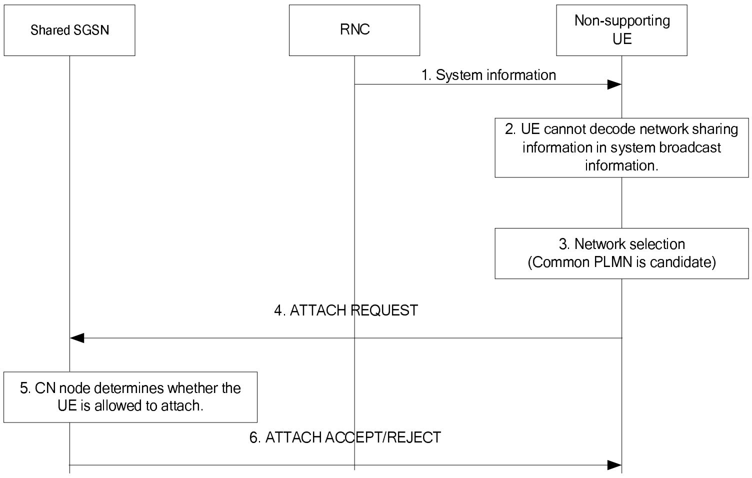

Figure 3: Network selection for a non-supporting UE in a shared network.

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 network..

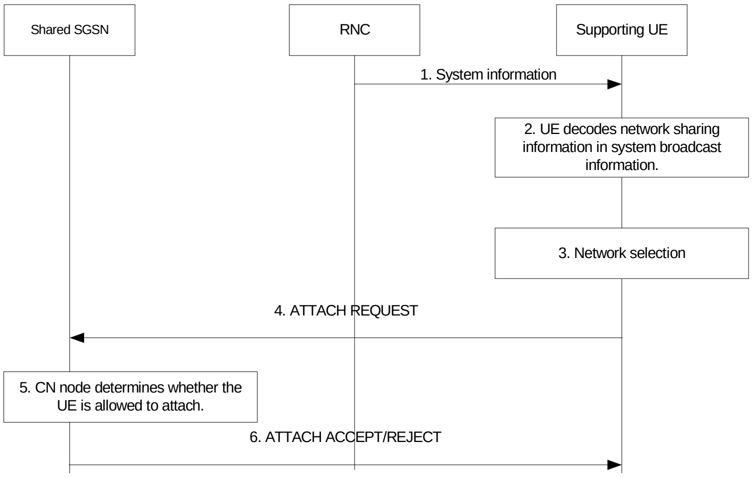

Figure 4: Network selection for a supporting UE in a shared network.

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. The common PLMN **is not given** as a candidate 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 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.

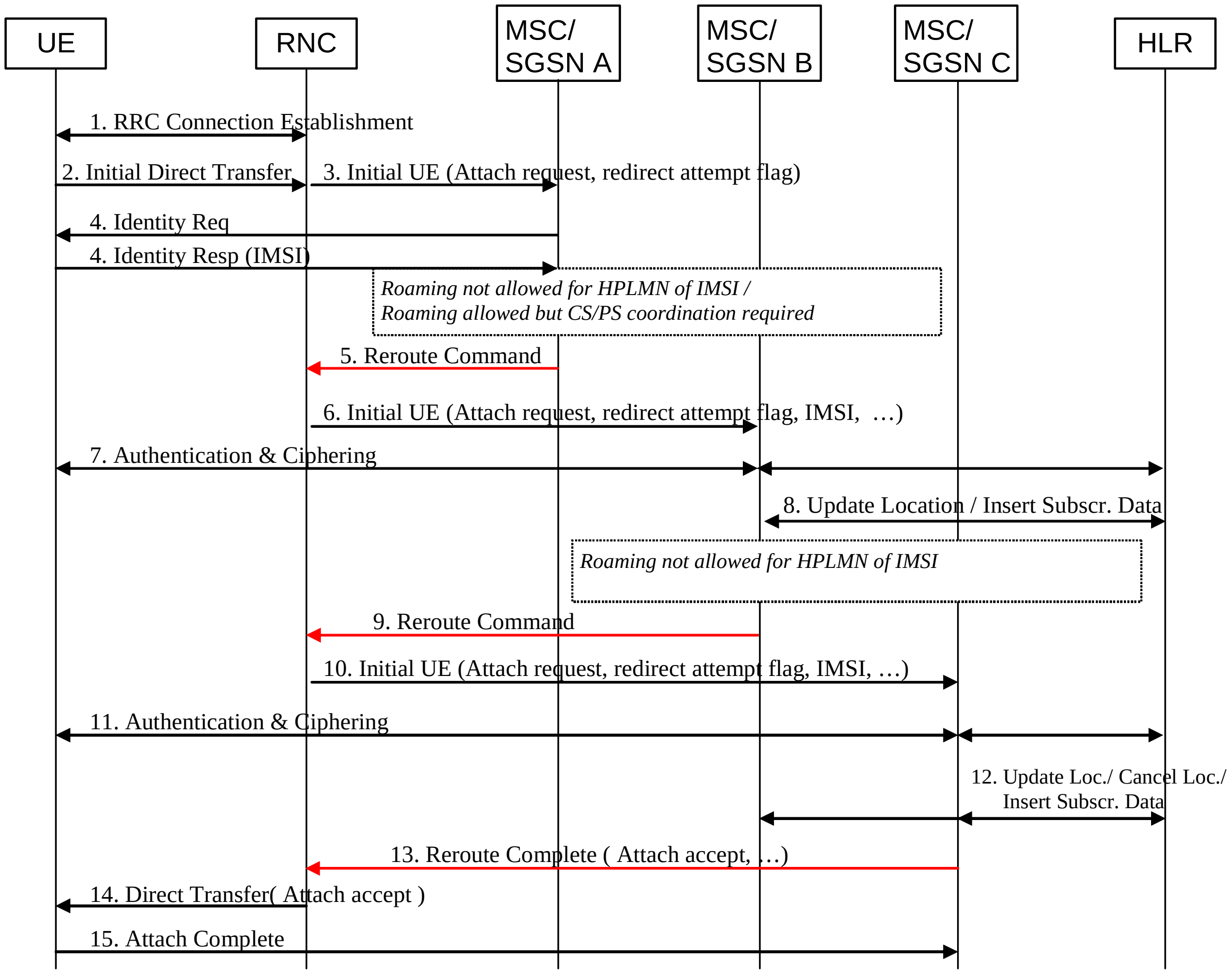

Figure 5: Information flow for redirection.

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 signaling flow is shown in the figure below.

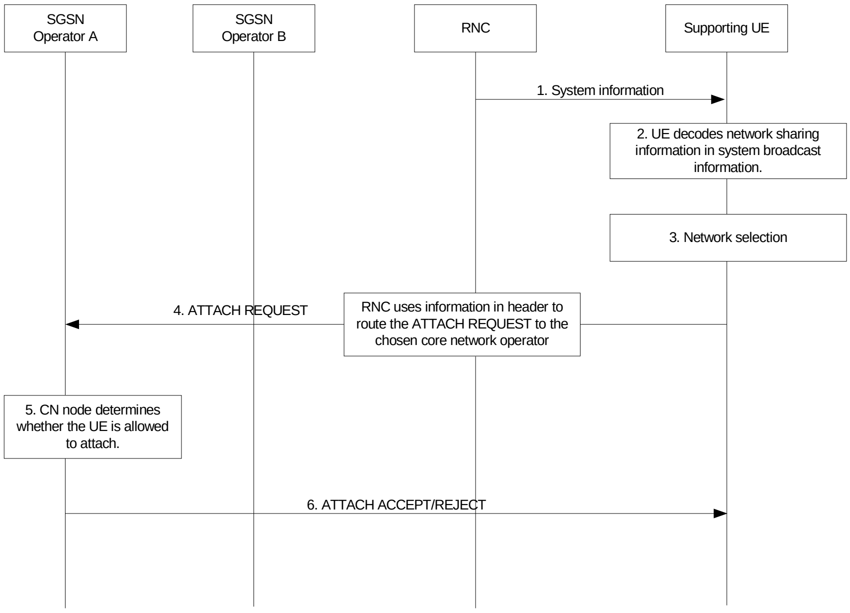

Figure 6: Network selection by a supporting UE in a MOCN.

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. The common PLMN **is not given** as a candidate 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 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 indentity 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.

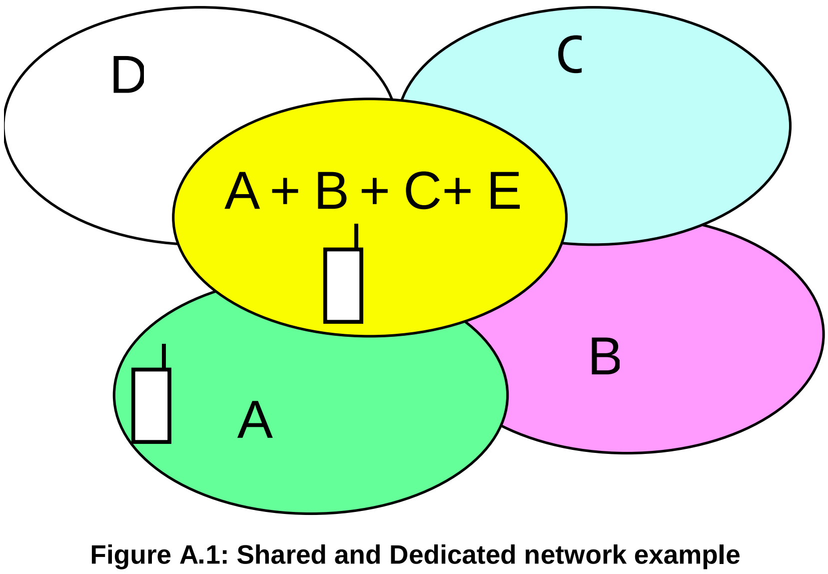

Figure A.1: Shared and Dedicated network example

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

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**	**Subject/Comment**	**Old**	**New**
2004-06	SA#24	SP-040445			Raised to v.6.0.0 after approval at SA#24	2.0.0	6.0.0
2004-09	SA#25	SP-040527	002	1	Introduction of network sharing (non-)supporting UEs	6.0.0	6.1.0
2004-09	SA#25	SP-040527	003	1	Handling of system information in connected mode	6.0.0	6.1.0
2004-09	SA#25	SP-040527	004	1	Core network operator identity as part of LAI/RAI for supporting UEs	6.0.0	6.1.0
2004-09	SA#25	SP-040527	005	1	Indication of selected core network operator to the CN for supporting UEs	6.0.0	6.1.0
2004-12	SA#26	SP-040759	007	1	Inclusion of informative Annex "NRI allocation examples"	6.1.0	6.2.0
2004-12	SA#26	SP-040759	008	3	Indication of selected CN operator in connected mode	6.1.0	6.2.0
2005-03	SA#27	SP-050111	011	1	Correction of references	6.2.0	6.3.0
2005-06	SA#28	SP-050341	0012	4	Clarification of PS and CS domain registration coordination	6.3.0	6.4.0
2005-09	SA#29	SP-050477	0013	1	Cleanup of RNC based PS and CS domain registration coordination	6.4.0	6.5.0
2006-03	SA#31	SP-060141	0014	1	Clarification of netshare re-routing	6.5.0	6.6.0
2007-06	-	-	-	-	Update to Rel-7 version (MCC)	6.6.0	7.0.0

History

Document history		
V7.0.0	June 2007	Publication