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Technical Report

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One Tunnel Functional description;
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Contents

Foreword

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

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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where:

x the first digit:

1 presented to TSG for information;

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y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

1 Scope

The present document is a temporary container for a stage-2 like description of an architecture that uses direct tunnelling of user plane data between the RNC and the GGSN, which is known as One Tunnel approach. The content of this report when stable will be moved into 3GPP Technical Specification TS 23.060 [1].

This report will further develop the One Tunnel approach described in TR 23.873 [2] and identify what changes are needed to PS core and potentially to UTRAN functionalities and protocols to support the One Tunnel functionality. This include the investigation of the functions added after Rel-4 up to Rel-6 (e.g. Iu-flex, Network sharing, MBMS, etc) and either verify that they are not affected or address any conflicts between these functions and the One Tunnel function.

The resulting system architecture shall be fully interoperable with pre-Rel-7 nodes and it should retain the existing network capabilities, or those that cannot be delivered need to be clearly documented.

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 TS 23.060:"General Packet Radio Service (GPRS); Service description; Stage 2".

[2] 3GPP TR 23.873 v.4.0.0: "Feasibility Study for Transport and Control Separation in the PS CN Domain".

[3] 3GPP TS 29.060:"General Packet Radio Service (GPRS); GPRS Tunnelling Protocol (GTP) across the Gn and Gp Interface".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the [following] terms and definitions [given in ... and the following] apply.

Definitions to be added

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

Abbreviations to be added

4 Architecture Baseline

The Release 6 network architecture is the logical reference architecture with following exceptions:

- One tunnel solution is not applicable for GERAN Gb interface.

Editors Note: The interfaces and network entities related to CS core and SMS service are not shown in figure 1 as they are not impacted by the functionality.

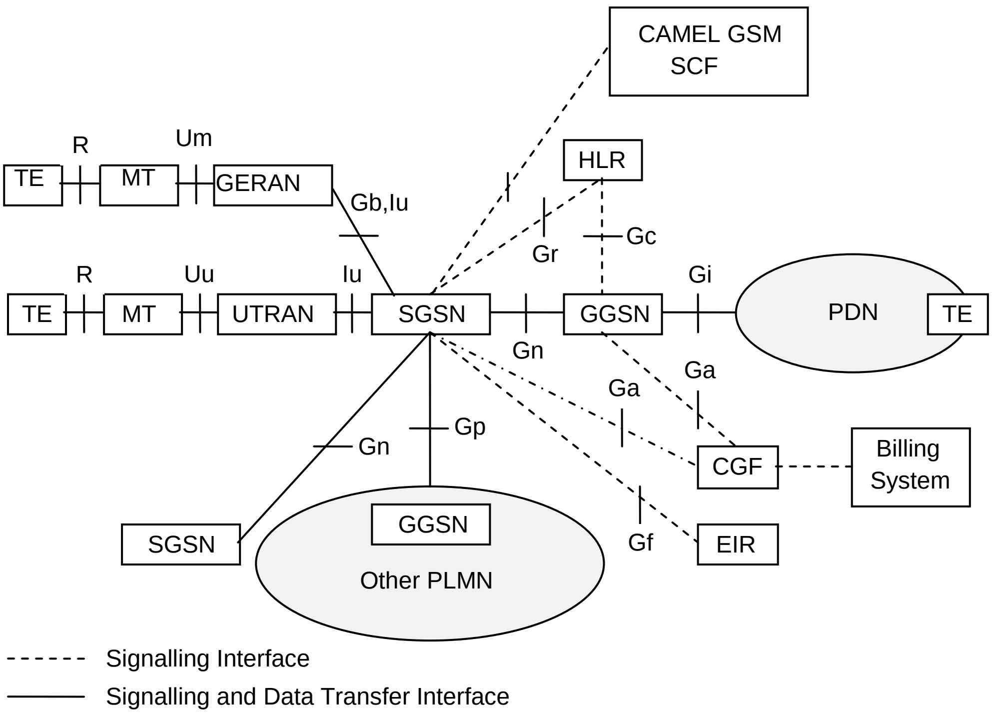


Figure 1: Baseline Architecture for One Tunnel

5 One Tunnel overview

5.1 General

The One Tunnel functionality enables direct user plane tunnel between RAN and GGSN within the PS domain.

In case of direct tunnel, the SGSN provides for the RAN the TEID and user plane address of the GGSN and for the GGSN the TEID and user plane address of the RAN.

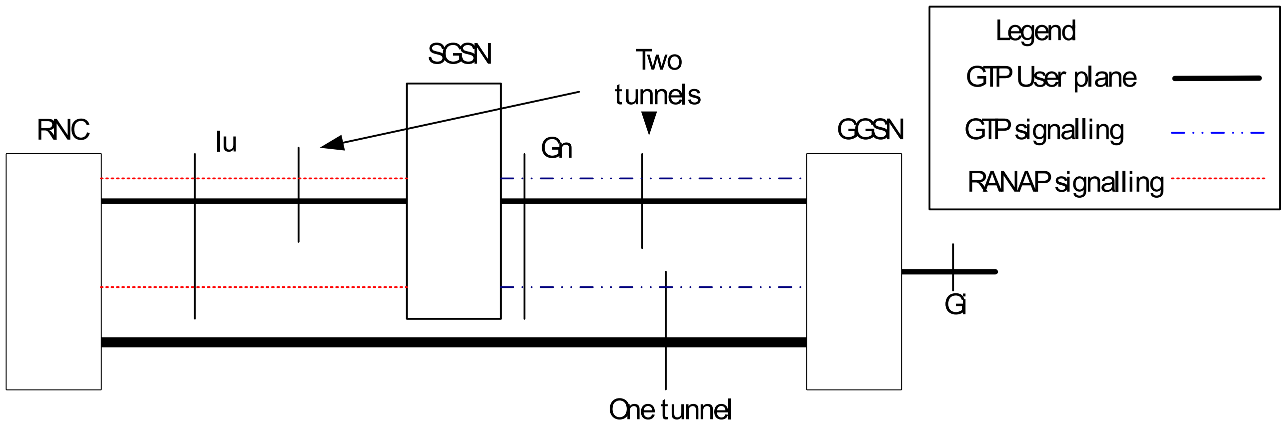


Figure 2: One Tunnel concept

There are three alternatives how current networks can deploy the One Tunnel functionality as described in the sub clauses below.

5.2 SGSN optimisation

This approach builds on the premise that the user plane functionality still stays in the SGSN and two tunnels are used in following traffic cases:

a) In roaming case;

b) For the subscriber that has Lawful Interception in the SGSN;

c) For the subscriber that has controlling Camel services active;

d) GGSN does not support one tunnel solution (FFS), e.g. error handling.

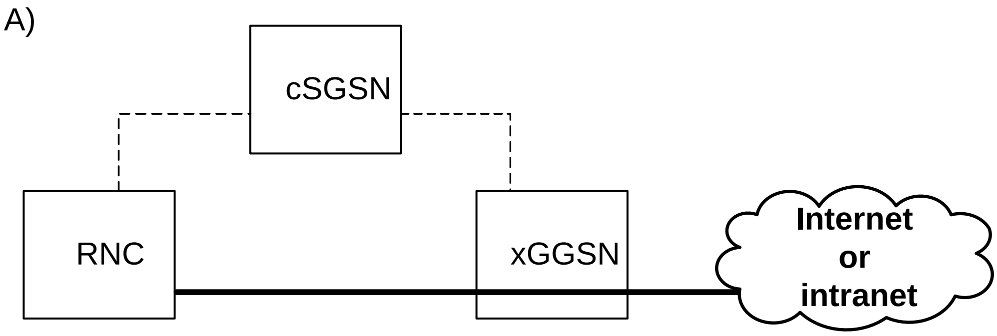
In all other traffic cases direct tunnel between RNC and GGSN is used.

The SGSN handles the control plane signalling and makes the decision when to establish direct tunnel between RNC and GGSN or use two tunnels see figure 2 above.

5.3 GGSN Bearer Relay

This approach builds on the premise that all the user plane transport functionality is removed from the SGSN. The new SGSN controller (cSGSN) only performs control functions of a legacy SGSN, while the enhanced GGSN (xGGSN) is responsible for all legacy SGSN and GGSN user plane transport functionality see figure 3, A).

In the Pooled Bearer configuration all bearer resources are maintained by the xGGSN in the visited network that acts as the bearer relay function in the transport path between the RNC and the GGSN. This is required to establish a PDP context towards a home network or legacy GGSN see figure 3, B).



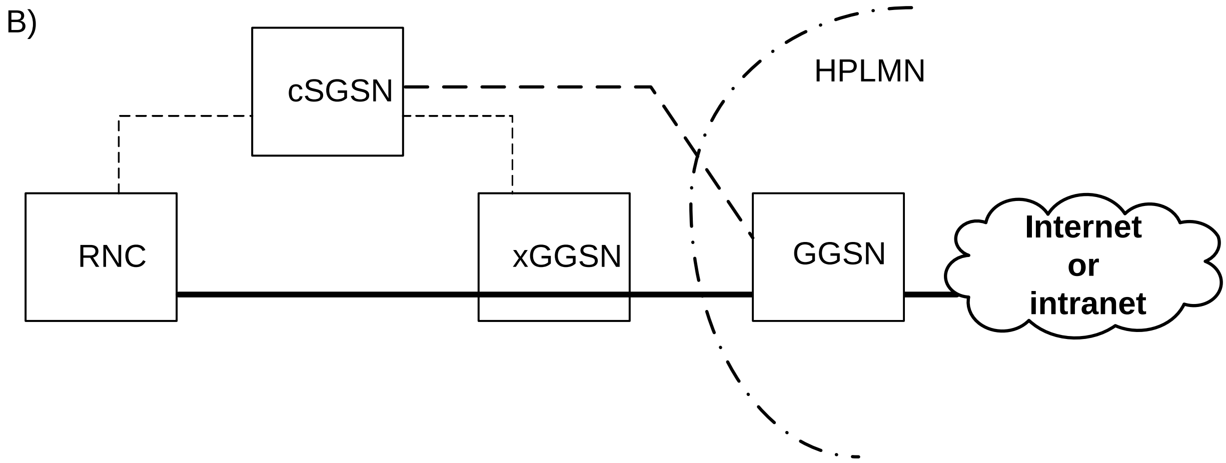


Figure 3: Pooled Bearer

During the PDP Context Activation procedure the cSGSN first allocates a bearer plane resource (TEID and user plane address) from the xGGSN. The cSGSN then provides the GGSN the TEID and user plane address of the xGGSN in the Gn Create PDP Request. During the RAB Establish procedure the cSGSN passes the TEID and user plane address of the xGGSN to the RNC. Note the interaction with the legacy GGSN in this scenario does not require any modification to existing procedures.

In the non roaming case, the cSGSN shall be able to discover whether the GGSN supports one tunnel solution or not. How to discover whether the GGSN supports one tunnel solution is FFS.

5.4 GGSN Proxy

This approach is an extension and enhancement of the One Tunnel approach described in the TR 23.873 [2]. The approach is similar to the GGSN Bearer Relay in subclause 5.3. The difference from that approach is that here the xGGSN instead of the cSGSN does the signalling to the HPLMN GGSN. SGSN communicates in most cases to the xGGSN as if it is the normal GGSN. The xGGSN then updates the HPLMN GGSN when necessary. The xGGSN acts as an SGSN towards the HPLMN GGSN and Gp interface is used between operators as today.

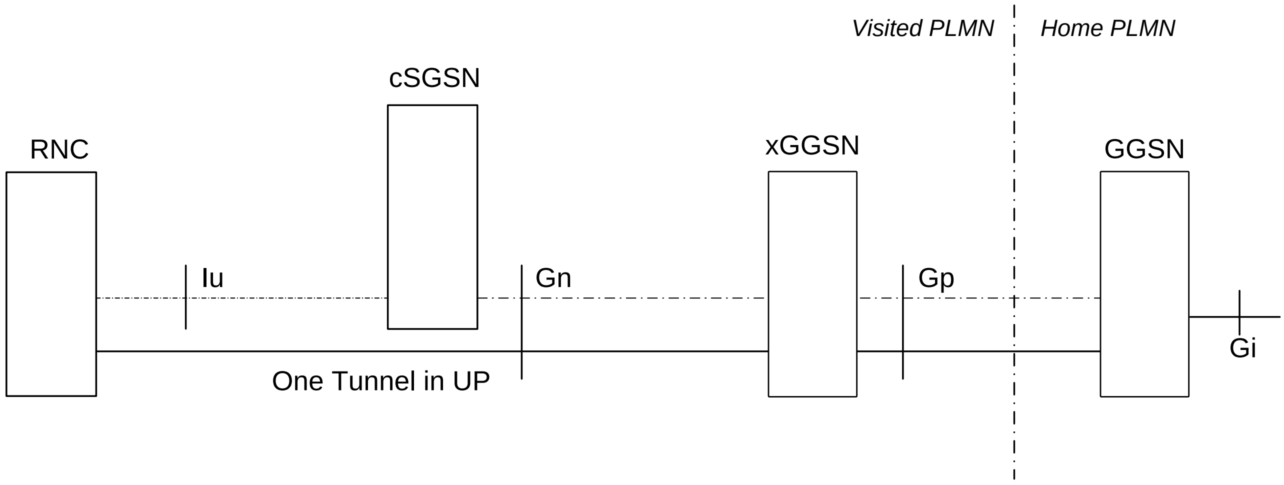


Figure 4: Handling of roaming traffic with the GGSN Proxy One Tunnel solution

When the cSGSN during the PDP Context Activation procedure finds an APN belonging to another PLMN, it selects an xGGSN for handling the roaming traffic and sends the Create PDP Context Request message to that node instead. The xGGSN creates the PDP Context, allocates additional TEIDs for the Gp interface and forwards the Create PDP Context Request message with these TEIDs to the GGSN corresponding to the APN. The response message from the GGSN is returned/forwarded by the xGGSN to the SGSN.

In the non roaming case, the cSGSN shall be able to discover whether the GGSN supports one tunnel solution or not. How to discover whether the GGSN supports one tunnel solution is FFS.

Mobility management procedures are handled in the same way as when the One Tunnel alternative is selected in the SGSN optimisation solution, with the GGSN in the HPLMN not involved in the procedure. The xGGSN forwards all modifications of PDP Contexts to the GGSN in HPLMN, unless the modification is only of local significance (i.e. updating TEIDs and IP addresses).

6 Impact to Functions and Characteristics

Editors Note: The impact to the Rel-6 PS functions depend on the approach selected for the One Tunnel deployment. This clause identifies the functions and characteristics of the 3GPP PS system that are potentially impacted. The main impacts of each solution are described. Any comparison between the approaches is found in subsequent clauses after this clause.

6.1 PDP Context Activation/Deactivation

6.1.1 SGSN optimisation

For the PDP Context Activation procedure this solution does not require new information elements or messages on the GPRS Tunnelling Protocol (GTP) defined in TS 29.060 [3]. SGSN provides the user plane addresses for RNC and GGSN as illustrated in Figure 6.1.1-1.

PDP Context Deactivation procedures (MS, SGSN and GGSN initiated) are not impacted by the One Tunnel functionality and are executed as described in TS 23.060 [1].

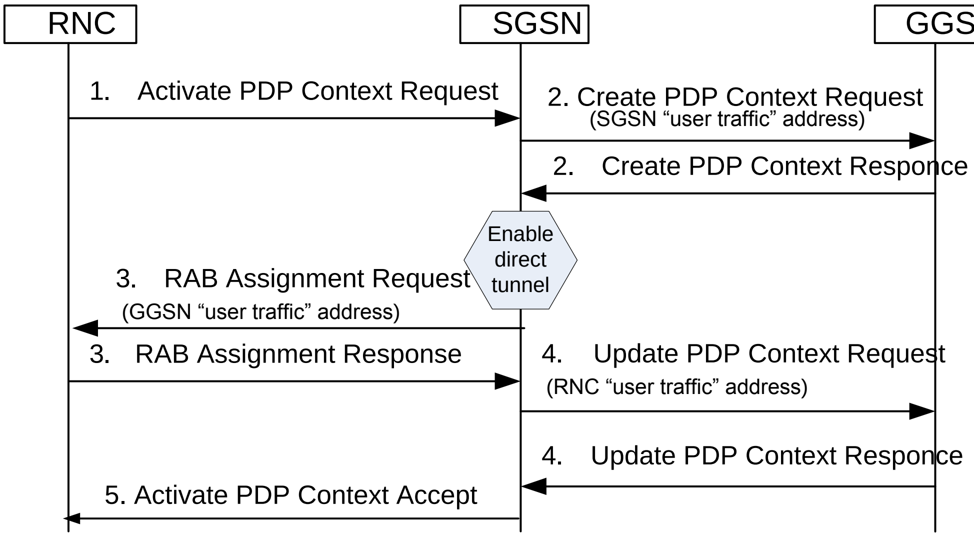


Figure 6.1.1-1: PDP context activation enabling direct tunnel

1, 2) Steps 1 and 2 are as described in TS 23.060 [1]. The SGSN shall include it's own address for the "user traffic" in the Create PDP Context Request. After the SGSN has received Create PDP Context Response it decide if direct tunnel can be enabled.

3) If the SGSN enabled direct tunnel RNC receives GGSN address for "user traffic" in the RAB Assignment Request.

4) After SGSN received RNC "user traffic" address in the RAB Assignment Response and if direct tunnel was enabled the SGSN shall send Update PDP Context Request to GGSN and include the RNC address for "user traffic". The GGSN shall update the "user traffic" address and use it when sending G-PDUs for the MS.

If the downlink data transmission start before GGSN receive and use RNC "user traffic" address the SGSN will forward these PDUs to RNC (this is an existing SGSN functionality).

6.1.2 GGSN Bearer relay

To be described.

6.1.3 GGSN Proxy

With a One Tunnel solution according to the GGSN Proxy alternative, a PDP context activation is always done using a direct tunnel between the RNC and a GGSN. For the non-roaming case (the major part of the traffic), this is done in the same way as for the other alternatives. For the roaming case (one or a few percent of the traffic), PDP context activation is done using a GGSN in the VPLMN, which acts a proxy and relays the PDP context activation/deactivation signaling to the GGSN in the HPLMN. This results in a direct tunnel between the RNC and the GGSN (Proxy) in the VPLMN and a normal GTP-U tunnel over the Gp reference point to the GGSN in the HPLMN.

The impact to the PDP context activation and deactivation procedures is minor. The TEID and IP address of the GGSN (GGSN Proxy in the roaming case) is provided by the SGSN to the RNC, and the TEID and IP address of the RNC is provided to the GGSN. No exception to the procedure is done e.g. for charging or LI, and hence the PDP context activation/deactivation procedure is simple and always done by setting up a direct tunnel. See figure below.

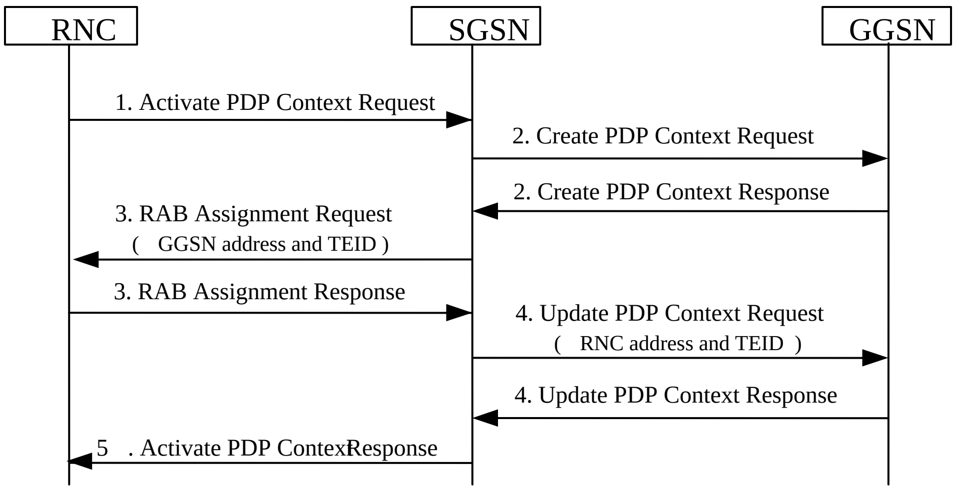


Figure 6.1.3-1: PDP context activation enabling direct tunnel in non-roaming case

In the roaming case the SGSN selects a GGSN in its own PLMN to act as a GGSN Proxy, and establishes the GTP-C connection with that GGSN Proxy instead of with the GGSN in the HPLMN. The IP address to the GGSN in the HPLMN is provided by the SGSN in the Create PDP Context Request. The GGSN receives the Create PDP Context Request (step 2a in figure below) and from the presence of the HPLMN GGSN IP address parameter it understands that this subscriber is roaming and that it shall act as a GGSN Proxy. Before it relays the Create PDP Context Request message to the home GGSN, it replaces the SGSN provided tunnel endpoints (UP & CP) with its own tunnel endpoints (on the Gp interface). That way the Gp interface will be the standard interface (see TS 23.060 subclause 9.2.2.1) and the GTP-U and GTP-C tunnels will have been established directly after step 2b and does not have to wait for the RAB assignment to be finished. The acknowledgement of the established RAB including a possible change of QoS in step 4b, after the RAB assignment, is in line with TS 23.060, clause 9.2.2.1.

The use of standard Gp interface between the GGSN Proxy and the GGSN in the HPLMN enables operators to deploy the GGSN Proxy One Tunnel feature without any inter-operator dependencies.

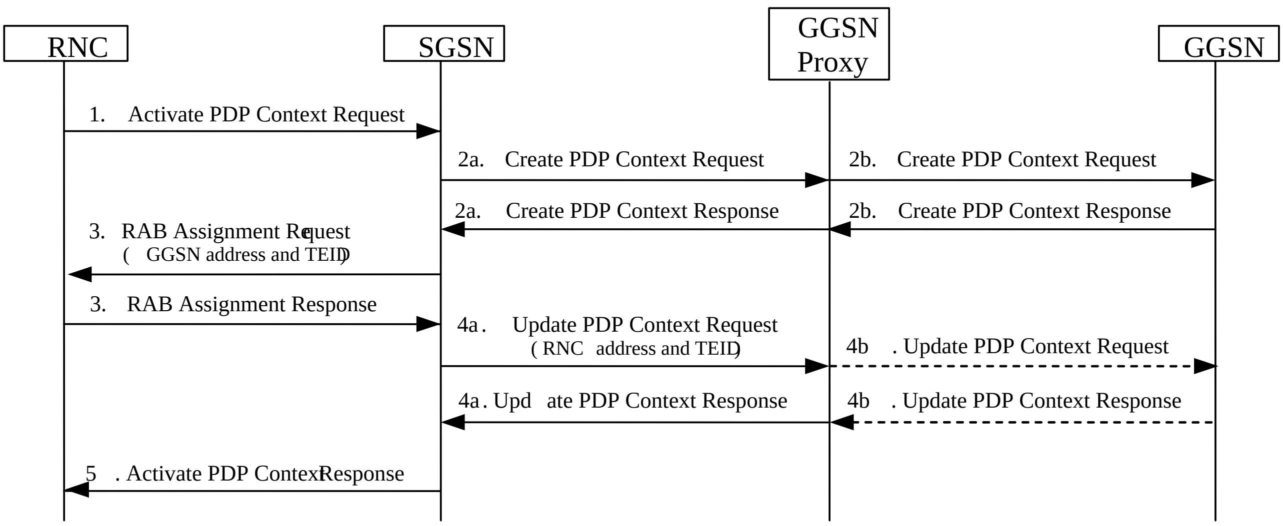


Figure 6.1.3-2: PDP context activation enabling direct tunnel in roaming case

6.2 RAB assignment

6.2.1 SGSN optimisation

The resource reservation for active PDP context(s) i.e. RAB assignment is part of the Service Request procedure. The MS initiated case is briefly described in figure 6.2.1-1 below and the network initiated case is described in clause 6.8 Paging.

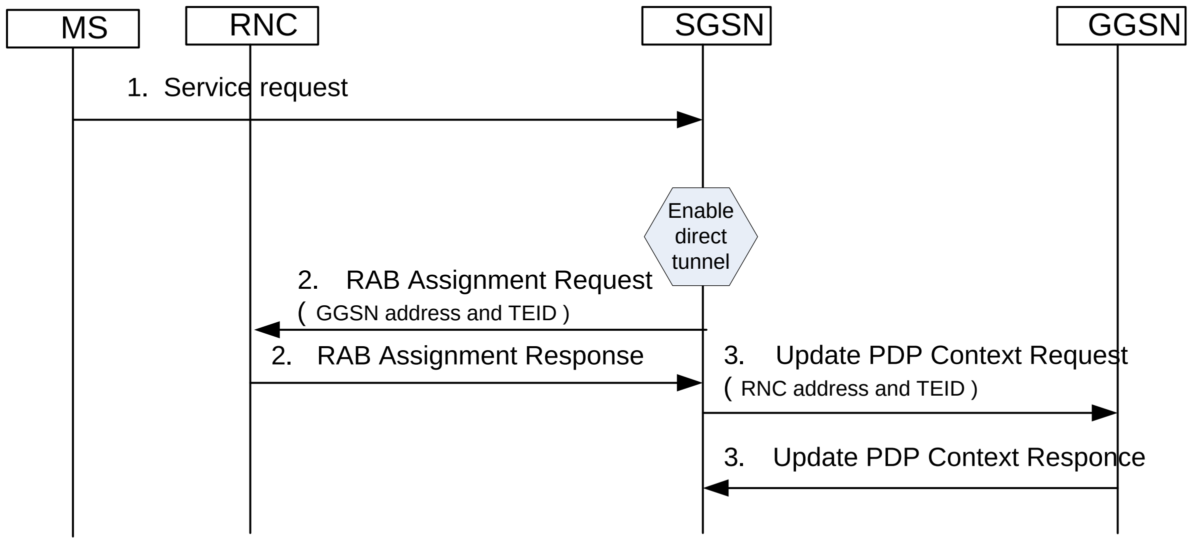


Figure 6.2.1-1: MS initiated service request; RAB assignment

1) If Service Type indicates Data the SGSN shall decide if direct tunnel can be enabled. At this point SGSN a lready knows the GGSN "user traffic" address, because the PDP Context has been established earlier and is preserved (see also clause 6.3.1).

2) If the SGSN enabled direct tunnel RNC receives GGSN address for "user traffic" in the RAB Assignment Request.

3) After SGSN received RNC "user traffic" address in the RAB Assignment Response and if direct tunnel was enabled the SGSN shall send Update PDP Context Request to GGSN and include the RNC address for "user traffic". The GGSN shall update the "user traffic" address and use it when sending G-PDUs for the MS.

6.2.2 GGSN Bearer relay

To be described.

6.2.3 GGSN Proxy

The SGSN provides to the RNC the TEID and user plane address of the GGSN and after SGSN has received TEID and user plane address of RNC it is sent to GGSN. This is depicted in figure X using PDP Context activation as an example. No new messages or information elements is needed, enabling direct tunnel just makes the Update PDP Context Request/Response message pair between SGSN and GGSN mandatory (in Rel-6 it is conditional).

In the roaming case, the direct tunnel is established to a GGSN Proxy in the same PLMN (see subclause 6.1.3).

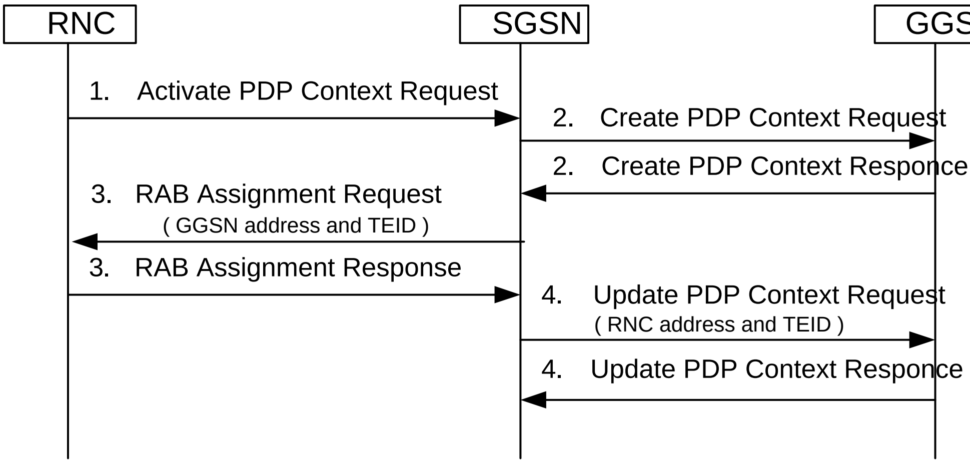


Figure 6.2.3-1: PDP context activation enabling direct tunnel

6.3 RAB release/ Iu release

6.3.1 SGSN optimisation

The principle of this solution is that whenever the RAB assigned for a PDP context is released without deactivating the PDP context (i.e. the PDP context is preserved) the GTP-U tunnel is established between the GGSN and SGSN in order to be able to handle the downlink packets.

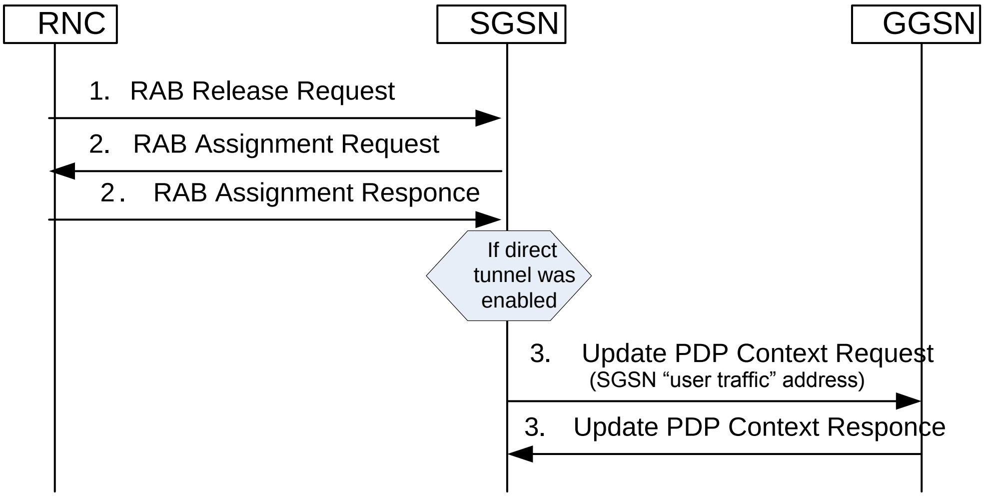


Figure 6.3.1-1: RAB release

1, 2) Steps 1 and 2 are as described in TS 23.060 [1].

3) If direct tunnel was enabled SGSN shall send Update PDP Context Request to GGSN and include it's own address for the "user traffic" in the Create PDP Context Request in order to be able to handle the downlink packets and trigger paging see clause 6.6.1. The GGSN shall update the "user traffic" address and use it when sending G-PDUs to the SGSN for the MS.

6.3.2 GGSN Bearer relay

To be described.

6.3.3 GGSN Proxy

Whenever the RAB assigned for a PDP context is released (i.e. the PDP context is preserved) the SGSN updates the GTP-U tunnel endpoint in the GGSN to a pre-defined value that is interpreted by the GGSN as "not allocated" (e.g. TEID = 0 and user-plane IP address = 0). If downlink packet(s) arrives to the GGSN for a PDP context where TEID is 'not allocated', one or a few packets are buffered and a PDU Notification message is sent to SGSN to start the paging. When the RAB has been re-established and the SGSN has updated the TEID and UP IP address, the GGSN sends any buffered packets to the RNC.

In the roaming case, only the GGSN Proxy is updated with a "not allocated" TEID. The GGSN in HPLMN remains unaffected by the RAB release (standard Gp interface to the home GGSN).

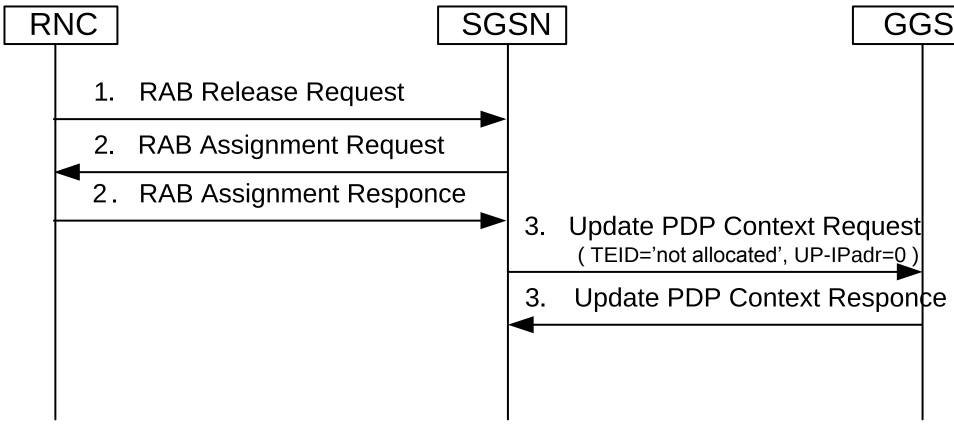


Figure 6.3.3-1: RAB release

6.4 RA Update

6.4.1 SGSN optimisation

Intra- and Inter-SGSN Routeing Area Update procedures are not impacted by this solution.

For an MS that is in PMM-IDLE state and have activated PDP Context(s) the GTP-U tunnel(s) are established between the GGSN and SGSN as described in clause 6.3.1. If the RA update is an Inter-SGSN RA update the new SGSN will include it's own address for the "user traffic" in the Update PDP Context Request and send it to the GGSNs concerned.

If the RA update is an Inter-SGSN RA update initiated by an MS in PMM-CONNECTED state the GTP-U tunnel(s) are first established between SGSN-GGSN. SGSN then makes the decision to enable direct tunnel when RABs are established as part of Service Request procedure as described in clause 6.2.1 RAB assignment procedure.

6.4.2 GGSN Bearer relay

To be described.

6.4.3 GGSN Proxy

For the GGSN Proxy alternative, the RA Update procedure remains consistent and the same regardless if a subscriber is roaming or not.

The Routing Area Update procedure for the GGSN Proxy alternative is modified in a similar way for this alternative as when a direct tunnel is used for the other alternatives. Basically a new Update PDP Context message needs to be sent to the GGSN if the RNC has changed, to update the RNC tunnel endpoints in the GGSN. For Inter-SGSN RAU, the GGSN Proxy acts as the 'GGSN' in the location management procedures described above and in clause 6.9.2 of TS 23.060 [1].

6.5 Serving RNS Relocation

6.5.1 SGSN optimisation

The serving RNC Relocation procedure is applicable as such, the impact of this solution is limited to the phase when the Radio Access Bearers are established as illustrated in Figure 6.5.1-1 (copied from TS 23.060 [1].

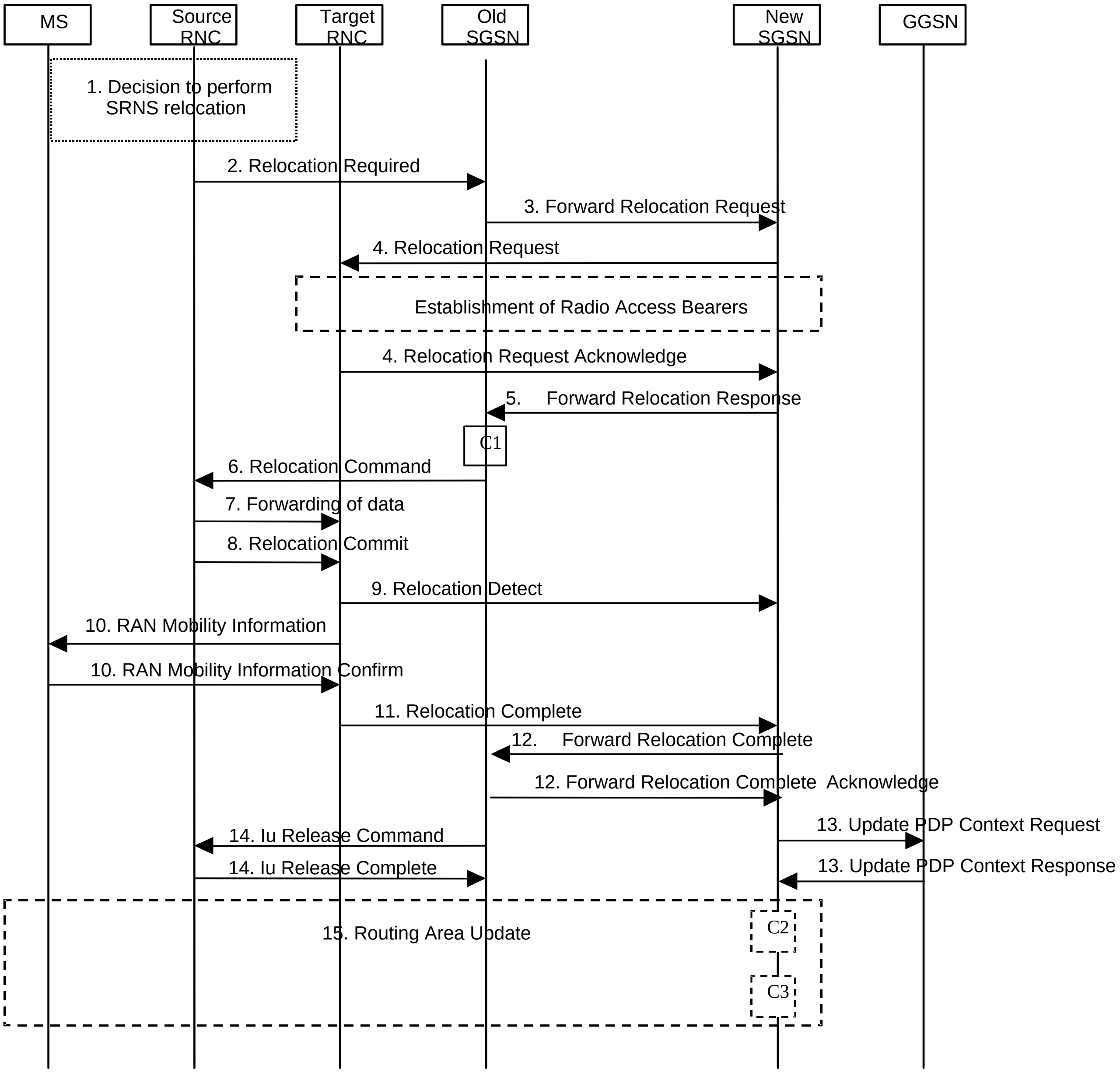


Figure 6.5.1-1: SRNS Relocation procedure

1-3) Steps 1 to 3 are as described in 3GPP TS 23.060 [1].

4) The new SGSN makes the decision to enable direct tunnel before it starts the establishment of Radio Access Bearers, this has following consequences:

- in Inter-SGSN relocation two tunnels are always established, because at the time when the new SGSN establish the RABs to target RNC there is not yet enough information available in the new SGSN to make a decision to establish direct tunnel e.g. CAMEL CSI comes from HLR in step 15) Routing Area Update.
- in Intra-SGSN case direct tunnel can be maintained if it was enabled in the source RNC.

5-15) Steps 5 to 15 are as described in TS 23.060 [1].

NOTE: After Inter-SGSN change the direct tunnel between RNC and GGSN can be enabled again when the RABs are re-established.

Optionally, if the CAMEL services are not active, then it is possible to establish the single tunnel between Target RNC and GGSN during the SRNS relocation procedure itself. The description of flows in figure 6.5.1-1 would then be as follows:

1-2) Step 1 and 2 are as described in TS 23.060 [1].

3) In addition to the text mentioned in TS 23.060 [1], Old SGSN includes UL TE IDs in Forward Relocation Request to New SGSN.

4) In addition to the text mentioned in TS 23.060 [1], the New SGSN includes UL TE IDs to Target RNC in Relocation Request.

5-12) Steps 5 to 12 are as described in TS 23.060 [1].

13) In Update PDP Context, the new SGSN includes UL TE ID and Target RNC UP ID to enable the single tunnel between Target RNC and GGSN.

14-15) Steps 14 to 15 are as described in TS 23.060 [1].

After the SGSN receives the CAMEL information from HSS, the target SGSN shall make the decision whether to keep one tunnel or switch to two tunnels via SGSN.

6.5.2 GGSN Bearer relay

To be described.

6.5.3 GGSN Proxy

For the GGSN Proxy alternative, the SRNS Relocation procedure remains consistent and the same regardless if a subscriber is roaming or not.

The SRNS Relocation procedure for the GGSN Proxy alternative is modified in a similar way for this alternative as when a direct tunnel is used for the other alternatives. Basically a new Update PDP Context message needs to be sent to the GGSN to update the RNC tunnel endpoints in the GGSN. The GGSN Proxy acts as the 'GGSN' in the location management procedures described above and in subclause 6.9.2 of TS 23.060.

6.6 Intersystem change

6.6.1 SGSN optimisation

The 2G-3G intersystem change requires no additional functionality. The data path via the 3G SGSN for data formatting and data forwarding is established when the intersystem change happens.

6.6.1.1 Intra SGSN intersystem change

6.6.1.1.1 Iu mode to A/Gb mode Intra-SGSN Change

If direct tunnel is enabled and MS is PMM_CONNECTED, GGSN is updated in phase 4 as shown in below, otherwise the intersystem change is as described in TS 23.060 [1], clause 6.13.1.1.

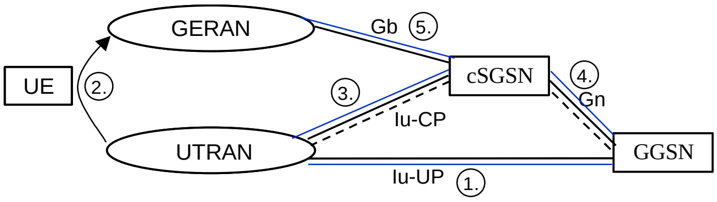


Figure 6.6.1-1: Iu mode to A/Gb mode Intra-SGSN Change

1. Before the intersystem change direct tunnel exist between RNC and GGSN.
2. UE moves from UTRAN to GERAN.
3. Intra SGSN intersystem RAU has started. Data from RNC has been requested.
4. Update PDP context request is sent to GGSN to establish the GTP tunnel between SGSN and GGSN.
5. After the intersystem change normal 2G two tunnel exist (one between BSS and SGSN and one between SGSN and GGSN).

6.6.1.1.2 A/Gb mode to Iu mode Intra-SGSN Change

The decision to enable direct tunnel will be done in phase 4 as shown in below, otherwise the intersystem change is as described in TS 23.060 [1], clause 6.13.1.2.

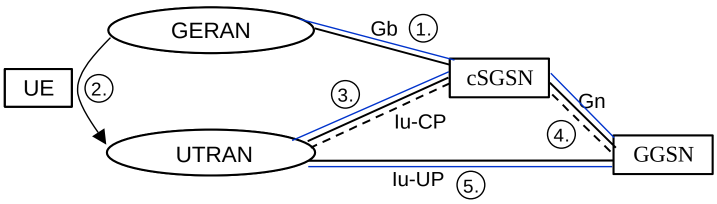


Figure 6.6.1-2 A/Gb mode to Iu mode Intra-SGSN Change

1. Before the intersystem change two tunnel exist (one between BSS and SGSN and one between SGSN and GGSN).
2. UE moves from GERAN to UTRAN
3. Intra SGSN intersystem RAU has started. RAB is established and data is forwarded to RNC.
4. Update PDP context request is sent to GGSN to establish the direct tunnel between RNC and GGSN, GGSN start send data directly to RNC.
5. After intersystem change direct tunnel exist between RNC and GGSN.

6.6.1.2 Inter-SGSN intersystem change

6.6.1.2.1 Iu mode to A/Gb mode Inter-SGSN Change

If direct tunnel is enabled and MS is PMM_CONNECTED, GGSN is updated in phase 4 as part of the existing procedure as described in TS 23.060 [1], clause 6.13.2.1.

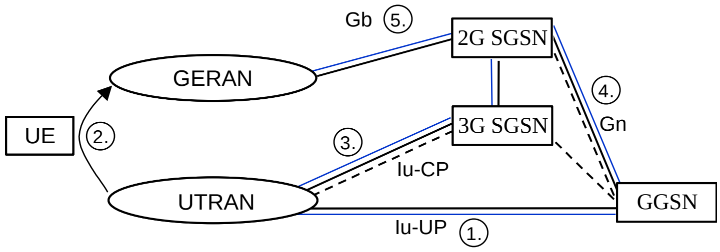


Figure 6.6.1-3: Iu mode to A/Gb mode Inter-SGSN Change

1. Before the intersystem change direct tunnel exist between RNC and GGSN.
2. UE moves from UTRAN to GERAN.
3. Old 3G-SGSN sends data forward command to RNC that starts duplicating and tunnelling the buffered GTP PDUs to the old 3G-SGSN that further tunnels these to the new 2G-SGSN(this is an existing SGSN functionality where data from RNC is requested and forwarded through 3G-SGSN to 2G-SGSN).
4. PDP context updated. Tunnel end point is changed to 2G-SGSN and the GTP tunnel is established between 2G-SGSN and GGSN.
5. After the intersystem change normal 2G two tunnel exist (one between BSS and SGSN and one between SGSN and GGSN).

6.6.1.2.2 A/Gb mode to Iu mode Inter-SGSN Change

The decision to enable direct tunnel will be done in phase 4 as shown in below, otherwise the intersystem change is as described in TS 23.060 [1], clause 6.13.2.2.

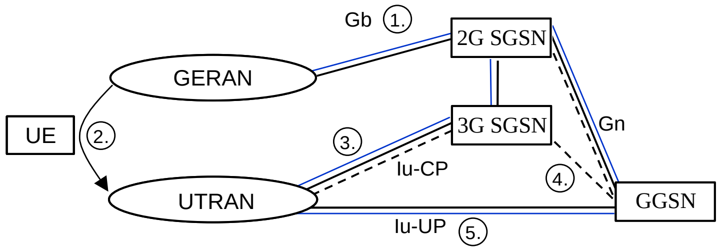


Figure 6.6.1-4: A/Gb mode to Iu mode Inter-SGSN Change

1. Before the intersystem change two tunnel exist (one between BSS and 2G-SGSN and one between 2G-SGSN and GGSN).
2. UE moves from GERAN to UTRAN
3. Inter SGSN intersystem RAU has started. 2G SGSN forward data to 3G SGSN. RAB is established and data is forwarded to RNC.
4. PDP context updated, direct tunnel is established between RNC and GGSN and GGSN start send data directly to RNC.
5. After intersystem change direct tunnel exist between RNC and GGSN.

6.6.1.3 Intersystem change in roaming scenario

In SGSN controlled bearer optimization solution all roaming cases are handled with two tunnel so all kind of intersystem change scenarios works as defined in 23.060.

6.6.2 GGSN Bearer Relay

To be described.

6.6.2.1 Intra SGSN intersystem change

6.6.2.1.1 Iu mode to A/Gb mode Intra-SGSN Change

6.6.2.1.2 A/Gb mode to Iu mode Intra-SGSN Change

6.6.2.2 Inter-SGSN intersystem change

6.6.2.2.1 Iu mode to A/Gb mode Inter -SGSN Change

6.6.2.2.2 A/Gb mode to Iu mode Inter-SGSN Change

6.6.2.3 Intersystem change in roaming scenario

6.6.3 GGSN Proxy

Intersystem change in the GGSN Proxy configuration is shown without forwarding. The assumption is that this procedure is mainly used for PDP contexts with non-real-time traffic (as opposed to the Inter-RAT PS Handover procedure which is used for real-time traffic). Some packet loss may be experienced but when the TCP transport protocol is used, TCP will ensure that lost packets are re-transmitted. Appropriate configuration in a network may also ensure that the intersystem change is only executed infrequently.

6.6.3.1 Intra SGSN intersystem change

6.6.3.1.1 Iu mode to A/Gb mode Intra SGSN Change

If direct tunnel is enabled and MS is PMM_CONNECTED, GGSN is updated in phase 3 as shown in below, otherwise the intersystem change is as described in 3GPP TS 23.060 [1] clause 6.13.1.1.

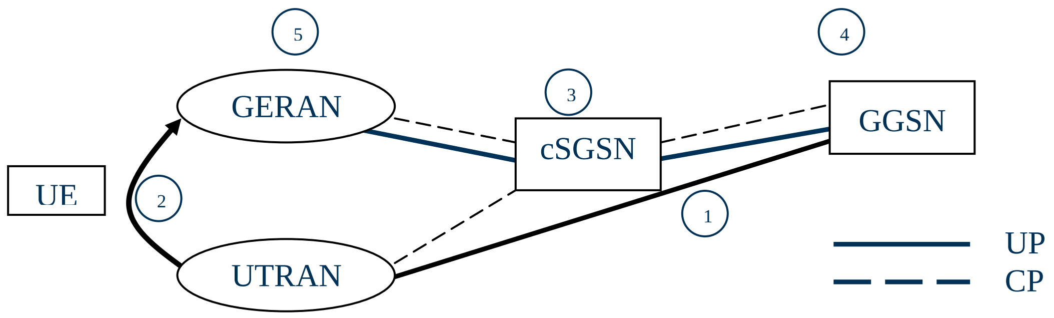


Figure 6.6.3-1: Iu mode to A/Gb mode Intra-SGSN Change

1. Before the intersystem change a direct tunnel exist between RNC and GGSN.
2. UE moves from UTRAN to GERAN.

3. Intra SGSN intersystem RAU has started. The cSGSN identifies a change of RAT, an SGSN UP TEID is allocated and the GGSN may be ordered to start bi-casting downlink payload (to cSGSN and RNC) during the intersystem change procedure.

4. UE is confirmed in GERAN through RAU procedure (reception of RAU Complete) and the GGSN may be informed to stop bi-casting and delete "old" tunnel towards RNC.

5. After the intersystem change a normal 2G two tunnel exist (one between BSS and cSGSN and one between cSGSN and GGSN).

6.6.3.1.2 A/Gb mode to Iu mode Intra-SGSN Change

The decision to enable direct tunnel will be done in phase 3 as shown in below, otherwise the intersystem change is as described in TS 23.060 [1], clause 6.13.1.2.

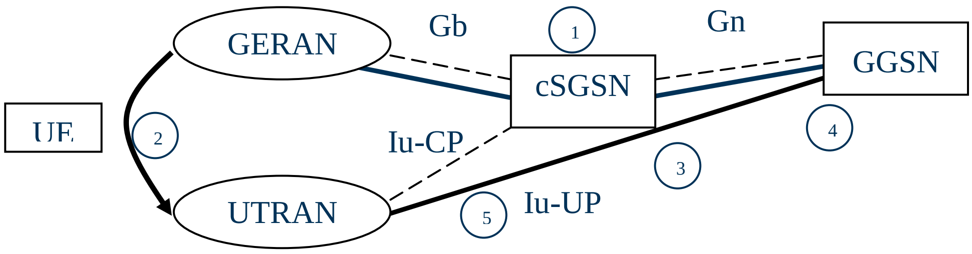


Figure 6.6.3-2: A/Gb mode to Iu mode Intra-SGSN Change

1. Before the intersystem change two tunnels exist (one between BSC and cSGSN and one between cSGSN and GGSN).

2. UE moves from GERAN to UTRAN.

3. Intra SGSN intersystem RAU has started. The cSGSN identifies a change of RAT and the user plane TEID value in the GGSN is set to "not allocated ". It is indicated to GGSN that paging shall not be triggered. The GGSN may buffer or drop any downlink packets during the intersystem change procedure.

4. UE is confirmed in UTRAN through RAU procedure (reception of RAU Complete), RAB's are setup towards the RNC and the GGSN is informed about the RNC user plane TEID received in the RAB Assignment Response message(s). Payload is resumed.

5. After the intersystem change a direct tunnel exists between RNC and GGSN.

6.6.3.2 Inter-SGSN intersystem change

6.6.3.2.1 Iu mode to A/Gb mode Inter -SGSN Change

If direct tunnel is enabled and MS is PMM_CONNECTED, GGSN is updated in phase 4 as part of the existing procedure as described in TS 23.060 [1], clause 6.13.2.1.

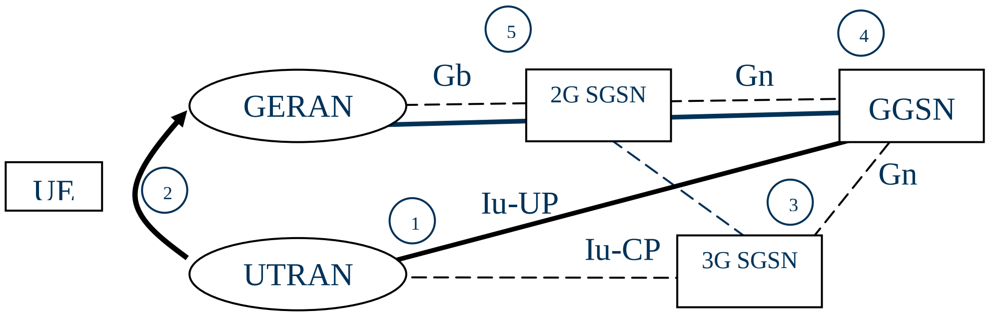


Figure 6.6.3-3: Iu mode to A/Gb mode Inter-SGSN Change

1. Before the intersystem change a direct tunnel exist between RNC and GGSN.
2. UE moves from UTRAN to GERAN.
3. Inter SGSN intersystem RAU has started. An SGSN Context Request is received in the 3G SGSN. The GGSN may be ordered to start bi-casting downlink payload (to 2G SGSN and RNC) during the intersystem change procedure.
4. GGSN is updated according to normal intersystem change procedure, this time with the 2G SGSN UP TEID and payload is resumed. Any bi-casting is ordered to be stopped and "old" tunnel towards RNC deleted.
5. After the intersystem change a normal 2G two tunnel exist (one between BSS and 2G SGSN and one between 2G SGSN and GGSN).

6.6.3.2.2 A/Gb mode to Iu mode Inter-SGSN Change

described in TS 23.060 [1], clause 6.13.2.2.

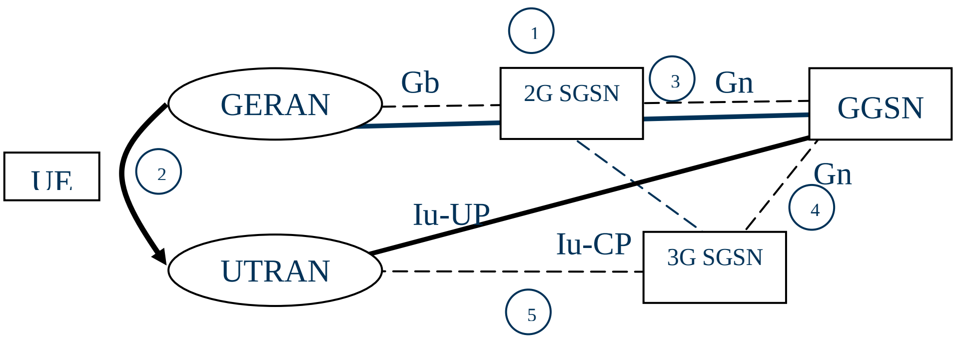


Figure 6.6.3-4: A/Gb mode to Iu mode Inter-SGSN Change

1. Before the intersystem change two tunnels exist (one between BSS and 2G SGSN and one between 2G SGSN and GGSN).
2. UE moves from GERAN to UTRAN.
3. Inter SGSN intersystem RAU has started. An SGSN Context Request is received in the 2G SGSN. The SGSN UP TEID value in GGSN is then set to "not allocated". It is indicated to GGSN that paging shall not be triggered. Any DL payload may be buffered or dropped.
4. GGSN is updated with the RNC UP TEID after RAB(s) are established.
5. After the intersystem change a direct tunnel exists between RNC and GGSN.

6.6.3.3 Intersystem change in roaming scenario

Roaming cases are handled as described in 6.5a.3.1 and 6.5a.3.2 with the GGSN being replaced by a GGSN Proxy in the VPLMN. The assumption is that a GGSN Proxy is used in the 2G roaming case as well to achieve the benefits with GGSN Proxy.

In case a GGSN Proxy is not used for 2G, the 3G SGSN uses a Create PDP Context message with a new relocate flag (described in the PLMN Roaming sub-clause) to introduce the GGSN Proxy in the VPLMN at A/Gb to Iu mode Inter-SGSN Change. Similarly the Delete PDP Context with a new relocate flag (see the PLMN Roaming sub-clause) is used to "remove" the GGSN Proxy in the VPLMN at Iu to A/Gb mode Inter-SGSN Change.

The HPLMN is unaffected by any use of the One Tunnel feature in the VPLMN since no new control communication is needed over the Gp interface.

6.7 PS handover

The PS Handover procedure is described in TS 43.129. One of the main purposes with the PS Handover feature is to minimize the interruption time at handover for realtime critical traffic, e.g. IP telephony. An important part of the PS Handover procedure to achieve that is the ability to ensure that packet data loss is minimized during the handover.

An issue with OTS in relation to PS Handover does exist in the intra-SGSN case, e.g. in step 2 for figure 12 (see note 1 below):

> *"2. When receiving the **Relocation Request Acknowledge** message the 3G/2G SGSN may, based on QoS, start downlink N-PDU relay and duplication to the target RNC/BSS"*

With OTS deployed on the 3G side the SGSN will not be able to start downlink PDU relay to the RNC.

A similar issue in relation to PS Handover exists in the inter-SGSN case, e.g. in step 2 for figure 14 (see note 2 below):

> *"2. When receiving the **Forward Relocation Response** message the old SGSN may, based on QoS, start downlink N-PDU relay and duplication to the target RNC/BSS via the new SGSN (if a Tunnel Endpoint is available) as follows..."*

With OTS deployed on the 3G side the new SGSN will not be able to start downlink PDU relay to the RNC.

These issues above will have impact on the One Tunnel feature. It is FFS what solution to use and if there are any differences in the solution for the three alternatives.

NOTE 1: "Figure 12" refers to figure 12 in clause 5.2.1.2 in TS 43.129 (Intra-SGSN GERAN A/Gb mode to UTRAN/GERAN Iu mode HO; Execution phase).

NOTE 2: "Figure 14" refers to figure 14 in clause 5.2.2.2 in TS 43.129 (Inter-SGSN GERAN A/Gb mode to UTRAN/GERAN Iu mode HO; Execution phase).

6.7.1 SGSN optimisation

Two different alternatives are identified and described in below, alternative A is selected to be the preferred solution as it does not impact GGSN.

6.7.1.1 Alternative A

Intra-SGSN PS Handover

a) From A/Gb to Iu case, the SGSN duplicate the packets to target RNC. At the end of Handover execution phase direct tunnel is enabled for Iu mode.

b) From Iu to A/Gb case, packets received by the source RNC are forwarded to target BSS via the SGSN. At the end of HO procedure user plane addresses are updated so that SGSN start receive packets from GGSN.

Inter-SGSN PS Handover

a) From A/Gb to Iu case, the old SGSN forward the packets to target RNC via the new SGSN. At the end of Handover execution phase direct tunnel is enabled for Iu mode.

b) From Iu to A/Gb case, packets received by the source RNC are forwarded via old and new SGSN to target BSS. At the end of HO procedure user plane addresses are updated so that SGSN start receive packets from GGSN.

6.7.1.2 Alternative B

The PS handover procedure from the GERAN A/Gb mode to the GERAN/UTRAN Iu mode is not impacted by the OTS because the in GERAN A/Gb mode the two tunnels are always used in the SGSN. So it is possible for the SGSN to duplicate and relay the downlink data.

For PS handover procedure from the GERAN/UTRAN Iu mode to the GERAN A/Gb mode, if the OTS is deployed in the old SGSN, the data cannot be forwarded via the old SGSN as the old SGSN is not in the user plane path. The following is one solution with some impacts on GGSN for this issue.

Step 1: After the handover preparation period the new SGSN brings the new SGSN user plane tunnel information to the GGSN in an Update PDP context request message to establish the user plane between the new SGSN and GGSN.

Step 2: The GGSN stores both of the SGSN tunnel information and the source RNC/BSS tunnel information. After receiving the Relocation Command the RNC forwards the downlink N-PDU back to the GGSN and the GGSN forwards this N-PDU to the to the new SGSN.

Step 3: After the PS handover complete the new SGSN informs the GGSN to remove the RNC/BSS tunnel

6.7.2 GGSN Bearer relay

To be described.

6.7.3 GGSN Proxy

Two different approaches for PS Handover in a GGSN Proxy configuration are described, PS Handover using Bi-casting and PS Handover using Forwarding.

Editor's Note: At the current stage, the recommended approach is using bi-casting, since PS Handover is designed for real-time traffic, which is sensitive to delay and delay variation, but robust to some packet loss. However further studies may be required to make a final decision.

Only the Inter-RAT cases are affected by the GGSN proxy solution.

6.7.3.1 PS Handover using Bi-casting

The Bi-casting approach should minimize delay and delay variation of packets during Inter-RAT handover. This means some minor packet loss or packet duplication may be experienced.

6.7.3.1.1 Intra SGSN Inter-RAT PS Handover

1. Preparation phase:

At the end of the preparation phase an Update PDP Context procedure is initiated towards the xGGSN containing IE bicast_address.

This address shall be used by the xGGSN for bi-casting of downlink payload, in A/Gb to Iu case then the RNC user plane TEID shall be included, in Iu to A/Gb mode the 2G/3G SGSN user plane TEID shall be included. Corresponding IP addresses shall also be included in the Update PDP Context Request message.

2. Execution phase:

   The cSGSN shall, after the UE has confirmed its presence in "target" RAN, inform the xGGSN to stop bi-casting by initiating another Update PDP Context procedure with IE bicast_address empty. The xGGSN shall then only send downlink payload to the user plane TEID included in the Update PDP Context Request message and stop sending payload to all other user plane TEID(s).

6.7.3.1.2 Inter SGSN Inter-RAT PS Handover

1. Preparation phase:

   Directly before Forward Relocation Response is sent from target SGSN, during the preparation phase, an Update PDP Context procedure is initiated towards the xGGSN containing IE bicast_address.

   This address shall be used by the xGGSN for bi-casting of downlink payload, in A/Gb to Iu case then the RNC user plane TEID shall be included, in Iu to A/Gb mode the 2G SGSN user plane TEID shall be included. Corresponding IP addresses shall also be included in the Update PDP Context Request message.

2. Execution phase:

   The cSGSN shall, during the Update PDP Context procedure specified in the execution phase, inform the xGGSN to stop bi-casting by sending the IE bicast_address empty. The xGGSN shall then only send downlink payload to the user plane TEID included in the Update PDP Context Request message and stop sending payload to all other user plane TEID(s).

6.7.3.2 PS Handover using Forwarding

The Forwarding approach should minimize packet loss during Inter-RAT handover. This means some delay and delay variation of packets may be experienced.

In Iu to A/Gb mode the source 3G RNC shall duplicate and forward the downlink packet to the target 2G SGSN via xGGSN. In A/Gb to Iu mode the 2G SGSN shall duplicate and forward the downlink packet to the target 3G RNC/BSS via xGGSN.

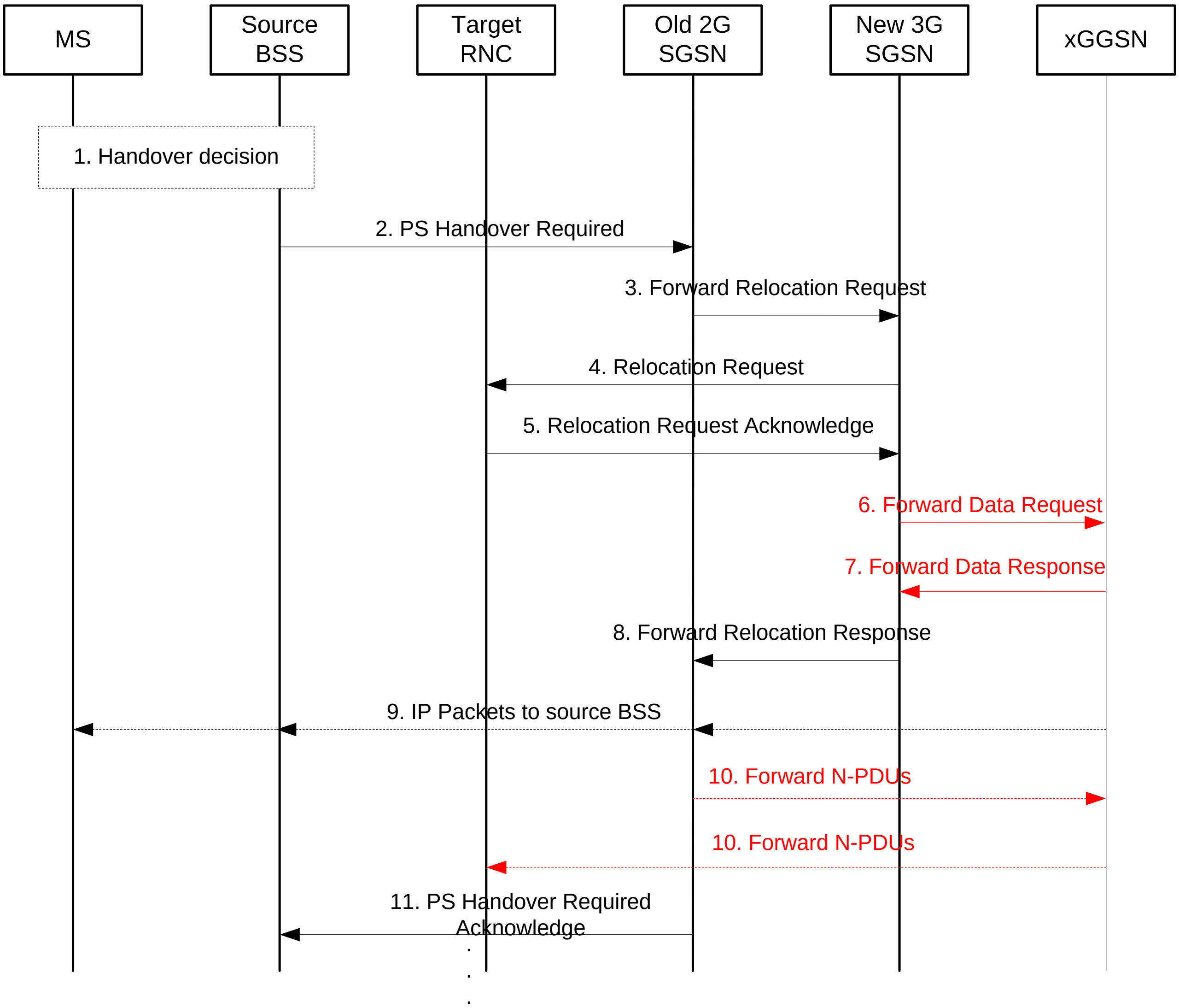


Figure 6.7.3.2-1: Forwarding during GERAN A/Gb mode to UTRAN Iu mode handover

1. Preparation phase:

   At the end of the preparation phase an Forward Data Request procedure is initiated towards the xGGSN containing Tunnel Endpoint Identifier of Target RNC. The Tunnel Endpoint Identifier of Target RNC shall be used by the xGGSN for data forwarding of downlink payload. Corresponding Tunnel Endpoint Identifier of xGGSN shall also be included in the Forward Data Response message. The Tunnel Endpoint Identifier of xGGSN shall be used by the 2G SGSN for data forwarding of downlink payload.

2. Execution phase:

   2G SGSN forwards downlink data to the target RNC via the xGGSN.

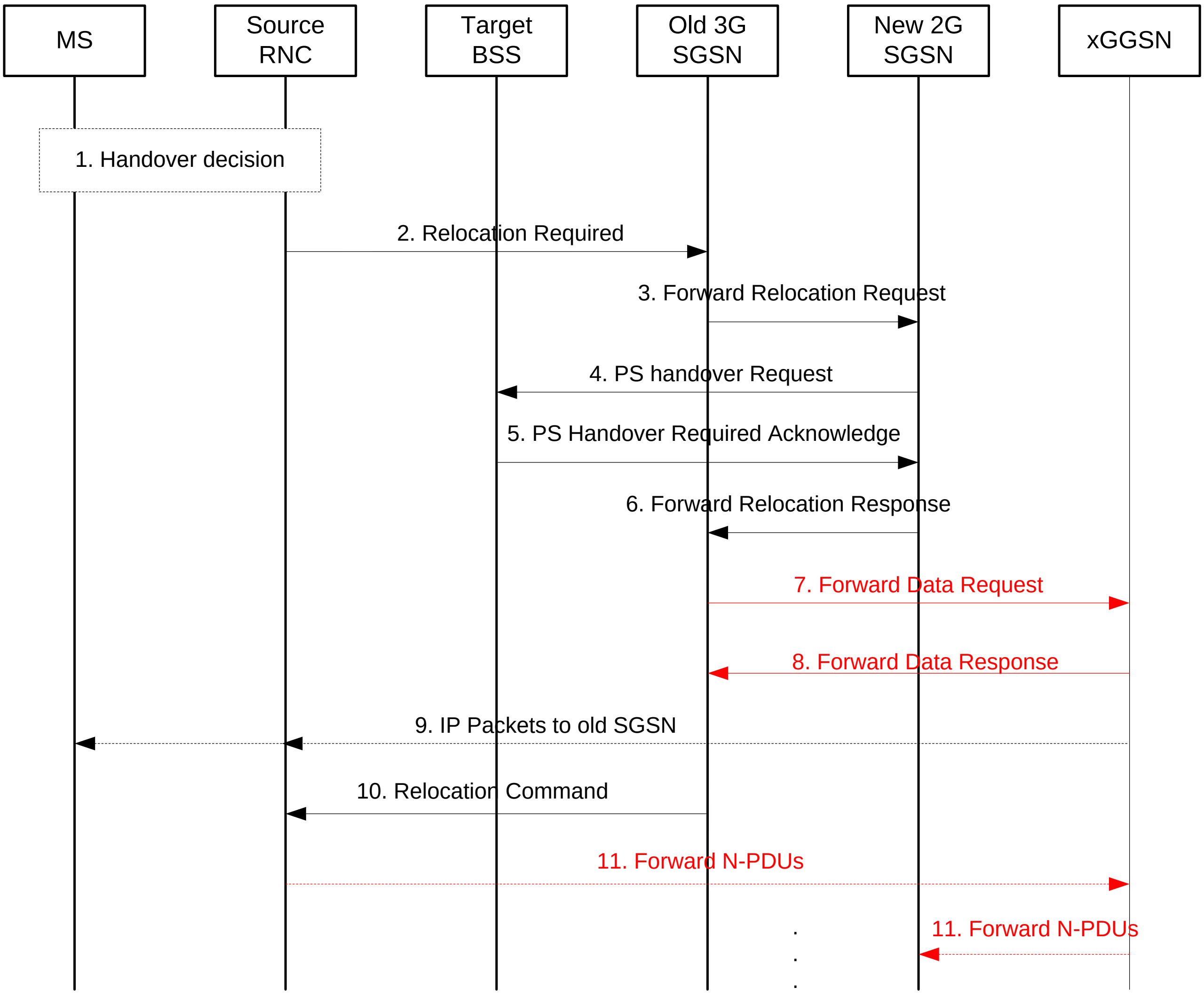


Figure 6.7.3.2-2: Forwarding during UTRAN Iu mode to GERAN A/Gb mode handover

1. Preparation phase:

   At the end of the preparation phase an Forward Data Request procedure is initiated towards the xGGSN containing Tunnel Endpoint Identifier of 2G SGSN. The Tunnel Endpoint Identifier of 2G SGSN shall be used by the xGGSN for data forwarding of downlink payload. Corresponding Tunnel Endpoint Identifier of xGGSN shall also be included in the Forward Data Response message. The Tunnel Endpoint Identifier of xGGSN shall be used by the Target RNC for data forwarding of downlink payload.

2. Execution phase:

   3G SGSN informs the Tunnel Endpoint Identifier of xGGSN to the source RNC during Relocation Command procedure.

   The source RNC forwards downlink data to the 2G SGSN via the GGSN.

6.8 Paging

Editors Note: This subclause discusses how paging initiation is done on the reception of a downlink PDU for a mobile in PMM-IDLE.

6.8.1 SGSN optimisation

As described in subclause 6.3.1 the principle of this solution is that whenever the RAB assigned for a PDP context is released without deactivating the PDP context (i.e. the PDP context is preserved) the GTP-U tunnel is established between the GGSN and SGSN in order to be able to handle the downlink packets.

When the SGSN receives a downlink packet (e.g. user data) for an MS in PMM-IDLE state, the SGSN sends a paging request to RAN. The paging request triggers the Service Request procedure in the MS as illustrated in Figure 6.8.1-1 (copied from 3GPP TS 23.060 [1].

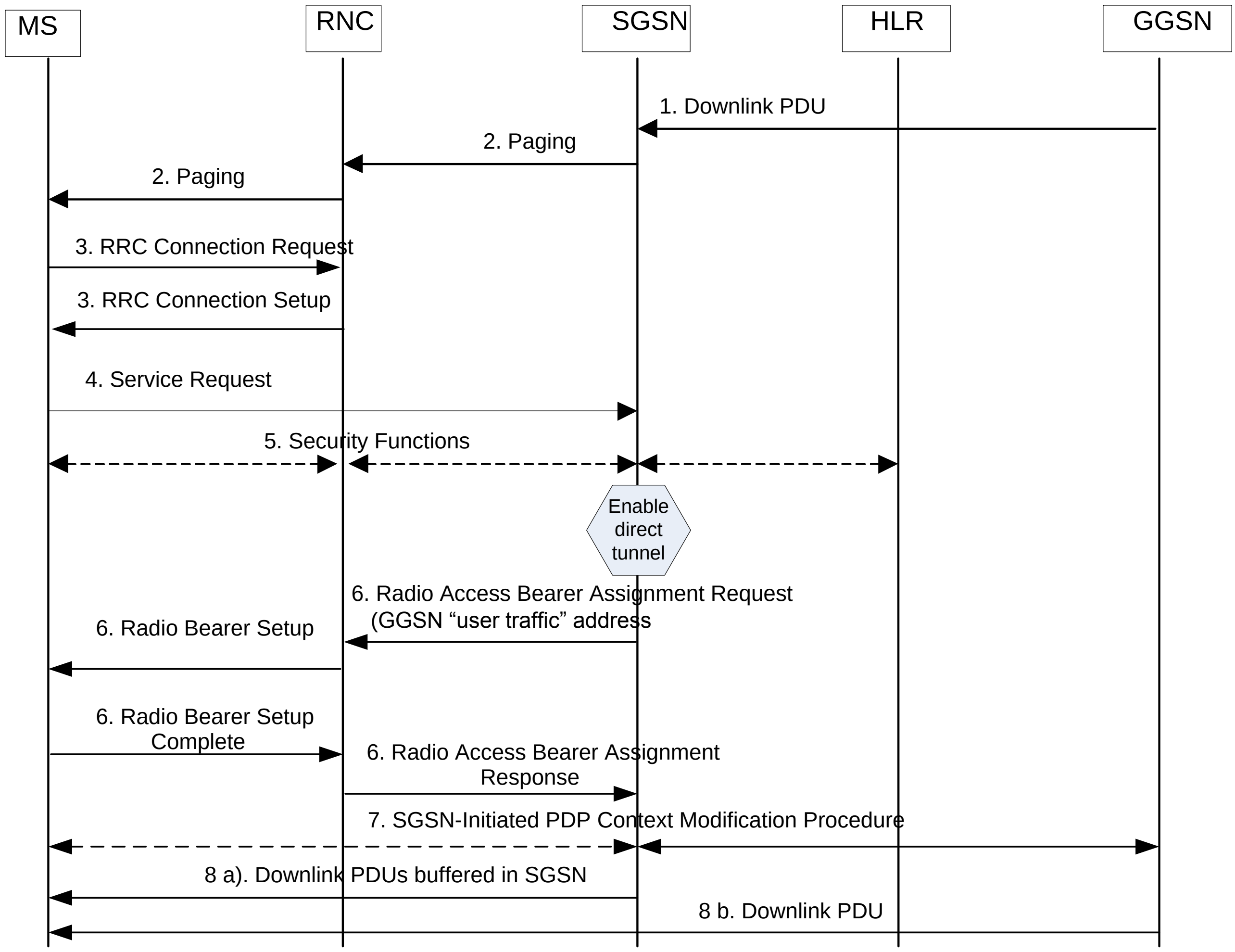


Figure 6.8.1-1: Network Initiated Service Request procedure

1-5) Steps 1 to 5 are as described in 3GPP TS 23.060 [1].

6) If the SGSN decide enable direct tunnel RNC receives GGSN address for "user traffic" in the RAB assignment procedure.

7) After SGSN received RNC "user traffic" address in the RAB Assignment Response and if direct tunnel was enabled the SGSN shall send Update PDP Context Request to GGSN and include the RNC address for "user traffic (Note: this may be part of the QoS profile modification if RAB was established with modified QoS). The PDP Context is also updated (7) every time towards the GGSN with the TEID-U and user plane IP-address of the RNC, in order to complete the 1T establishment. Otherwise there are no changes to this procedure.

8) Direct tunnel establishment will not result in any packet loss. RNC may possibly receive packets from the SGSN and GGSN at the same time, when the SGSN forwards the buffered packets and the GGSN starts the downlink transfer. Also packets may be received in a different order at the RNC than when they arrived at the GGSN. This is not a an issue since the end users application will re-order the packets.

6.8.2 GGSN Bearer relay

To be described.

6.8.3 GGSN Proxy

Paging is initiated when DL packets arrives at the GGSN, for a PDP context having RNC TEID set to 'not allocated'. The first DL packet (possibly including subsequent packets) is buffered in GGSN. The GGSN sends a Paging Notification on the existing GTP-C tunnel to the SGSN to start the paging. The SGSN responds by doing a paging and setting up a new RAB. The TEID and IP address of the GGSN is stored in the SGSN and is used when the RAB is re-established. The new RNC TEID and IP address returned to the SGSN in the RAB establishment is then provided to the GGSN, and the GGSN can start to send DL packets. The first packets it sends are the buffered packets.

The Paging Notification message is a new message. It has some similarities to the existing PDU Notification message, but the Paging Notification is sent on an already existing GTP-C tunnel. The PDU Notification if different in that there is no GTP-C tunnel or PDP Context that can be used, as the purpose in that case is to create a PDP Context. In the Paging Notification case a PDP context already exists, and the purpose is to re-establish a released user plane.

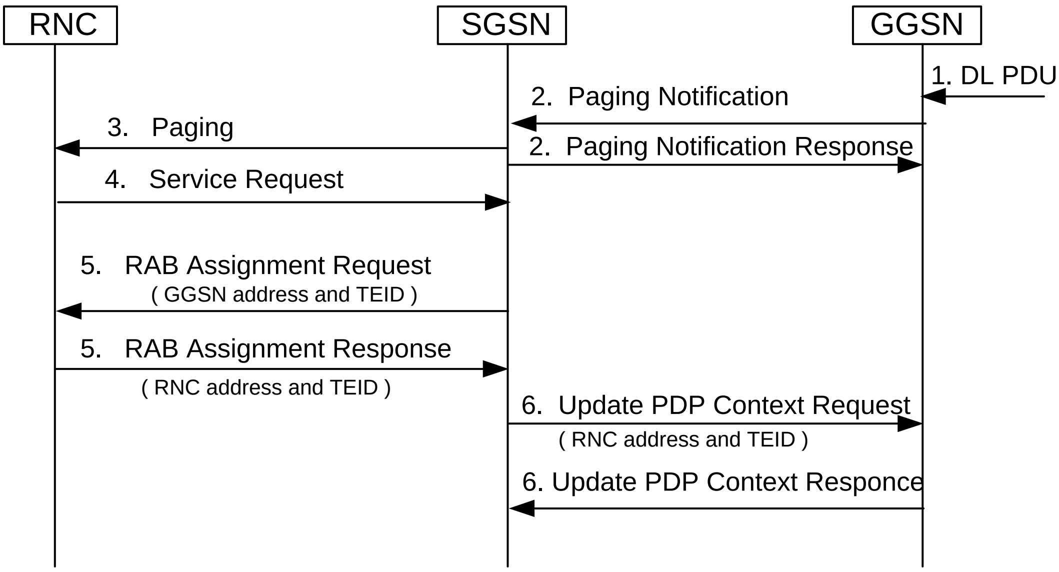


Figure 6.8.3-1: Paging Notification

6.9 IP version interworking

Editors note: This sub clause discusses of how the different Transport Network options supported on the Gn and Iu-PS interfaces will be handled when direct tunnel is used.

Within the network area where direct tunnel is used RNC and GGSN/xGGSN should support same IP version (IPv4 or IPv6). IP version interworking is dependent of the solution.

6.10 Relay function support

Editors note: The relay function of a network node transfers the PDP PDUs received from the incoming link to the appropriate outgoing link.

6.10.1 SGSN optimisation

This solution does not require to add GTP-U relay functionality in GGSN.

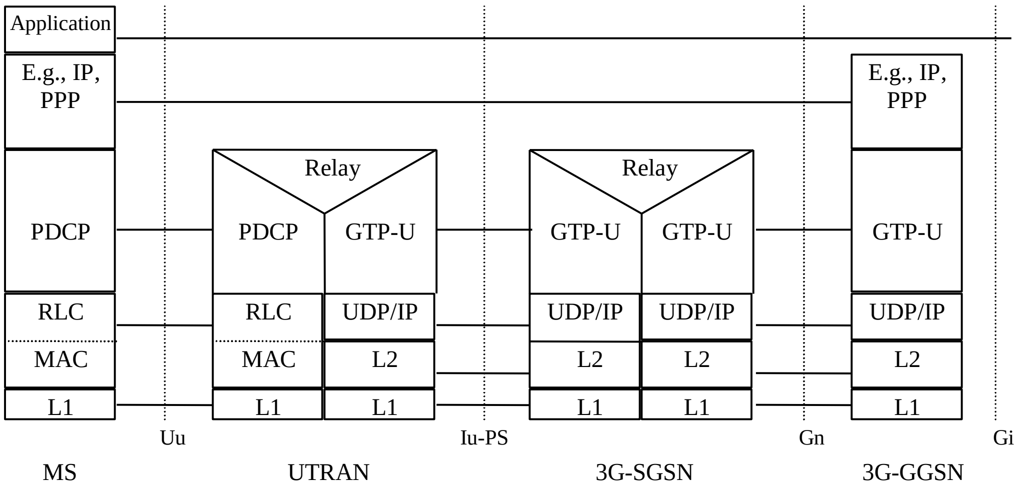


Figure 6.10.1-1: User Plane with UTRAN

The relay capability of SGSN is used as today in the cases when direct tunnel has not been enabled (in case of CAMEL, Lawful Interception and for roaming cases).

NOTE: Also for 2G SGSN relay function is needed and cannot be complete removed from the SGSN.

6.10.2 GGSN Bearer relay

To be described.

6.10.3 GGSN Proxy

For the GGSN Proxy alternative no impact is expected to the Relay function at the RNC and the GGSN (Proxy). At the SGSN the Relay function may be optionally removed.

6.11 Encapsulation function support

Editors note: Encapsulation is the addition of address and control information to a data unit for routeing packets within and between the PLMN(s). Decapsulation is the removal of the addressing and control information from a packet to reveal the original data unit.In 3G, two different encapsulation schemes are used; one for the backbone network between two GSNs and between an SGSN and an RNC.

6.11.1 SGSN optimisation

In Iu mode same encapsulation scheme (GTP) is used for both GSN-GSN and SGSN-RNC interfaces. So direct tunnel between RNC and GGSN in Iu mode does no require any changes to encapsulation schemes.

Encapsulation function(ref. 3GPP TS 23.060 [1], clause 9.6

GPRS transparently transports PDP PDUs between packet data networks and MSs. All PDP PDUs are encapsulated and decapsulated for routeing purposes. Encapsulation functionality exists at the MS, at the RNC, at the Iu mode BSC, at the SGSN, and at the GGSN. Encapsulation allows PDP PDUs to be delivered to and associated with the correct PDP context in the MS, the SGSN, or the GGSN. Two different encapsulation schemes are used; one for the backbone network between two GSNs and between an SGSN and an RNC, and one for the A/Gb mode connection between the SGSN and the MS or for the Iu mode RRC connection between the RAN and the MS.

6.11.2 GGSN Bearer relay

To be described.

6.11.3 GGSN Proxy

For the GGSN Proxy alternative no impact is expected to the Encapsulation function at the RNC, the SGSN , or the GGSN (Proxy).

6.12 Error Indication

GSN/RNC sends GTP-U error indication if it can not find the PDP context or RAB for the received G-PDU. When direct tunnel is established between RNC and GGSN, possible GTP-U error indication is sent from GGSN to RNC or vice versa.

In such case SGSN does not receive information about PDP context or RAB release immediately because also GTP-U error indication bypasses SGSN.

6.12.1 Rel-6 Error Indication

SGSN failure (ref. TS 23.060 [1], clause 13.8.2)

> *When the SGSN receives a GTP-U PDU from the GGSN for which no PDP context exists, it shall discard the GTP-U PDU and send a GTP error indication to the originating GGSN. The GGSN shall mark the related PDP context as invalid.*
>
> *When the SGSN receives a GTP-U PDU from the RNC for which no PDP context exists, the SGSN shall discard the GTP-U PDU and send a GTP error indication to the originating RNC. The RNC shall locally release the RAB.*

GGSN Failure (ref. 3GPP TS 23.060 [1], clause 13.8.3)

> *When the GGSN receives a GTP-U PDU for which no PDP context exists, it shall discard the GTP-U PDU and return an error indication to the originating SGSN. The SGSN shall mark the related PDP context as invalid and send a Deactivate PDP Context Request message to the MS. The MS may then reactivate the PDP context.*

RNC Failure (ref. TS 23.060 [1], clause 13.8.6)

> *When the RNC/BSC receives a GTP-U PDU from the SGSN for which no RAB context exists, the RNC/BSC shall discard the GTP-U PDU and return a GTP error indication to the originating SGSN. The SGSN shall locally release the RAB. The SGSN should preserve the associated PDP context. The SGSN may initiate the RAB Assignment procedure in order to re-establish the RAB.*

6.12.2 SGSN optimisation

If direct tunnel is enabled and GGSN sends GTP error indication, RNC just releases the RAB locally. If RNC sends error indication then GGSN marks the PDP context as invalid. As SGSN does not receive the error indication this may cause PDP context hanging in the SGSN for some period of time.

SGSN recovers from the error when one of the following occurs:

1) When RNC receives GTP-U error indication for the last RAB of the Iu connection, then Iu release procedure is executed.

2) If UE tries to send data through the PDP context then MS initiated Service Request for data is received by SGSN at the point when all RABs are established already according to SGSN. Then SGSN need to check status of PDP context from GGSN by sending PDP context update message. If GGSN does not know the PDP context any more it need to be released also from UE by sending Deactivate PDP Context Request to UE.

3) New RABs are established. List of all RABs (also existing ones) are signalled between RNC and SGSN. If RNC responds that some RAB does not exist anymore then SGSN detects the situation and releases PDP context to UE.

4) The inactivity timer expires in RNC and Iu connection is released. Released RAB list is received in Iu release procedure. As described in sub clause 6.3.1 whenever the RAB assigned for a PDP context is released GTP-U tunnel is established between the GGSN and SGSN in order to be able to handle the downlink packets. At this point SGSN gets error response from GGSN if the PDP context does not exist in the GGSN.

6.12.2.1 SGSN optimisation with Improvement

The preservation function allows the active PDP contexts associated with the released RABs to be preserved in the CN, and the RABs can then be re-established at a later stage. The aim of the preservation function is to fast the state transition of MS from idle to active. When direct tunnel is established between RNC and GGSN, possible GTP-U error indication is sent from RNC to GGSN in case RNC failure.

In such case, if the GTP-U error indication is sent from RNC to GGSN, which just indicates that no RAB context existed for related PDP context, the GGSN will preserve the related PDP context for later possible data transfer resuming. The GGSN shall inform the SGSN of the fact when receiving GTP-U error indication from RNC, so that the SGSN can preserve the related PDP context. The SGSN may select to re-establish the RAB. The following is the message flow to depict this concept.

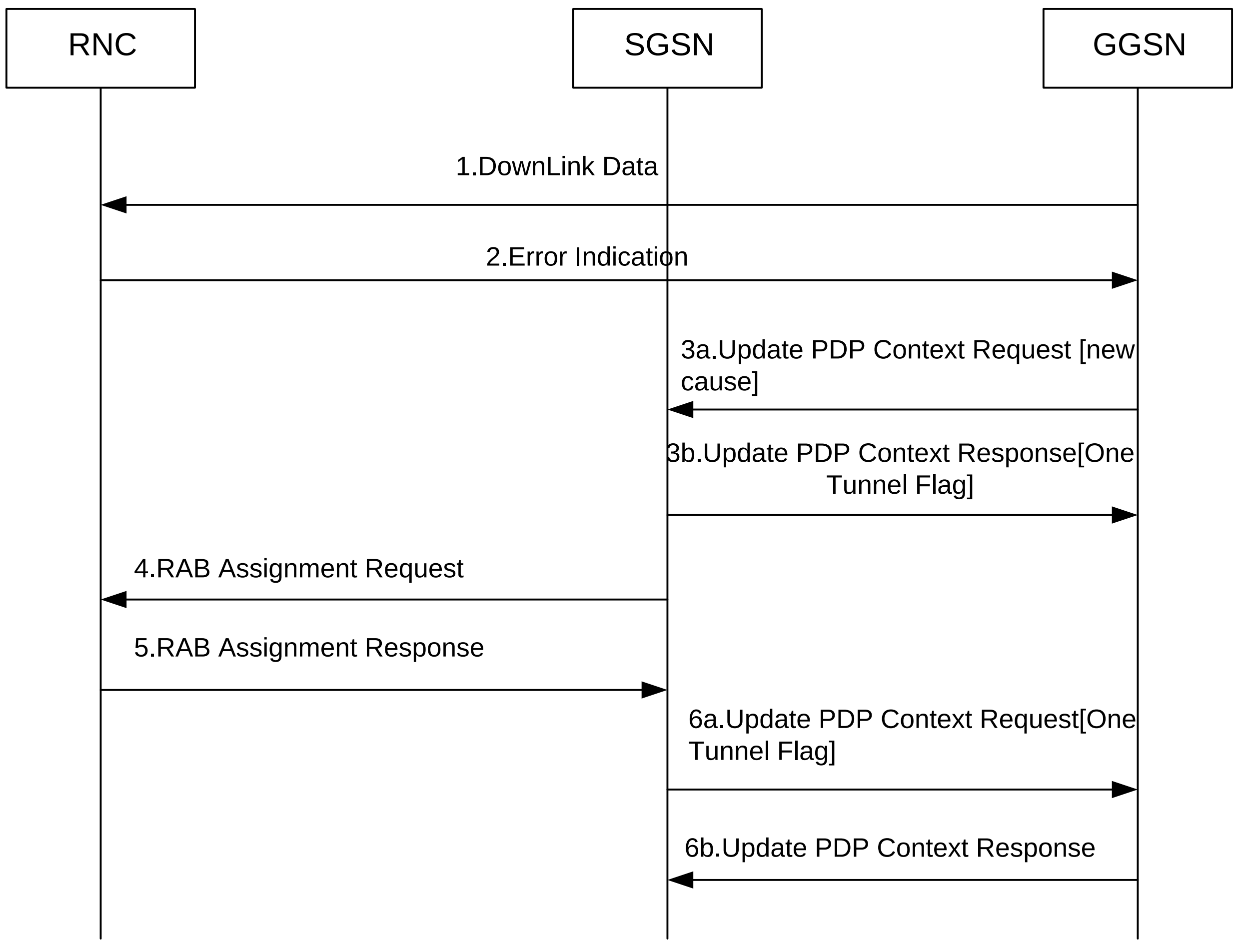


Figure 6.12.2.1-1: Error Indication from RNC handle if direct tunnel enabled

1-2) Steps 1 and 2 are as described in TS 23.060 [1].

3) If direct tunnel was enabled, the GGSN shall send Update PDP Context Request with a new cause which indicates the GGSN receiving an Error Indication from RNC to inform SGSN to preserve the related PDP context. SGSN sends an Update PDP Context Response to GGSN and include it's own address for the "user traffic" in order to be able to handle the downlink packets and trigger paging see clause 6.6.1. And a "One Tunnel Flag" IE included in the response message is to be used to inform GGSN that direct tunnel is disabled. The GGSN shall update the "user traffic" address and use it when sending G-PDUs to the SGSN for the MS.

4) SGSN may initiate RAB assignment to re-establish the RAB immediately after receiving the "Update PDP Context Request" from GGSN, or after receiving the downlink packet from GGSN. RNC receives GGSN address for "user traffic" in the RAB Assignment Request.

5) Step 5 is as described in TS 23.060 [1].

6) After SGSN received RNC "user traffic" address in the RAB Assignment Response and if direct tunnel was enabled the SGSN shall send Update PDP Context Request to GGSN and include the RNC address for "user traffic". And a "One Tunnel Flag" IE included in the request message is to be used to inform GGSN that direct tunnel is enabled. The GGSN shall update the "user traffic" address and use it when sending G-PDUs for the MS.

To achieve this goal, in the PDP Context Activation procedure, the GGSN which supports the One Tunnel Solution shall be known by the SGSN of it's capability of support one tunnel solution so that the SGSN can make decision if direct tunnel could be enabled. The way to achieve this goal can be locally configuration or indicating OTS capability during the negotiation between the SGSN and GGSN. Furthermore, the SGSN shall inform the GGSN if direct tunnel is enabled for each activated PDP context in the GGSN.

The procedure of PDP context activation enabling direct tunnel in Section 6.1.1 needs to be further modified as below:

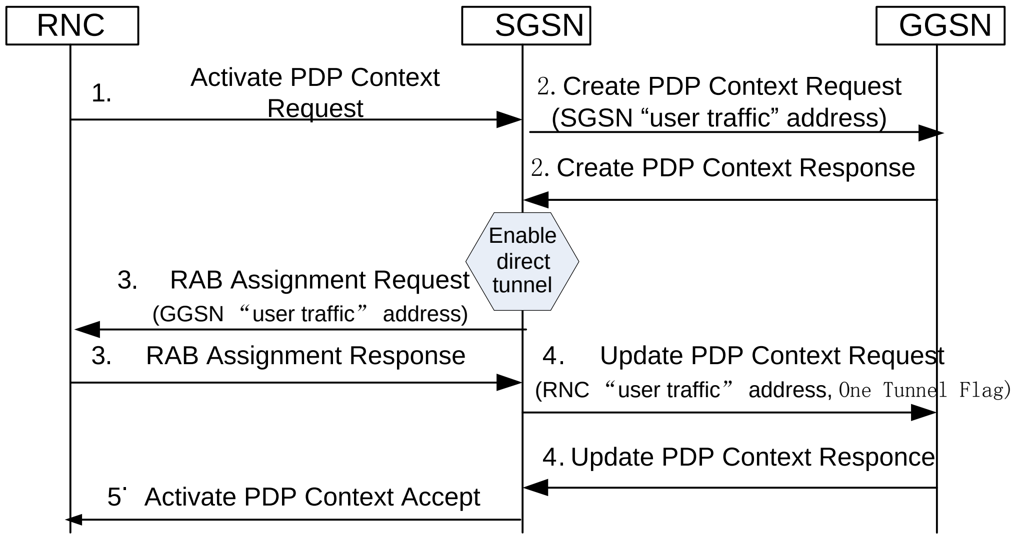


Figure 6.12.2.1-2: PDP context activation enabling direct tunnel

1-2) Steps 1 and 2 are as described in TS 23.060 [1]. The SGSN shall include it's own address for the "user traffic" in the Create PDP Context Request. After the SGSN has received Create PDP Context Response it decides if direct tunnel can be enabled.

3) If the SGSN enabled direct tunnel RNC receives GGSN address for "user traffic" in the RAB Assignment Request.

4) After SGSN received RNC "user traffic" address in the RAB Assignment Response and if direct tunnel was enabled the SGSN shall send Update PDP Context Request to GGSN and include the RNC address for "user traffic". And if direct tunnel between the RNC and GGSN is enabled, the SGSN shall include "One Tunnel Flag=true" in Update PDP Context Request. The GGSN shall update the "user traffic" address and use it when sending G-PDUs for the MS. The GGSN also stores the "One Tunnel Flag" Information in the PDP context for later use when receiving GTP-U error indication from RNC.

If the downlink data transmission start before GGSN receive and use RNC "user traffic" address the SGSN will forward these PDUs to RNC (this is an existing SGSN functionality).

6.12.3 GGSN Bearer relay

To be described.

6.12.4 GGSN Proxy

When an Error Indication is received by the RNC on the direct tunnel from a GGSN, an OTS specific Error Indication shall be sent to SGSN on the signalling connection for the concerned PDP Context. According to TS 23.060 subclause 13.8.3, the SGSN shall then mark the related PDP context as invalid and send a Deactivate PDP Context Request message to the MS. The MS may then reactivate the PDP context.

When an Error Indication is received by the GGSN Proxy on the direct tunnel from an RNC, an OTS specific Error Indication shall be sent to SGSN on the signalling connection (GTP-C tunnel) for the concerned PDP Context. According to TS 23.060 subclause 13.8.6, the SGSN shall then locally release the RAB. The SGSN should preserve the associated PDP context. The SGSN may initiate the RAB Assignment procedure in order to re-establish the RAB.

6.13 Firewalls towards external inter-operator networks

To be described.

6.13.1 SGSN optimisation

In this solution direct tunnel between RNC and GGSN is not used in roaming cases, therefore it does not change external inter-operator interfaces. User layer (and control layer) goes from VPLMN's SGSN through Border Gateway to HPLMN's GGSN. Border Gateways include firewall.

6.13.2 GGSN Bearer relay

To be described.

6.13.3 GGSN Proxy

To be described.

6.14 Network separation and topology hiding

All solutions require that user plane IP addresses of RNCs are visible to Gn network.

This is minor security drawback, but it applies to all solutions. The risk could be reduced by using firewall between Iu and Gn networks instead of simple router. Only IP traffic to predefined IP-addresses/ports from predefined addresses/ports would be allowed between Iu and Gn networks.

There need to be ATM capable IP router in between ATM based Iu network and Gn network as shown in figure 7.6-2. If IP based Iu-PS is used then standard IP router need to be in between the Iu and Gn networks as shown in figure 7.6-1.

6.14.1 SGSN optimisation

Only IP traffic from predefined addresses/ports to predefined addresses/ports is allowed between Iu and Gn networks.

6.14.2 GGSN Bearer relay

To be described.

6.14.3 GGSN Proxy

The GGSN Proxy solution allows topology hiding (only GGSN Proxies may need to be exposed to external networks). This may also facilitate the use of a private address domain for the Gn and Iu subnetworks.

6.15 Traffic routing in Core Network

6.15.1 SGSN optimisation

With this solution most of the user layer traffic is by passing SGSN. It is recommended that a IP router connects Iu and Gn networks as shown in figure 6.7.1-1.

6.15.2 GGSN Bearer relay

To be described.

6.15.3 GGSN Proxy

The user plane traffic in a network built using the GGSN Proxy solution will always be routed in the same way in the operators' core network. Regardless of LI, Charging used , etc. This may for example facilitate traffic management in the CN, and the use of different supplementary probes (e.g. for monitoring, charging etc), and other nodes intervening the traffic (e.g. firewalls, proxies etc).

6.16 CAMEL support

6.16.1 SGSN optimisation

Direct tunnel is not enabled for a subscriber that has controlling CAMEL services active. Standard two tunnels are established in the case.

6.16.2 GGSN Bearer relay

Editors Note: Text from S2-061620 can be used as basis.

6.16.3 GGSN Proxy

To simplify the architecture it is assumed that the One Tunnel and the CAMEL feature does not need to be compatible, i.e. deployed simultaneously in an operators' network. This is based on the assumption that in the timeframe when One Tunnel will be deployed on the market, the large majority of operators should have migrated to the new GGSN based charging possibilities that have been developed in the recent 3GPP releases, including the GGSN based on-line charging functions. For operators still using CAMEL in that timeframe, other possibilities for handling the increased 3G HSPA traffic should also be available, e.g. capacity upgrade of SGSN

6.17 Lawful Interception support

Editor's Note: A deeper analysis of the implications on Lawful Intercept for the different alternatives should be done by WG SA3-LI.

6.17.1 SGSN optimisation

Direct tunnel is not enabled for a subscriber that has active a request to collect communication content from SGSN. Standard two tunnels are established in the case.

6.17.2 GGSN Bearer relay

To be described.

6.17.3 GGSN Proxy

With the GGSN Proxy solution, the GGSN may provide a single point in the network where lawful intercept is done for both roaming and non-roaming traffic. Both the visited and home operator will have the ability to perform lawful intercept in their networks using a single node (the GGSN). Some control plane related information such as SMS and MM-related information does still need to be collected in the SGSN though.

6.18 Charging support

6.18.1 SGSN optimisation

Direct tunnel is not enabled in the roaming case when the visited network need to provide local charging functions. Standard two tunnels are established in this case.

6.18.2 GGSN Bearer relay

To be described.

6.18.3 GGSN Proxy

With the GGSN Proxy solution, the GGSN may become a single point in the network where charging is done for both roaming and non-roaming traffic. Both the visited and home operator will have charging control and policy control over roaming and non-roaming in their networks.

6.19 Legacy GGSN support

6.19.1 SGSN optimisation

This solution work with any GGSN that support GTP protocol version 1 as defined in 3GPP TS 29.090 [3]. SGSN makes the decision when to establish direct tunnel between RNC and GGSN or use two tunnels, this can be configured per APN basis.

6.19.2 GGSN Bearer relay

To be described.

6.19.3 GGSN Proxy

To be described.

6.20 Roaming support

6.20.1 SGSN optimisation

Direct tunnel is not used and visited SGSN provide local charging functions roaming traffic as today. This can be configured per APN basis

6.20.2 GGSN Bearer relay

Roaming is supported with xGGSN as a relay between VPLMN SGSN and HPLMN GGSN.

6.20.3 GGSN Proxy

Roaming is supported with the GGSN Proxy as a relay between VPLMN SGSN and HPLMN GGSN. The GGSN Proxy acts as an SGSN towards the HPLMN GGSN and the normal Gp interface is used between operators as today.

6.21 Limited Connectivity between RNCs and GGSNs

Inter-SGSN RA Update in large scale network or across the PLMNs, the SGSN may need to decide whether to allow the RNC connecting to the GGSN directly or whether another additional user plane node needs to be connected.

6.21.1 SGSN optimisation

To be described.

6.21.2 GGSN Bearer relay

To be described.

6.21.3 GGSN Proxy

To be described.

6.22 Data Volume Report

Data volume reporting function is responsible for reporting unsuccessfully transmitted DL data volume over UTRAN for specific RAB. The RNC shall collect the amount of not transferred downlink data, i.e., data that the RNC has either discarded or forwarded to a 2G-SGSN. The RNC reports the total amount of unsuccessfully transmitted DL data for the RAB to SGSN when the RAB is release. In order to accurate charging, the SGSN deducts the unsuccessfully transmitted DL data volume of RNC from charging record.

Charging is managed in GGSN when direct tunnel is enabled, so charging in the GGSN will be un-accurate if the unsuccessfully transmitted DL data volume of RNC can't be sent to GGSN.

On solution that is common for three alternatives is:

- In the RAB release procedure, RNC reports the unsuccessfully transmitted DL Data Volume to SGSN during the RAB release signalling. And this DL data volume shall be included in Update PDP Context Request message sent from SGSN to GGSN, if direct tunnel was enabled. And the GGSN includes the un-transmitted data volume counts from RNC into charging record.

NOTE 1: The DL Data Volume Report in this sub-clause is not working for Flow Based Charging.

NOTE 2: Whether the DL Data Volume Report is needed or not will be further evaluated.

6.23 Inter-PLMN Mobility Scenarios

6.23.1 SGSN optimisation

There is no specific functionality for such a scenario. The decision for one-tunnel depends as in all other scenarios on GGSN address only.

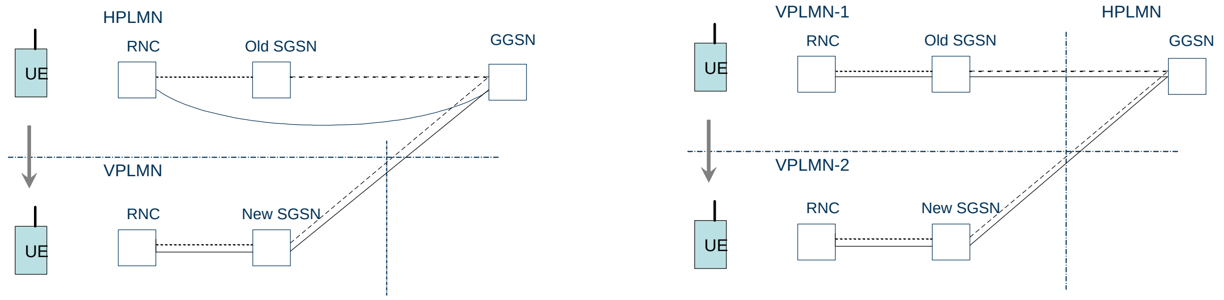


Figure 6.23.1-1: Inter PLMN Roaming

6.23.2 GGSN Bearer relay

6.23.3 GGSN Proxy

The signalling diagram for PLMN roaming showed in figure 6.23.3-2 below is a generic procedure that applies for inter-PLMN Mobility Management procedures in general. It shows the signalling for a UE that roams from one VPLMN to another VPLMN as shown as an overview in figure 6.31.3-1. If one or both of the VPLMN's uses the One Tunnel feature and hence has a GGSN Proxy node configured for roaming traffic, the GGSN Proxy node needs to be switched during MM procedures. Inter PLMN roaming, which is still only rarely deployed in today's GPRS networks, but which can be expected to be more important in the future, is made possible using a new flag in the Create and Delete PDP Context messages. This is explained in the text below figure 6.23.3-2.

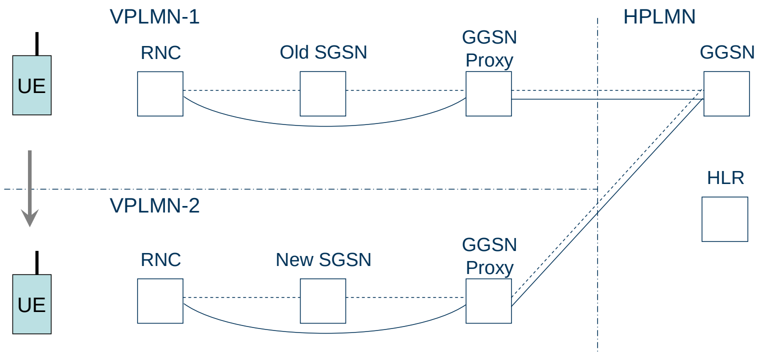


Figure 6.23.3-1: Inter PLMN Roaming

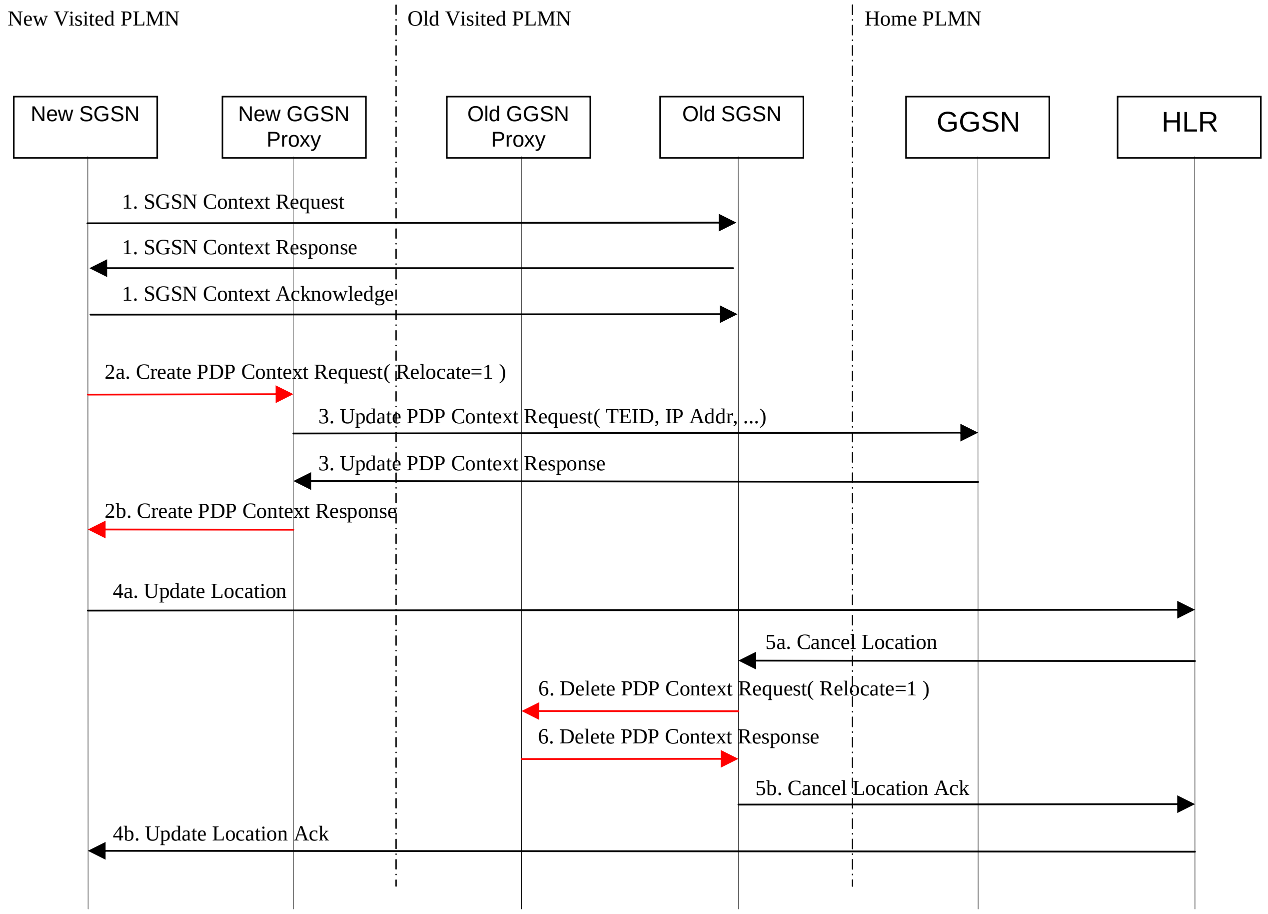


Figure 6.23.3-2: Signaling diagram for Inter PLMN Roaming

1. At some point in the MM procedure, the PDP Contexts are moved over to the new SGSN in the new VPLMN. The content of these messages should be unchanged, which guarantees the interoperability between operators using Rel-7 One Tunnel Networks and operators not using One Tunnel or using Rel-6 or older networks.

2. When One Tunnel is used in the new SGSN in the new VPLMN, the new SGSN identifies the UE as a visiting subscriber and therefore selects a GGSN Proxy for it. Instead of sending Update PDP Context messages to the HPLMN GGSNs, it then sends Create PDP Context Requests with a new relocate flag set, to the selected GGSN Proxy. The HPLMN GGSN address is provided to the GGSN Proxy.

3. The GGSN Proxy establishes the relocated PDP Contexts and sends Update PDP Context messages to the HPLMN GGSNs to switch the GTP tunnels to the new VPLMN. (From the HPLMN GGSN point of view, the GGSN Proxy acts as an SGSN, i.e. sends Update PDP context during MM).

4. When the new SGSN has received the Create PDP Context Responses and thereby knows the HPLMN GGSNs have acknowledged the updated PDP contexts, it updates the HLR with the new location of the UE.

5. The HLR responds to the location update by sending a Cancel Location to the old SGSN for removal of context information in the SGSN.

6. The old SGSN removes all its context information. From the context exchange in step 1, the old SGSN knows that the new SGSN is located outside the PLMN (or region). Therefore it sends one or more messages, Delete PDP Context Request with a relocate flag set, to the GGSN Proxy. Since it is a deletion of relocated PDP contexts, the GGSN Proxy deletes its PDP context but doesn't forward any Delete PDP Context Request to home GGSN.

Below is shown the generic procedure is applied on Inter SGSN Routeing Area Update (clause 6.9.1.2.2 in TS 23.060).

NOTE: Bi-casting and forwarding in the inter-PLMN mobility case is ffs. Therefore step 5 has been omitted in the figure below.

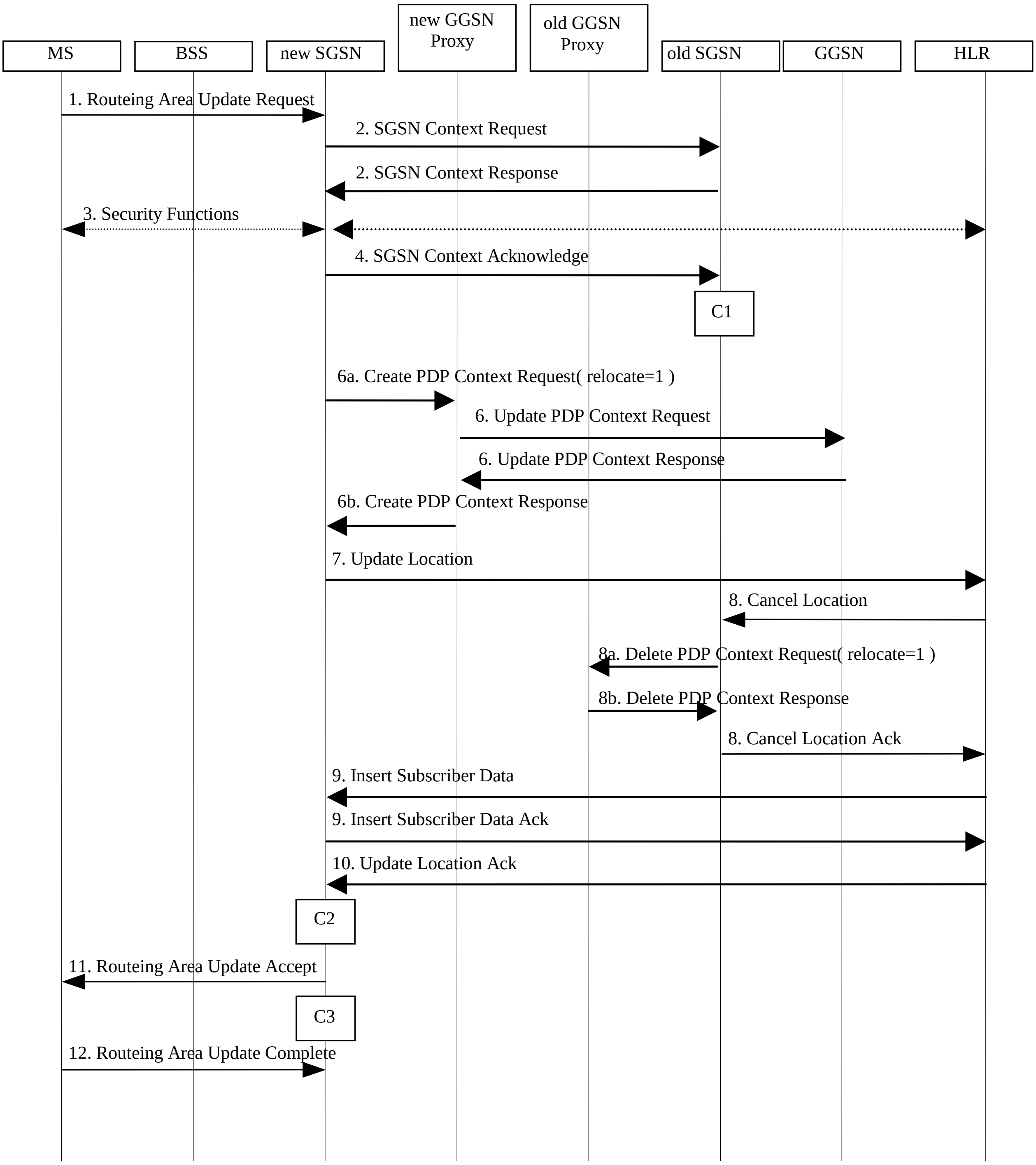


Figure 6.23.3-3: Inter SGSN Routeing Area Update Procedure with GGSN Proxy

7 Functional Nodes, interfaces and other 3GPP entities

The impact to the functional nodes of PS core network and their interfaces depend on the approach selected for the One Tunnel deployment. The following sub clauses describe the main impacts of the potential solutions.

7.1 SGSN

7.1.1 SGSN optimisation

The main principle of this solution is that whenever RABs are assigned for a PDP context (or re-assigned) the SGSN decides whether to enable direct user plane tunnel between RNC and GGSN or if it needs to handle user plane data and use two tunnels as today. Further whenever the RAB assigned for a PDP context is released (i.e. the PDP context is preserved) the GTP-U tunnel is established between the GGSN and SGSN in order to be able to handle the downlink packets.

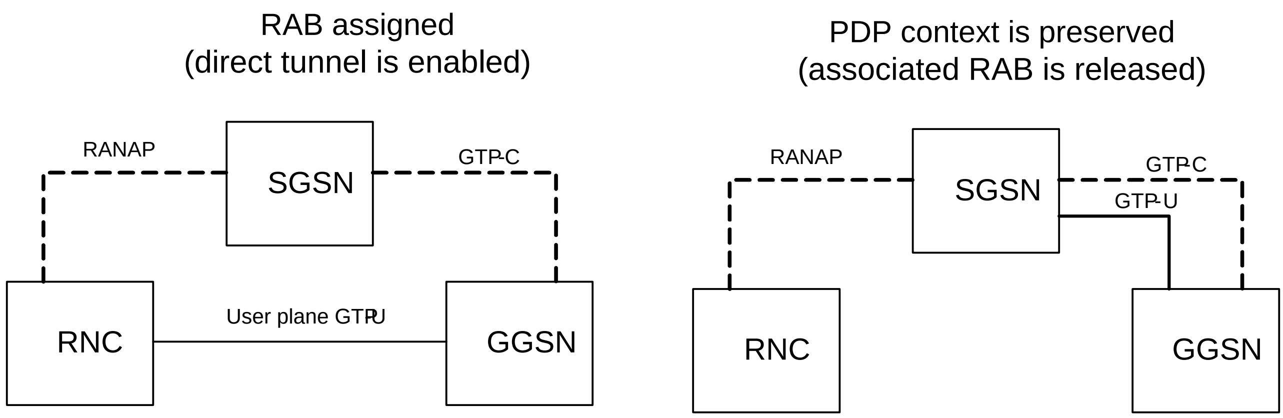


Figure 7.1.1-1: IDLE mode handling

7.1.1.1 Direct Tunnel decision

SGSN need to decide before every RAB assignment if direct tunnel can be used or not.

Direct tunnel is not used in following traffic cases:

1) In roaming case when visited SGSN need to provide local charging functions
   - This can be configured per APN basis.
2) SGSN has received Camel Service Information (CSI).
   - If one tunnel is used then volume reporting from SGSN is not possible. Because the nature of Camel service can not be deduced based on CSI in SGSN before service execution standard two tunnels must be used always when Camel service is involved.
3) Lawful interception is activated
   - in the cases when communication content is needed from SGSN
4) GGSN does not support GTP protocol version 1.
   - This can be configured per APN basis.

7.1.2 GGSN Bearer relay

To be described.

7.1.3 GGSN Proxy

To be described.

7.2 GGSN

In order to inform GGSN the IP address of RNC and TEID for the active PDP, SGSN will send an Update PDP Context Request message to GGSN. This message, which is an optional message in two-tunnel system, increases the signalling load of GGSN.

RAB release and re-establishment procedures, which become visible to GGSN in one-tunnel system, also increase the signalling load of GGSN. When air-link is bad, the frequent RAB release and re-establishment increase the signalling load of GGSN.

7.2.1 SGSN optimisation

Requires no new functionality in GGSN.

NOTE 1: It is FFS if error indication handling requires modifications.

NOTE 2: Statistic counters of GGSN may be impacted.

7.2.2 GGSN Bearer relay

To be described.

7.2.3 GGSN Proxy

To be described.

7.3 RNC

RNC's that only support ATM transport should be upgraded to support IP transport. Alternatively an IP router with ATM interface can be deployed between ATM network and IP backbone as illustrated in figure 7.6-2.

7.3.1 SGSN optimisation

Presumed no impact to RNC.

NOTE 1: It is FFS if error indication handling requires modifications.

7.3.2 GGSN Bearer relay

To be described.

7.3.3 GGSN Proxy

To be described.

7.4 Gn interface

7.4.1 SGSN optimisation

No changes to Gn protocol or interface.

7.4.2 GGSN Bearer relay

To be described.

7.4.3 GGSN Proxy

To be described.

7.5 Iu interface

7.5.1 SGSN optimisation

No changes on Iu protocol or interface.

7.5.2 GGSN Bearer relay

To be described.

7.5.3 GGSN Proxy

To be described.

7.6 IP Backbone Network

Within the network area where direct tunnel is used between RNC and GGSN the Iu and Gn transport networks must be made visible to each other, this is a network configuration issue.

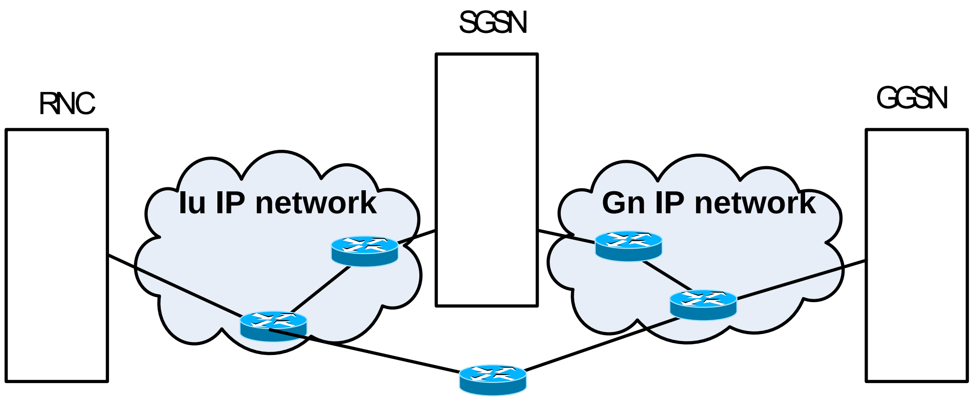


Figure 7.6-1: Connectivity with IP based Iu-PS

ATM and Iu transport can be adapted with an ATM capable IP router as show in Figure 7.6-1.

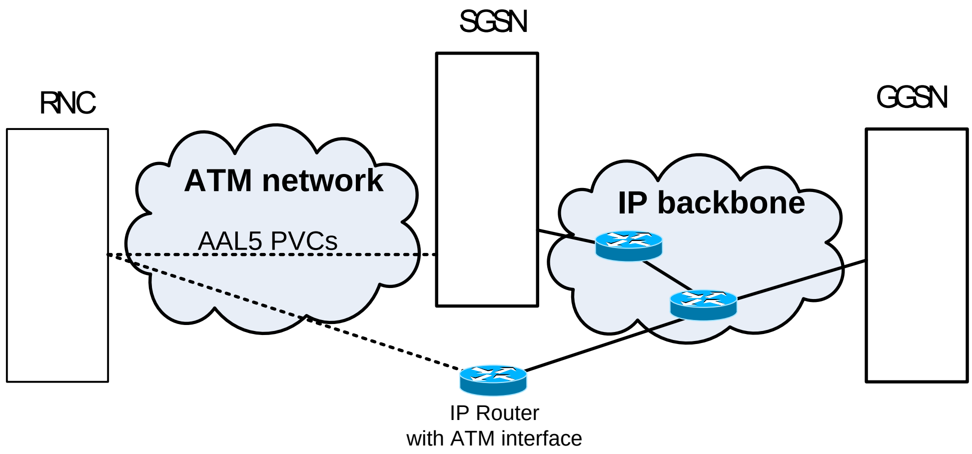


Figure 7.6-2: Connectivity through and by SGSN with ATM based Iu-PS

There is no identified difference between the solution alternatives described in this TR.

7.6.1 SGSN optimisation

To be described.

7.6.2 GGSN Bearer relay

To be described.

7.6.3 GGSN Proxy

To be described.

8 Impacts to other functionalities

8.1 Charging

Editor's Note: This subclause may be replaced by description in clause 6.

8.2 Camel

Editor's Note: This subclause may be replaced by description in clause 6.

8.3 Lawful interception

Editor's Note: This subclause may be replaced by description in clause 6.

8.4 Security

The GGSN Proxy solution increases security by decreasing the number of nodes that are exposed to external networks (only GGSN Proxies may need to be exposed to external networks). This may also facilitate the use of a private address domain for the Gn and Iu subnetworks.

8.5 Iu-Flex

When GGSN Proxy solution is used, the Iu-flex function is not affected. When a new subscriber attaches or roams into a PLMN, an SGSN in the pool is selected by the RNC very early in the procedure. The selected SGSN will then establish direct tunnels for all non-roaming, in the same way as the SGSN controlled bearer optimization solution establishes direct tunnels. For the fraction of traffic which is roaming traffic, the selected SGSN will also establish direct tunnels but to a GGSN Proxy it selects. No impact on Iu-flex for neither case has been identified.

8.6 Network sharing

Presumed no impact when the GGSN Proxy solution is used.

8.7 MBMS

Presumed no impact. However would be reasonable to optimize the MBMS user plane for the same reason that justifies One Tunnel.

9 Considerations for future functions and evolution aspects.

9.1 SGSN optimisation

To be described.

9.2 GGSN Bearer relay

To be described.

9.3 GGSN Proxy

To be described.

10 Conclusions

This TR has studied alternative solutions how the capability to have a direct tunnel between RNC and GGSN can be deployed.

This report recommends to undertake stage 2 specification work for the "SGSN optimisation" solution outlined in clause 5.2. It is expected that this work can be completed in the Rel7 timeframe.

The other solution (that was discussed as part of the alternative way forward) denoted as "GGSN Proxy" outlined in clause 5.4 is a further possible enhancement for the GPRS core network would require more time to realize, due to additional impacts of the solution on the system. A conclusion on such a solution may be taken later.

Annex A:
Pooled Bearer

A.1 Description of Pooled Bearer

A.1.1 PDP Context Activation

Figure A.1 shows the message flow for a PDP Context Activation Procedure using the Pooled Bearer for connectivity to either a legacy GGSN or a GGSN in the Home Network. An extra step is added in the control path to allocate a pooled bearer resource. The pooled bearer is used in the Create PDP Context Request sent to the legacy GGSN (or in the case of roaming the xGGSN in the Home Network). There is no change in any of the messages and/or parameters exchanged with the legacy GGSN.

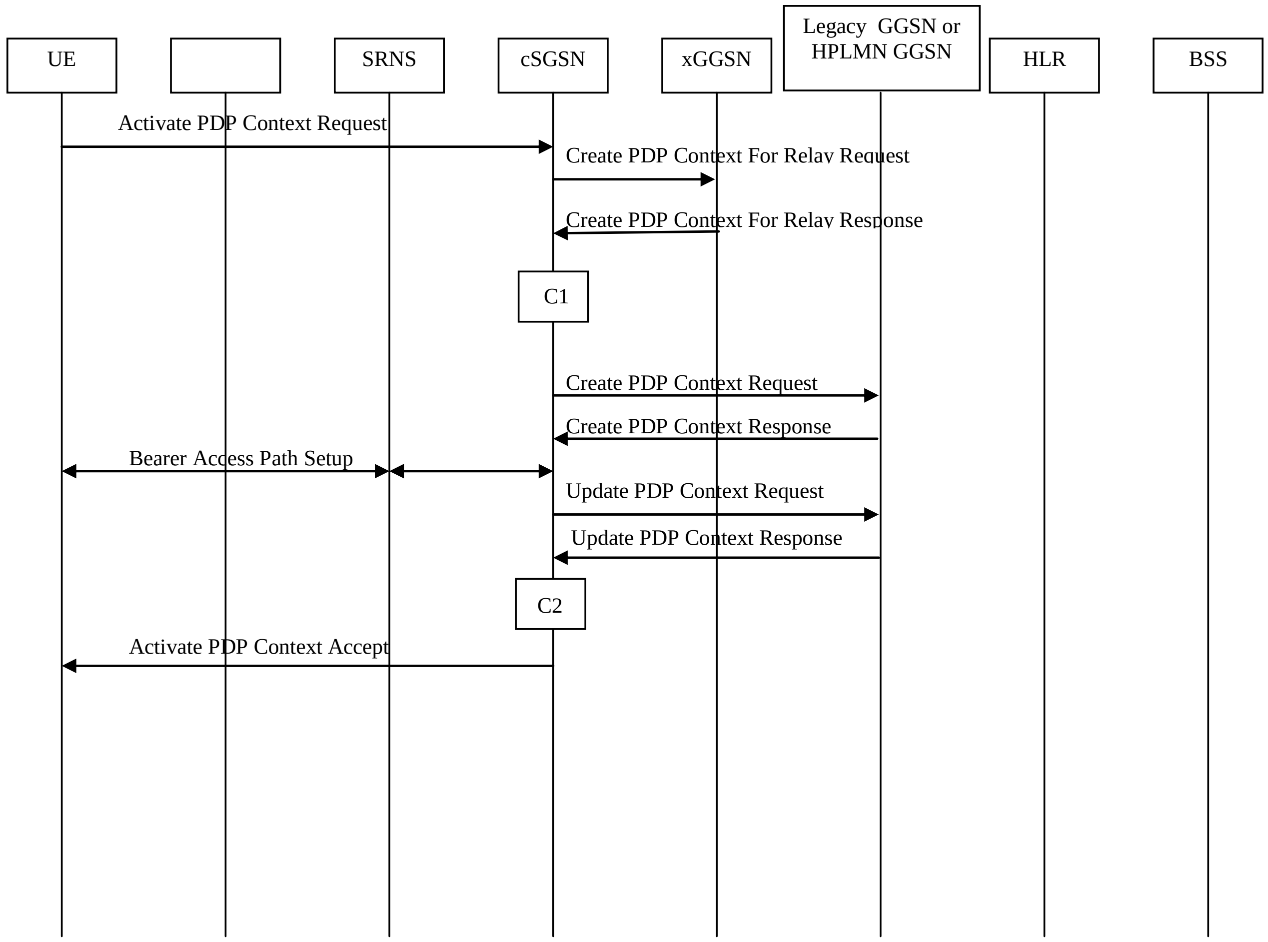


Figure A.1: Pooled Bearer Message Flow for Roaming or Legacy GGSN

In the above figure the cSGSN and xGGSN are so denoted to indicate the support of One Tunnel. The legacy GGSN not capable of One Tunnel or is a xGGSN located in the Home Network (in the case of roaming).

New messages are needed on Gn interface to support direct tunnel:

- A Create PDP Context For Relay procedure is introduced to allocate pooled bearer resources in xGGSN.
- A Delete PDP Context For Relay procedure is introduced to deallocate pooled bearer resources.

In the case of a roamer or inter-working with a legacy GGSN, a GSN to GSN bearer relay function is first allocated before continuing on with the PDP Context Activation.

A.1.2 Interfaces:

This alternative introduced the following enhancements to the Gn interface:

Pooled Bearer:

- Bearer Resource Allocation procedure is added to allow the cSGSN to request the xGGSN to allocate user plane resource. Parameters included are QoS, charging information (Time, Volume, Tariff Time, etc), CAMEL information (i.e. initial budget).
- Bearer Resource De-allocation procedure is added to all the cSGSN to return user plane resources back to the xGGSN. Parameters included in the response charging information (uplink and downlink volume counts).

Annex B:
Change history

Change history							
Date	**TSG #**	**TSG Doc.**	**CR**	**Rev**	**Subject/Comment**	**Old**	**New**
2006-03	*SA2#51*				*Includes approved documents S2-060685, S2-060687, S2-061190. In addition added clause 10 Conclusions.*	*V0.0.1*	*V0.0.2*
2006-04					*Figure 3. redrawn to ease maintenance*	*V0.0.2*	*V0.1.0*
2006-05	*SA2#52*				*Includes approved documents S2-061812 and S2-061813*	*V0.1.0*	*V0.2.0*
2006-07	*SA2#53*				*Includes approved documents S2-062449, S2-062450, S2-062550, S2-062551, S2-062552, S2-062553 and S2-062554. In addition figure 2 corrected as agreed in the meeting.*	*V0.2.0*	*V0.2.9*
2006-07	*SA2#53*				*Includes S2-062539 approved in e-mail approval.*	*V0.2.9*	*V0.3.0*
2006-09	*SA2#54*				*Includes documents approved in meeting: S2-062938, S2-063253, S2-063362, S2-063400 and from S2-063145 only the part proposing text for 6.5a.1.* *Includes documents approved in e-mail approval: S2-063358, S2-063359, S2-063360, S2-063361rev2, S2-063363 and S2-063365*	*V0.3.0*	*V0.4.0*
2006-09					Section 6 sub clauses re-numbered from 6.5a onwards to ease maintenance (6.5a to 6.6, 6.5b to 6.7, 6.6 to 6.8 etc.)	V0.4.0	V0.5.0
2006-09	SP-33	SP-060585	-	-	Editorial update by MCC for presentation to TSG SA for information	0.5.0	1.0.0