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Technical Specification

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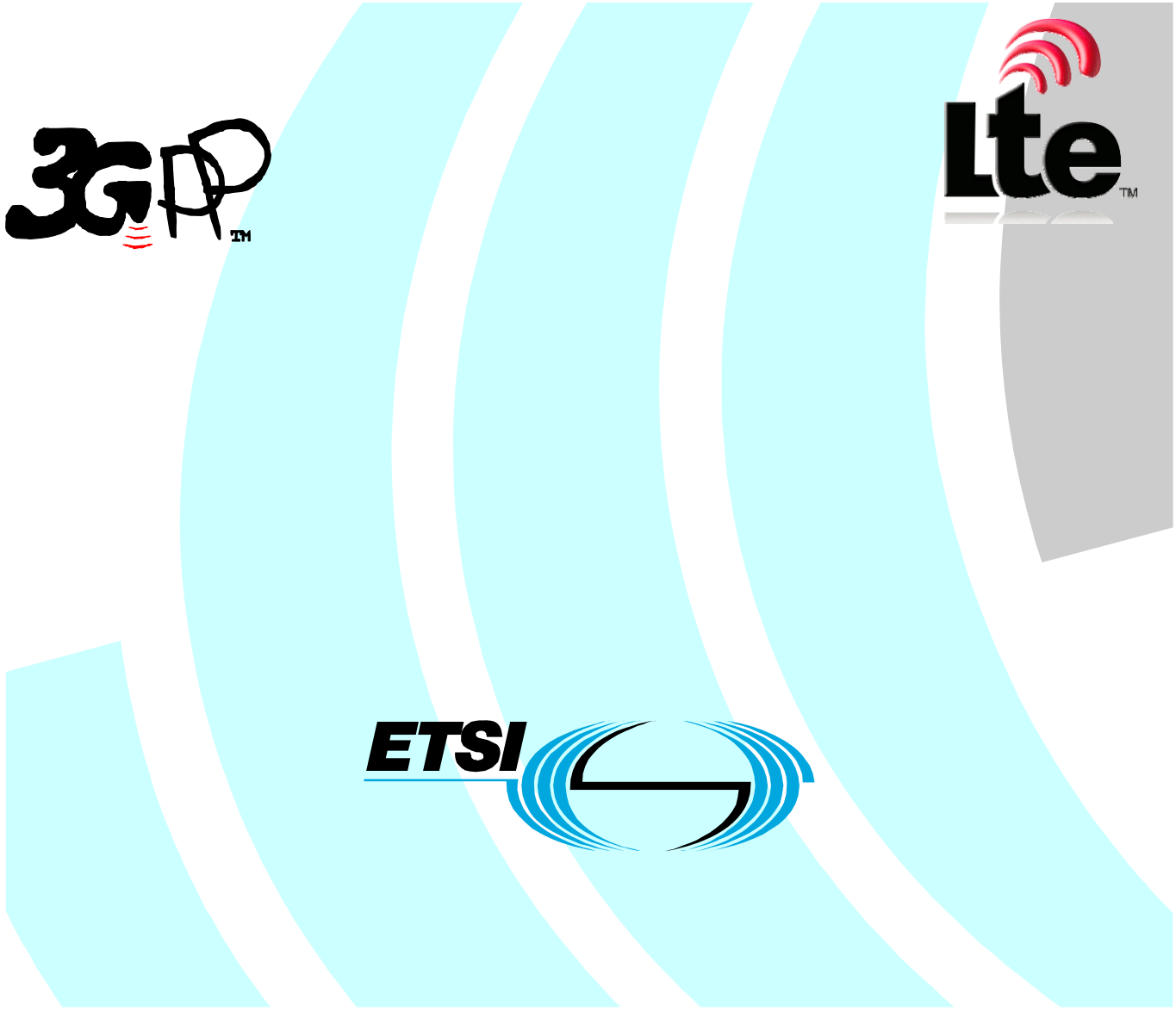

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Foreword

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

The present document may refer to technical specifications or reports using their 3GPP identities, UMTS identities or GSM identities. These should be interpreted as being references to the corresponding ETSI deliverables.

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Contents

Foreword

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

The present document defines the restoration procedures within the 3GPP system.

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:

Version x.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- 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 data stored in location registers are automatically updated in normal operation; the main information stored in a location register defines the location of each mobile station and the subscriber data required to handle traffic for each mobile subscriber. The loss or corruption of these data will seriously degrade the service offered to mobile subscribers; it is therefore necessary to define procedures to limit the effects of failure of a location register, and to restore the location register data automatically. The present document defines the necessary procedures.

The basic principle is that restoration should be based on radio contact to avoid faulty data being spread in the system.

Subscriber data for supplementary services must also be correctly restored, although the impact on service of corruption of supplementary service data is less severe.

Procedures for supporting these functions are defined in 3GPP TS 29.002 and 3GPP TS 29.060.

The MAP operation "IMSI Attach" is used only in MAP version 1; in MAP version 2 the same function is performed by the MAP operation "Update Location Area". References in this specification to IMSI attach apply only to MAP version 1 network entities.

If the restoration of subscriber data in the VLR is triggered by Location Updating or IMSI Attach, the VLR retrieves subscriber data from the HLR by sending an "Update Location" request, which triggers one or more "Insert Subscriber Data" operations from the HLR. The "Update Location" request may also be used to send the LMSI to the HLR.

If the restoration of subscriber data in the VLR is triggered by a "Provide Roaming Number" request, the behaviour of the VLR depends on whether it is implemented according to MAP version 1 or MAP version 2. For MAP version 2, the VLR retrieves subscriber data from the HLR by sending a "Restore Data" request, which triggers one or more "Insert Subscriber Data" operations from the HLR. The "Restore Data" request is also used to send the LMSI to the HLR. For MAP version 1, the VLR retrieves subscriber data from the HLR by sending a "Send Parameters" request with parameter type "Subscriber Data", which cannot be used to send the LMSI to the HLR.

The VLR number and MSC number in the subscriber data in the HLR are updated by the "Update Location" procedure.

The GGSN (Gateway GPRS Support Node) is the point of PDN interconnection with the GSM PLMN supporting GPRS. The GGSN contains routing information for GPRS users with a PDP context active. The necessary procedures needed to restore GGSN data information after a restart are described in this document.

The SGSN (Serving GPRS Support Node) is the node that is serving the MS. The SGSN stores information regarding e.g. mobility management, routing and security. The necessary procedures needed to restore this SGSN information after a restart are described in this document.

The MME (Mobility Management Entity) is the node that is serving the UE when attached to E-UTRAN. The MME stores information regarding e.g. mobility management, routing and security. The necessary procedures needed to restore this MME information after a restart are described in this document.

A Type A LMU (Location Measurement Unit) is a network node, accessed over the GSM air interface, that is functionally similar to an MS. All requirements associated with a non-GPRS MS in this specification apply also to a Type A LMU except where specified otherwise.

1.1 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary of 3GPP Specifications ".

[2] 3GPP TS 23.018: "Basic Call Handling - Technical realisation".

[3] 3GPP TS 23.022: "Functions related to Mobile Station (MS) in idle mode".

[4] 3GPP TS 23.040: "Technical realisation of SMS Point to Point".

[5] 3GPP TS 23.060: "General Packet Radio Service (GPRS) Service description; Stage 2".

[6] 3GPP TS 29.002: "Mobile Application Part (MAP) specification".

[7] 3GPP TS 29.018:"Serving GPRS Support Node (SGSN) - Visitors Location Register (VLR); Gs interface layer 3 specification".

[8] 3GPP TS 29.060: "GPRS Tunneling Protocol (GTP) across the Gn and Gp Interface".

[9] 3GPP TS 43. 005: "Digital cellular telecommunication system: Technical performance objectives".

[10] 3GPP TS 23.071: "Digital cellular telecommunications system; Location Services (LCS); Functional Description; Stage 2".

[11] Void

[12] 3GPP TS 23.246: "Multimedia Broadcast/Multicast Service (MBMS) Architecture and Functional Description"

[13] 3GPP TS 29.274: " Evolved GPRS Tunnelling Protocol for EPS (GTPv2)"

[14] 3GPP TS 29.118:"Mobility Management Entity (MME) – Visitor Location Register (VLR) SGs interface specification".

[15] 3GPP TS 23.401: "General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access"

[16] 3GPP TS 29.275: "Proxy Mobile IPv6 Mobity and Tunneling Protocols"

1.2 Abbreviations

For the purposes of the present document, the abbreviations listed in 3GPP TR 21. 905 [1] apply.

2 Design objectives

To avoid loss of all the data stored in a location register when part of the equipment of the location register fails, a regime must be implemented to secure the data. This regime can include replication of volatile storage units and periodic back-up of data to non-volatile storage. If the data security regime ensures the integrity of the data in spite of failure of part of the location register equipment then there will be no impact on service. This Technical Specification describes the procedures to be used when the integrity of data in the location register cannot be ensured; that situation is referred to below as "failure".

The VLR and SGSN shall erase all IMSI records affected by the failure when it restarts after a failure. The GGSN shall erase all non-static PDP records affected by the failure and restore static PDP records when it restarts after a failure.

For the HLR, periodic back-up of data to non-volatile storage is mandatory.

The reliability objectives of location registration are listed in 3GPP TS 43. 005 [9].

The MME, S-GW and P-GW must similarly have a regime to secure the PDN connection and bearer data at failures. When an MME, SGW or PGW has a full node restart or fails all PDN connections and bearer records associated with the failing node shall be erased and any internal resources released.

Clause 18 "GTP-C based restart procedures" specifies how a GTP-C entity restart is detected and handled by the peer.

3 Restoration indicators in location registers and in GPRS support nodes

3.1 Restoration Indicators in the VLR

Three restoration indicators are provided in the VLR for each IMSI record: "Confirmed by Radio Contact", "Subscriber Data Confirmed by HLR" and "Location Information Confirmed in HLR".

The indicator "Confirmed by Radio Contact" indicates whether the VLR"s record of location area identity and MSC number for the mobile station is confirmed by radio contact.

The indicator "Confirmed by Radio Contact" in an IMSI record is set to the initial value "Not Confirmed" when the VLR receives a "Provide Roaming Number" request, an "Update Location Area" request or an "IMSI Attach" request for an MS for which the VLR does not have an IMSI record. The indicator "Confirmed by Radio Contact" in an IMSI record is also set to the initial value "Not Confirmed" when the VLR receives a Reset indication message from the SGSN serving the MS if the MS is attached to both GPRS and non-GPRS services.

The indicator "Confirmed by Radio Contact" is set to "Confirmed" when the radio contact that has been established with the MS is authenticated.

The indicator "Subscriber Data Confirmed by HLR" indicates whether the subscriber data set for the mobile station held by the VLR is consistent with that held by the HLR.

The indicator "Subscriber Data Confirmed by HLR" is set to the initial value "Not Confirmed" when the VLR receives a "Provide Roaming Number" request, an "Update Location Area" request or an "IMSI Attach" request for an MS for which the VLR does not have an IMSI record.

The indicator "Subscriber Data Confirmed by HLR" is set to "Confirmed" at either of the following events:

- The VLR successfully performs an "Update Location" to the HLR;
- The VLR successfully performs a "Restore Data" operation to the HLR.

The indicator "Location Information Confirmed in HLR" indicates whether the HLR"s record of VLR number and MSC number for the mobile station is confirmed by radio contact.

The indicator "Location Information Confirmed in HLR" is set to "Not Confirmed" at any of the following events:

- The VLR receives an "Update Location Area" request or an IMSI Attach" request for an MS for which the VLR has no IMSI record;
- A VLR which serves two or more MSCs receives a "Provide Roaming Number" request for an MS for which the VLR has no IMSI record;
- The VLR receives a "Reset" message from the HLR with which the MS is registered;
- The VLR in a Super-Charged network receives a Send Identification message from the serving VLR;
- The VLR in a Super-Charged network receives a Cancel Location message that indicates an "updateProcedure".

The indicator "Location Information Confirmed in HLR" is set to "Confirmed" at either of the following events:

- A VLR which serves only one MSC receives a "Provide Roaming Number" request for an MS for which the VLR has no IMSI record;
- Successful completion of the "Update Location" procedure triggered by authenticated radio contact.

The indicator "Location Information Confirmed in SMLC" indicates whether an SMLC's record of MSC number for a particular LMU is confirmed by radio contact.

The indicator "Location Information Confirmed in SMLC" is set to "Not Confirmed" at any of the following events:

- The VLR receives an "Update Location Area" request or an "IMSI Attach" request for an MS for which the VLR has no IMSI record. The indicator, in this case, becomes valid only if HLR subscriber data later indicates an LMU;

- The VLR receives an "LCS Reset" message from an SMLC where the message is targetted to either a specific LMU or all LMUs registered with the SMLC;

- The VLR receives an "IMSI Detach" from an LMU that is registered with an SMLC.

The indicator "Location Information Confirmed in SMLC" is set to "Confirmed" at the following event:

- Successful completion of the "LCS Registration" procedure triggered by a successful location update;

- Successful transfer of an LCS Information message from an SMLC to the LMU.

3.2 Restoration Indicators in the HLR

As an implementation option, one restoration indicator may be provided in the HLR for each IMSI record: "Check SS".

The "Check SS" indicator is set to "Check Required" when the HLR restarts after a failure.

The "Check SS" indicator is checked whenever the HLR receives an "Update Location" request from a VLR. If it is set to "Check Required", after successful completion of subscriber data retrieval that ran embedded in the "Update Location" procedure the HLR sends a "Forward Check SS Indication" request message to the VLR and sets the "Check SS" indicator to "Check Not Required".

3.3 Restoration Indicators in the SGSN

Two restoration indicators are provided in the SGSN for reach IMSI record: "Subscriber Data Confirmed by HLR" and "Location Information Confirmed in HLR".

The indicator "Subscriber Data Confirmed by HLR" indicates whether the subscriber data set for the mobile station held by the SGSN is consistent with that held by the HLR.

The indicator "Subscriber Data Confirmed by HLR" is set to the initial value "Not Confirmed" when the SGSN receives a Routing Area Update request or an IMSI- and/or GPRS Attach request for an MS for which the SGSN does not have an IMSI record.

The indicator "Subscriber Data Confirmed by HLR" is set to "Confirmed" at the following event:

- The SGSN successfully performs an Update GPRS Location to the HLR;

The indicator "Location Information Confirmed in HLR" indicates whether the HLRs record of the SGSN address for the mobile station is confirmed by radio contact.

The indicator "Location Information Confirmed in HLR" is set to "Not Confirmed" at any of the following events:

- The SGSN receives a Routing Area Update request or an IMSI- and/or GPRS Attach request for an MS for which the SGSN has no IMSI record;

- The SGSN receives a "Reset" message from the HLR with which the MS is registered;

- The SGSN in a Super-Charged network receives a Send Identification message from the serving SGSN;

- The SGSN in a Super-Charged network receives a Cancel Location message that indicates an "updateProcedure".

The indicator "Location Information Confirmed in HLR" is set to "Confirmed" at the following event:

- Successful completion of the Update GPRS Location procedure to the HLR.

The indicator "VLR-Reliable" indicates whether the VLR serving the MS has performed a restart.

The indicator "VLR-Reliable" is set to the value "false" when the SGSN receives a Reset indication message from the VLR serving the MS if the MS is attached to both GPRS and non-GPRS services. The indicator "VLR-Reliable" is set to the value "true" when the SGSN receives a confirmation from a VLR that a location update procedure to the affected VLR has been successfully performed.

The indicator "SGSN-Reset" indicates whether the SGSN has recently experienced a restart.

The indicator "SGSN-Reset" is set to the value "true" when the SGSN suffers a restart. This indicator is unique per SGSN. The indicator "SGSN-Reset" is set to the value "false" after a certain time specified by the operator. The value of the timer controlling the reset of the "SGSN-Reset" indicator shall be longer than the periodic routeing area update timer value used by the MSs.

3.4 Restoration Indicators in the MME

Two restoration indicators are provided in the MME for each IMSI record: "Subscriber Data Confirmed by HSS" and "Location Information Confirmed in HSS".

The indicator "Subscriber Data Confirmed by HSS" indicates whether the subscriber data set for the mobile station held by the MME is consistent with that held by the HSS.

The indicator "Subscriber Data Confirmed by HSS" shall be set to the initial value "Not Confirmed" when the MME receives a Tracking Area Update request or an Attach request for an UE for which the MME does not have an IMSI record.

The indicator "Subscriber Data Confirmed by HSS" shall be set to "Confirmed" at the following event:

- The MME successfully performs an Update Location to the HSS;

The indicator "Location Information Confirmed in HSS" indicates whether the HSS"s record of the MME address for the UE is confirmed by radio contact.

The indicator "Location Information Confirmed in HSS" shall be set to "Not Confirmed" at any of the following events:

- The MME receives a Tracking Area Update request or an Attach request for an UE for which the MME has no IMSI record;

- The MME receives a "Reset" message from the HSS with which the UE is registered;

The indicator "Location Information Confirmed in HSS" shall be set to "Confirmed" at the following event:

- Successful completion of the Update Location procedure to the HSS.

4 Restoration of data in the VLR

The effect on service of failure of a VLR is different from the effect of failure of an HLR. The procedures for restoration of a VLR and an HLR are therefore different.

4.0 VLR Failure

When a VLR fails, all its associations with SGSNs affected by the failure become invalid and may be deleted. Based on configuration data, the MSC/VLR sends a BSSAP+ Reset message to each of its associated SGSNs. The SGSNs mark all associations containing the restarted VLR as invalid. After receipt of the first valid LLC frame (for A/Gb mode) or after receipt of the first valid GTP-U packet or uplink signalling message (for Iu mode) from an MS that is both GPRS-attached and IMSI-attached, the SGSN shall return a Detach Request (Detach Type) message in order to request the MS to perform a combined RA / LA update. Detach Type shall be set to IMSI Detach. The detach procedure may be delayed by the SGSN for a maximum operator-configuration depending on resource utilisation during given time period to avoid high signalling load.

4.1 Restart of the VLR

When a VLR restarts after a failure, all IMSI records affected by the failure are erased.

There will be no subscriber data or location information stored for an affected mobile station until after the VLR has received either a "Provide Roaming Number" request or an "Update location Area" request for that mobile station.

The VLR causes all affected TMSIs and all affected LMSIs to become invalid. "Invalid" in this context means that the TMSI and LMSI can no longer be regarded as accurate. The term is used to avoid unnecessary constraints on the implementation.

On receipt of either a "Provide Roaming Number" request or an "Update Location Area" request, restoration of subscriber data in the VLR is triggered individually for each IMSI record as described below.

4.2 Restoration Procedures

The objective of the restoration procedure is to handle all traffic for each mobile subscriber correctly. In order to meet this objective, the procedure must make the subscriber data in the VLR consistent with that in the HLR, and make the location information in the HLR and VLR reflect accurately the current location of the MS.

4.2.1 Incoming Call

a) Send Routing Information (GMSC->HLR):

The HLR sends "Provide Roaming Number" to the VLR as for normal operation. The LMSI is updated by the VLR when the VLR requests the transfer of subscriber data from the HLR using the "Restore Data" operation.

b) Provide Roaming Number (HLR->VLR):

- Regardless of whether the VLR has an IMSI record corresponding to the IMSI in the "Provide Roaming Number", it returns an MSRN. If no IMSI record exists, the VLR creates a skeleton IMSI record, sets the indicators "Subscriber Data Confirmed by Radio Contact" and "Confirmed by HLR" to "Not Confirmed" and (if IMSI Attach is used) marks the IMSI as attached. If the VLR serves two or more MSCs, the VLR sets the indicator "Location Information Confirmed in HLR" to "Not Confirmed". Otherwise, if the VLR serves only one MSC, the indicator "Location Information Confirmed in HLR" is set to the initial value "Confirmed".

- If the indicator "Subscriber Data Confirmed by HLR" is "Not Confirmed" the VLR requests authentication data, if required and still not available and subscriber data from the HLR. When the dialogue that covers the subscriber data retrieval procedure is completed successfully, the VLR sets the indicator "Subscriber Data Confirmed by HLR" to "Confirmed". The indicators "Confirmed by Radio Contact" and "Location Information Confirmed in HLR" remain unchanged.

- If the IMSI record for the MS is marked "Subscriber Data Confirmed by HLR" but "Not Confirmed by Radio Contact" the operator may choose an appropriate method to limit the number of "Search for MS" procedures for that MS.

- Ic) Send Information for I/C Call Setup (MSC->VLR)

- If the VLR has no IMSI record, or if the record is marked "Subscriber Data Not Confirmed by HLR" the VLR returns a "System Failure" error.

- If the VLR has an IMSI record marked "Subscriber Data Confirmed by HLR" and "Not Confirmed by Radio Contact", the VLR handles the request in the normal way, except that the "Search for MS" procedure is used instead of the "Page MS" procedure.

- If the VLR has an IMSI record marked "Subscriber Data Confirmed by HLR" and "Confirmed by Radio Contact", the VLR handles the request in the normal way; for this MS, VLR restoration is complete.

- The state of the indicator "Location Information Confirmed in HLR" does not affect the "Send Information for I/C Call Setup" procedure.

d) Process Access Request in Response to Search (MSC->VLR):

- If the MS responds to paging, the MSC sends a positive response to the search request and a "Process Access Request" to the VLR. After successful authentication, if required, the VLR sets the indicator "Confirmed by Radio Contact" to "Confirmed", sets the location area information for the MS, and handles the request in the normal way.

- The VLR checks the indicator "Location Information Confirmed in HLR". If it indicates "Not Confirmed" the VLR starts an "Update Location" procedure to the HLR. When this procedure is successfully completed the VLR sets the indicator "Location Information Confirmed in HLR" to "Confirmed".

For this MS, VLR restoration is complete.

4.2.2 Mobile Terminated Short Message

a) Send Routing Information for MT SMS (SMS-GMSC->HLR):

The HLR returns the MSC number as for normal operation.

b) Send Information for MT SMS (MSC->VLR) - MAP version 2:

- If the VLR has no IMSI record, or if the record is marked "Subscriber Data Not Confirmed by HLR" the VLR returns an "Unidentified Subscriber" error. This causes the MSC to report a short message delivery failure, with cause "Unidentified Subscriber", to the SMS gateway MSC. The Gateway MSC sends a "Report SM Delivery Status" request, with a cause of "Absent Subscriber", to the HLR. This causes the HLR to set the "Mobile Station Not Reachable Flag" for the MS, as described in Technical Specifications 3GPP TS 23.040 and 3GPP TS 29.002.

- If the VLR has an IMSI record marked "Subscriber Data Confirmed by HLR" and "Not Confirmed by Radio Contact", the VLR handles the request in the normal way, except that the "Search for MS" procedure is used instead of the "Page MS" procedure.

- If the VLR has an IMSI record marked "Subscriber Data Confirmed by HLR" and "Confirmed by Radio Contact", the VLR handles the request in the normal way; for this MS, VLR restoration is complete.

- The state of the indicator "Location Information Confirmed in HLR" does not affect the "Send Information for MT SMS" procedure.

c) Send Information for I/C Call Setup (MSC->VLR) - MAP version 1:

- If the VLR has no IMSI record, or if the record is marked "Subscriber Data Not Confirmed by HLR" the VLR returns a "System Failure" error. This causes the MSC to report a short message delivery failure, with cause "System Failure", to the SMS gateway MSC.

- If the VLR has an IMSI record marked "Subscriber Data Confirmed by HLR" and "Not Confirmed by Radio Contact", the VLR handles the request in the normal way, except that the "Search for MS" procedure is used instead of the "Page MS" procedure.

- If the VLR has an IMSI record marked "Subscriber Data Confirmed by HLR" and "Confirmed by Radio Contact", the VLR handles the request in the normal way; for this MS, VLR restoration is complete.

- The state of the indicator "Location Information Confirmed in HLR" does not affect the "Send Information for MT SMS" procedure.

d) Process Access Request in Response to Search (MSC->VLR):

- If the MS responds to paging, the MSC sends a positive response to the search request and a "Process Access Request" to the VLR. After successful authentication, if required, the VLR sets the indicator "Confirmed by Radio Contact" to "Confirmed", sets the location area information for the MS, and handles the request in the normal way.

- The VLR checks the indicator "Location Information Confirmed in HLR". If it indicates "Not Confirmed" the VLR starts an "Update Location" procedure to the HLR. When this procedure is successfully completed, the VLR sets the indicator "Location Information Confirmed in HLR" to "Confirmed".

For this MS, VLR restoration is complete.

4.2.3 Mobile Terminating Location Request (MT-LR)

Receipt of an MT-LR for a target MS identified by its IMSI in a serving MSC during VLR restoration is supported by the procedures below.

a) Provide Subscriber Location (GMLC->MSC/VLR):

- If the VLR has no IMSI record, or if the record is marked "Subscriber Data Not Confirmed by HLR" the VLR returns an "Unidentified Subscriber" error. This causes the MSC to report a location failure, with cause "Unidentified Subscriber", to the GMLC.

- If the VLR has an IMSI record marked "Subscriber Data Confirmed by HLR" and "Not Confirmed by Radio Contact", the VLR handles the request in the normal way, except that the "Search for MS" procedure is used instead of the "Page MS" procedure when paging for the MS.

- If the VLR has an IMSI record marked "Subscriber Data Confirmed by HLR" and "Confirmed by Radio Contact", the VLR handles the request in the normal way; for this MS, VLR restoration is complete.

- The state of the indicator "Location Information Confirmed in HLR" does not affect the "Provide Subscriber Location" procedure.

b) Process Access Request in Response to Search (MSC->VLR):

- If the MS responds to paging, the MSC sends a positive response to the search request and a "Process Access Request" to the VLR. After successful authentication, if required, the VLR sets the indicator "Confirmed by Radio Contact" to "Confirmed", sets the location area information for the MS, and handles the request in the normal way.

- The VLR checks the indicator "Location Information Confirmed in HLR". If it indicates "Not Confirmed" the VLR starts an "Update Location" procedure to the HLR. When this procedure is successfully completed, the VLR sets the indicator "Location Information Confirmed in HLR" to "Confirmed".

For this MS, VLR restoration is complete.

4.2.4 Incoming LCS Information Request (GSM only)

Receipt of an incoming BSSMAP-LE LMU Connection Request from an SMLC directed to a specific Type A LMU is supported by the procedures below.

a) Request associated with an LMU (SMLC->MSC/VLR):

- If the VLR has no IMSI record, or if the record is marked "Subscriber Data Not Confirmed by HLR", the VLR returns an "Unidentified Subscriber" error.

- If the VLR has an IMSI record for an LMU marked "Subscriber Data Confirmed by HLR" and "Not Confirmed by Radio Contact", the VLR handles the request in the normal way, except that the "Search for MS" procedure is used instead of the "Page MS" procedure when paging for the LMU.

- If the VLR has an IMSI record marked "Subscriber Data Confirmed by HLR" and "Confirmed by Radio Contact", the VLR handles the request in the normal way. For this LMU, data restoration is complete.

- The state of the indicator "Location Information Confirmed in HLR" does not affect the incoming LMU Connection Request.

b) Process Access Request in Response to Search (MSC->VLR):

- If the LMU responds to paging, the MSC sends a positive response to the search request and a "Process Access Request" to the VLR. After successful authentication, if required, the VLR sets the indicator "Confirmed by Radio Contact" to "Confirmed", sets the location area information for the LMU, and handles the request in the normal way.

- The VLR checks the indicator "Location Information Confirmed in HLR". If it indicates "Not Confirmed" the VLR starts an "Update Location" procedure to the HLR. When this procedure is successfully completed, the VLR sets the indicator "Location Information Confirmed in HLR" to "Confirmed".

For this LMU, VLR restoration is complete.

4.2.5 Outgoing MS request

An outgoing request (MS originated call, mobile originated Short Message or call-independent supplementary service activity) from the MS causes the VLR to check its IMSI record for that MS.

- If the MS is unknown in this VLR (i.e. the VLR has no IMSI record for the MS) or there is an IMSI record marked "Subscriber Data Not Confirmed by HLR" the outgoing request is rejected with error cause "Unidentified Subscriber". This causes the MS to initiate the location registration procedure described below.

- If the VLR has an IMSI record for the MS marked "Subscriber Data Confirmed by HLR" the request is handled in the normal way, and after any necessary authentication and/or IMEI checking the record is marked "Confirmed by Radio Contact".

- The VLR checks the indicator "Location Information Confirmed in HLR". If it indicates "Not Confirmed" the VLR starts an "Update Location" procedure to the HLR. When this procedure is successfully completed the VLR sets the indicator "Location Information Confirmed in HLR" to "Confirmed".

For this MS, VLR restoration is complete.

4.2.6 Outgoing LMU Request (GSM only)

An outgoing request (CM ServiceRequest) for LCS from a Type A LMU causes the VLR to check its IMSI record for that LMU.

- If the LMU is unknown in this VLR (i.e. the VLR has no IMSI record for the LMU) or there is an IMSI record marked "Subscriber Data Not Confirmed by HLR" the outgoing request is rejected with error cause "Unidentified Subscriber". This causes the LMU to initiate the location registration procedure described below.

- If the VLR has an IMSI record for the MS marked "Subscriber Data Confirmed by HLR", the request is handled in the normal way, and after any necessary authentication and/or IMEI checking the record is marked "Confirmed by Radio Contact".

- The VLR checks the indicator "Location Information Confirmed in HLR". If it indicates "Not Confirmed" the VLR starts an "Update Location" procedure to the HLR. When this procedure is successfully completed the VLR sets the indicator "Location Information Confirmed in HLR" to "Confirmed".

For this LMU, VLR restoration is complete.

4.2.7 Location Updating or IMSI Attach

A location registration request (location updating or IMSI attach) from an MS causes the VLR to check its IMSI record for that MS.

- If the MS is unknown in this VLR (i.e. the VLR has no IMSI record for the MS) the VLR creates a skeleton IMSI record for the MS and sets the indicators "Confirmed by Radio Contact", "Location Information Confirmed in HLR" and "Subscriber Data Confirmed by HLR" to "Not Confirmed". If authentication is required, the VLR retrieves authentication data. When the radio contact with the Mobile Station is authenticated, the VLR sets the indicator "Confirmed by Radio Contact" to "Confirmed. The VLR then performs an "Update Location" to the HLR. If this is successful, the VLR sets the indicators "Location Information Confirmed in HLR" and "Subscriber Data Confirmed by HLR" to "Confirmed". For this MS, VLR restoration is complete.

- If the VLR has an IMSI record for the MS, after successful authentication, if required, the VLR sets the indicator "Confirmed by Radio Contact" to "Confirmed". If the record is marked "Location Information Not Confirmed in HLR" or "Subscriber Data Not Confirmed by HLR" the VLR performs an "Update Location" to the HLR. If this is successful, the VLR sets the indicators "Location Information Confirmed in HLR" and "Subscriber Data Confirmed by HLR" to "Confirmed". For this MS, VLR restoration is complete.

4.2.8 Use of TMSI

After the VLR has restarted but before the next authenticated radio contact the TMSI known by the MS is invalid, as it was allocated before the VLR restarted. The VLR therefore uses the IMSI to identify the MS on the first radio contact during restoration.

- A VLR which initiates a "Search for Subscriber" procedure uses the IMSI to identify the MS.
- If an MS identifies itself by a TMSI in a "Location Registration" request, the VLR proceeds as follows:

  a) The VLR checks the location area identity (LAI) of the previous location area sent by the MS. If this LAI is in a VLR different from the current one, the request is handled in the normal way.

  b) If the LAI is in the current VLR, the status of the TMSI is checked:

  - If the TMSI was allocated after the VLR restarted, and corresponds to a valid IMSI record, the request is handled as described in subclause 4.2.7.
  - If the TMSI was allocated before the VLR restarted, or does not correspond to a valid IMSI record, the VLR requests the IMSI from the MS. If the MS returns an IMSI the VLR proceeds as described in subclause 4.2.7. If the MS does not return an IMSI the network aborts the location registration procedure.
  - If an MS identifies itself by a TMSI in an outgoing MS request, the VLR proceeds as follows:
  - If the TMSI was allocated after the VLR restarted, and corresponds to a valid IMSI record, the request is handled as described in subclause 4.2.5.
  - If the TMSI was allocated before the VLR restarted, or does not correspond to a valid IMSI record, the VLR requests the IMSI from the MS. If the MS returns an IMSI the VLR proceeds as described in subclause 4.2.5. If the MS does not return an IMSI the network aborts the outgoing request.

4.2.9 SGSN associations

Based on configuration data, "Reset" messages are sent on the Gs-interface to the SGSNs in the Location Areas served by the VLR as described in the 3GPP TS 29.018 [7]. The SGSNs mark all associations with the VLR as unreliable by setting the restoration indicator "VLR-Reliable" to "False" for the UEs served by that VLR. The associations will be re-initiated one by one by the SGSN at the next Routing Area update or combined RA/LA update from each UE.

4.2.10 MME associations

Based on configuration data, "Reset" messages are sent on the SGs-interface to the MMEs by the VLR as described in the 3GPP TS 29.118 [14]. The MMEs mark all associations with the VLR as unreliable by setting the restoration indicator "VLR-Reliable" to "False" for the UEs served by that VLR. The associations will be re-initiated one by one by the MME at the next Tracking Area update or combined TA/LA update from each UE.

5 Restoration of data in the HLR

The loss or corruption of subscriber data in the HLR has an impact not only in the HLR"s own PLMN but also on the service for its mobiles in other PLMNs. Restoration of the data in the HLR requires co-operation from all the VLRs to which its mobiles have roamed.

5.1 Restart of the HLR/HSS

When an HLR restarts, it sends to each SGSN where one or more of its MSs are registered a Reset message. This causes the SGSN to mark the relevant MM contexts as invalid, and to set NGAF if an SGSN – MSC/VLR association exists. After receipt of the first valid LLC frame (for A/Gb mode) or after receipt of the first valid GTP-U packet or uplink signalling message (for Iu mode) from a marked MS, the SGSN performs an update location to the HLR as in the attach or inter-SGSN RA update procedures, and, if NGAF is set, the procedure in clause "Non-GPRS Alert" is followed. The update location procedure and the procedure towards the MSC/VLR may be delayed by the SGSN for a maximum

operator configuration-depending on the utilisation of resources during given time period to avoid high signalling load. The periodic backup of HLR data to non-volatile storage is mandatory.

When an HLR restarts after failure it shall perform the following actions for the subscriber data records that have been affected by the HLR fault:

- reload all data from the non-volatile back-up;
- reset all "MS Purged" flags;
- mark each subscriber record "SS Check Required" by setting the "Check SS" indicator if the "Forward Check SS Indication" service is implemented;
- send a "Reset" message to each VLR where one or more of its MSs are registered. This causes each VLR concerned to mark each relevant subscriber record "Location Information Not Confirmed in HLR", and
- send a "Reset" message to each SGSN where one or more of its MSs are registered. This causes each SGSN to mark each relevant MM context "Location Information Not Confirmed in HLR".
- send a "Reset" message to each MME where one or more of its UEs are registered. This causes each MME to mark each relevant MM context "Location Information Not Confirmed in HSS".

5.2 Procedures During Restoration

5.2.1 Mobile terminated call

If the VLR receives a "Process Access Request" request in response to a "Page" or "Search for MS" operation, after successful authentication, if required, it checks the indicator "Location Information Confirmed in HLR". If this indicates "Not Confirmed" the VLR triggers an "Update Location" to the HLR as described in subclause 4.2.1.d).

When the HLR receives the "Update Location" request it stores the VLR number, MSC number and LMSI in the subscriber record as for normal operation.

If the "Forward Check SS Indication" service is implemented, the HLR checks the indicator "Check SS". If this indicates "Check Required", after successful completion of the subscriber data retrieval procedure that ran embedded in the "Update Location" procedure the HLR sends a "Forward Check SS Indication" to the VLR and marks the subscriber record "Check Not Required. When the VLR receives the "Forward Check SS Indication" request it forwards an indication to the MS to alert the user that supplementary service parameters should be checked.

5.2.2 Mobile Originated Activity

When the VLR receives a request from an MS (MS originated call, mobile originated Short Message, call-independent supplementary service activity or location registration request) whose IMSI record is marked "Location Information Not Confirmed in HLR", it will perform an "Update Location" to the HLR as described in subclauses 4.2.5 and 4.2.7 above.

When the HLR receives an "Update Location" request from the VLR, it proceeds as described in subclause 5.2.1.

6 Periodic location updating

The time taken to confirm the location of an MS after location register failure is governed by the frequency with which the MS establishes radio contact with the network. The location information for an MS which remains silent for a long time will remain doubtful for a long time.

A method of reducing this time is to require the MS to establish radio contact with the network at intervals, purely to confirm its location, if the MS does not move to a new location area (which would lead to a normal location registration) or respond to paging for a mobile terminated call or request a mobile originated call or call-independent supplementary service activity.

The interval between successive periodic location updatings is controlled by a timer in the MS; this timer is reset to its initial value at the end of each successfully established radio contact between the MS and the network.

The use of the periodic location update timer is described in 3GPP TS 43.022.

7 Periodic routeing area updating

All GPRS-attached MSs, except MSs in class-B mode of operation engaged in CS communication, shall perform periodic RA updates. For MSs that are both IMSI-attached and GPRS-attached, the periodic updates depend on whether the Gs interface is installed or not:

- If the Gs interface is installed, periodic RA updates shall be performed, and periodic LA updates shall not be performed. If the SGSN has the indicator "VLR-reliable" set to ´false´ the SGSN shall perform a location area update procedure towards the VLR
- If the Gs interface is not installed, both periodic RA updates and periodic LA updates shall be performed independently. RA updates are performed via the Gb interface, and LA updates are performed via the A interface.

The periodic routeing area update is described in 3GPP TS 23.060.

8 Stand-alone operation of the VLR

In a 2G authentication regime, triplets, regardless of its nature (generated in a 2G AuC or derived from quintuplets in a 3G VLR or a 3G HLR), may be reused when no unused authentication triplets are available in the VLR for an IMSI record. It is an operator option to define how many times an authentication triplet may be reused in the VLR.

In a 3G authentication regime, quintuplets, regardless of its nature (generated in a 3G AuC or derived from triplets in a 3G VLR), shall not be reused when no unused authentication quintuplets are available in the VLR for an IMSI record.

If the Update Location response contains an error different from "Unknown Subscriber" or "Roaming Not Allowed" or if there is a parameter problem (e.g. no HLR number included), no error shall be indicated to the MSC and the IMSI record in the VLR shall not be affected, provided that the associated "Subscriber Data Confirmed by HLR" indicator is in the "Confirmed" status.

9 Stand-alone operation of the SGSN

In a 2G authentication regime, triplets, regardless of their nature (generated in a 2G AuC or derived from quintuplets in a 3G SGSN or a 3G HLR), may be reused when no unused authentication triplets are available in the SGSN for an IMSI record. It is an operator option to define how many times an authentication triplet may be reused in the SGSN.

In a 3G authentication regime, quintuplets, regardless of their nature (generated in a 3G AuC or derived from triplets in a 3G SGSN), shall not be reused when no unused authentication quintuplets are available in the SGSN for an IMSI record.

9A Stand-alone operation of the MME

In a E-UTRAN authentication regime, EPS authentication vectors, regardless of their nature (generated in an AAA/AuC or derived from 3G authentication vectors in an IWF), shall not be reused when no unused EPS authentication vectors are available in the MME for an IMSI record.

Editor"s Note: The IWF does not need to derive EPS authentication vectors from 3G authentication vectors if SAE interworking to pre-Rel-8 HSS is forbidden by SA1/3.

10 Restoration of data in the GGSN

10.0 GGSN failure

When a GGSN fails, all its PDP contexts affected by the failure become invalid and may be deleted. GGSN storage of subscriber data is volatile.

When the GGSN receives a GTP-U PDU for which no PDP context exists, it shall discard the GTP-U PDU and return a a GTP error indication to the originating node (the SGSN or, if Direct Tunnel is established, the RNC).

If the RNC receives a GTP error indication, it shall initiate the RAB Release procedure with the error cause "GTP Resources Unavailable" and immediately locally release the RAB (i.e. without waiting for a response from the SGSN).

If the SGSN receives a GTP error indication from a GGSN or a RAB Release Request from the RNC with the error cause "GTP Resources Unavailable" (indicating that the PDP context does not exist on GGSN) it shall mark the related PDP context as invalid and send a Deactivate PDP Context Request message to the MS with cause "re-activation required".

The GGSN should ensure as far as possible that previously used TEID values are not immediately reused after a GGSN restart, in order to avoid inconsistent TEID allocation throughout the network.

10.1 Restart of the GGSN

After a GGSN restart, all the PDP contexts, the MBMS UE contexts, and the MBMS Bearer contexts stored in the GGSN and affected by the restart become invalid and may be deleted.

When the SGSN detects a restart in a GGSN (see clause X "GTP-C based restart procedures") with which it has one or more PDP contexts activated, it shall deactivate all these PDP contexts and request the MS to reactivate them. When the SGSN detects a restart in a GGSN with which it has MBMS Bearer context(s) and/or MBMS UE context(s), it shall delete all these MBMS Bearer context(s) and/or MBMS UE context(s).

10.2 Restoration Procedures

10.2.1 Mobile terminated transmission

When the GGSN receives a mobile terminated PDU for which no valid PDP context exists the GGSN discards the received PDU and may also return an appropriate Error message depending on the protocol used. No further actions are performed by the GGSN. Alternatively, if the GGSN has static PDP information about the PDP address, the GGSN may try to deliver the PDU by initiating the Network-Requested PDP Context Activation procedure (see 3GPP TS 23.060).

10.2.2 Mobile originated transmission

When the GGSN receives a tunnel PDU for which no PDP context exists it discards the tunnel PDU and sends an Error indication message to the originating SGSN. The SGSN deactivates the PDP context and sends an Error indication to the MS. The MS may then re-activate the PDP context.

11 Restoration of data in the SGSN

11.0 SGSN Failure

11.0.1 Gn/Gp SGSN failure

When an SGSN fails, it deletes all MM and PDP contexts affected by the failure. SGSN storage of subscriber data is volatile. Based on configuration data, the SGSN shall send a Reset message to each of its associated VLRs. The VLR

shall mark all associations containing the restarted SGSN as unreliable. See TS 23.007 [5]. In the case of optional CAMEL interaction the failing SGSN shall invoke the CAMEL-GPRS-Exception procedure towards the GSM-SCFs.

If data or signalling, except GPRS attach and RA update, is received in an SGSN from an MS for which no MM context exists in the SGSN, the SGSN shall discard the data or signalling.

If an RA update request is received in an SGSN from an MS for which no MM context exists in the SGSN, or in the old SGSN for the inter-SGSN RA update case, the SGSN shall reject the RA update with an appropriate cause. In order to remain GPRS-attached, the MS shall then perform a new GPRS attach and should (re-)activate PDP contexts.

If a service request is received in a 3G-SGSN from an MS for which no MM context exists in the 3G-SGSN, the 3G-SGSN shall reject the service request with an appropriate cause. In order to remain GPRS-attached, the MS shall then perform a new GPRS attach and should (re-) activate PDP contexts.

NOTE: In some cases, user interaction may be required, and then the MS cannot (re-)activate the PDP contexts automatically.

When the SGSN receives a PDU Notification Request message for which no MM context exists, the SGSN returns a PDU Notification Response message to the GGSN with an appropriate cause (see clause "Unsuccessful Network-Requested PDP Context Activation Procedure"), and the SGSN may search the MS by paging with the IMSI in the SGSN area. An MS that is paged for PS services with IMSI as the identifier shall perform a new GPRS attach and should (re-)activate PDP contexts.

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 initiate the RAB Release procedure with the error cause "GTP Resources Unavailable" and shall immediately locally release the RAB (i.e. without waiting for a response from the SGSN).

When the SGSN receives a mobile-terminated SM from the SMS-GMSC for an IMSI unknown in the SGSN, it rejects the request.

When the SGSN receives a paging request over the Gs interface for an IMSI unknown in the SGSN and the SGSN has not completed recovery, the SGSN may page the MS for packet services with IMSI as identifier in the area specified by the location information provided by the MSC/VLR. If no such location information is provided, the SGSN may page the MS in the routeing areas corresponding to that MSC/VLR. After the MS performs a combined GPRS attach, the SGSN may continue serving the Gs interface paging request.

11.0.2 SGSN Failure using S4

When the SGSN receives a Downlink Data Notification Request message for which no MM context exists, the SGSN returns a Downlink Data Notification Response message to the Serving GW with an appropriate cause. The Serving GW shall delete the related Bearer context towards SGSN; and if there is no ISR associated MME recorded on the related Bearer context the Serving GW shall also notify the PDN GW to delete the Bearer context.

When the SGSN receives a GTP-U PDU from the Serving GW for which no Bearer context exists, it shall discard the GTP-U PDU and send a GTP error indication to the originating Serving GW. The Serving GW shall mark the related Bearer context towards SGSN as invalid; and if there is no ISR associated MME recorded on the related Bearer context the Serving GW shall also notify the PDN GW to delete the Bearer context.

11.1 Restart of the SGSN

After an SGSN restart, the SGSN deletes all MM, PDP, MBMS UE, and MBMS Bearer contexts affected by the restart.

When the GGSN detects a restart in an SGSN (see clause X "GTP-C based restart procedures") with which it has PDP context(s) activated and/or MBMS UE context(s), it shall delete all these PDP context(s) and/or MBMS UE context(s). When the GGSN detects a restart in an SGSN with which it has any MBMS Bearer context, it shall not delete the MBMS bearer context unless all SGSNs connected to the GGSN restart.

11.2 Restoration Procedures

11.2.1 Mobile terminated user data transmission

When the SGSN receives a tunnel PDU for which no PDP context or MBMS Bearer Context exists it discards the tunnel PDU and sends an Error indication message to the originating GGSN.

11.2.2 Mobile terminated services requested by the MSC/VLR

When the SGSN receives a request for CS paging from an MSC/VLR for an IMSI unknown by the SGSN, if the "SGSN-Reset" indicator is set to "true", the SGSN sends the paging request with the location information provided by the VLR. If no such location information is provided, the SGSN should page for the MS in all the routeing areas corresponding to that SGSN.

If the "SGSN-Reset" indicator is set to "false" and the IMSI is unknown or the MS is marked as GPRS or non-GPRS detached by the SGSN, the paging request is rejected.

If the "SGSN-Reset" indicator is set to "false" and the IMSI is known and the MS is marked as GPRS and is non-GPRS attached by the SGSN, the paging request shall be sent to the MS.

11.2.3 Mobile terminated SMS over GPRS

a) Send Routing Information for MT SMS (SMS-GMSC -> HLR):

The HLR returns the SGSN number as for normal operation.

b) Send Information for MT SMS:

- When the SGSN receives a mobile terminated SMS for an unknown MM context for the MS, or if the SGSN indicator "Subscriber Data Confirmed by HLR" is marked "Not Confirmed" it rejects the SMS request and returns a failure report with cause value "Unidentified Subscriber" to the SMS gateway MSC indicating unsuccessful delivery of the SMS. The Gateway MSC sends a "Report SM Delivery Status" request, with a cause of "Absent Subscriber", to the HLR. This causes the HLR to set the "Mobile Station Not Reachable for GPRS Flag" for the MS, as described in the Technical Specifications3GPP TS 23.040 and 3GPP TS 29.002.

- If the SGSN has the indicator "Subscriber Data Confirmed by HLR" set to "Confirmed", the SGSN handles the SMS request in the normal way.

The state of the indicator "Location Information Confirmed in HLR" does not affect the Mobile Terminated SMS procedure.

11.2.4 Mobile originated Routeing Area Updating or Attach

For attach, where the MS is unknown in the SGSN (i.e. the SGSN has no MM context for the MS) the SGSN creates an MM context for the MS and sets the indicators "Location Information Confirmed in HLR" and "Subscriber Data Confirmed by HLR" to "Not Confirmed". If authentication is required, the SGSN retrieves authentication data. The SGSN then performs an "Update GPRS Location" to the HLR. If this is successful, the SGSN sets the indicators "Location Information Confirmed in HLR" and "Subscriber Data Confirmed by HLR" to "Confirmed".

For routing area update, where the MS is unknown in the SGSN (i.e. the SGSN has no MM context for the MS) or for inter-SGSN routing area update, where the MS is unkown in the old SGSN, the SGSN shall reject the RA update with an appropriate cause. In order to remain GPRS-attached, the MS shall then perform a new GPRS attach and should (re-)activate its PDP contexts.

If the SGSN has an MM context for the MS, and the indicators "Location Information Confirmed in HLR" or "Subscriber Data Confirmed by HLR" is set to "Not Confirmed" the SGSN performs an "Update GPRS Location" to the HLR. If this is successful, the SGSN sets the indicators "Location Information Confirmed in HLR" and "Subscriber Data Confirmed by HLR" to "Confirmed".

If the SGSN has an MM context for the MS with the indicator "Subscriber Data Confirmed by HLR" marked "Confirmed" the originated transmission is handled in the normal way.

The SGSN retrieves subscriber data from the HLR by sending an "Update GPRS Location" request, which triggers one or more "Insert Subscriber Data" operations from the HLR.

11.2.5 Mobile originated LLC frame

If an SGSN receives an LLC frame for which no MM context exists in the SGSN, and if the LLC frame does not contain an Attach Request or a Routeing Area Update Request signalling message, then the LLC frame shall be discarded. The MS may determine that the network is not responding and attempt to re-attach or eventually a periodic Routing Area Update message is sent by the MS which initiates the attach procedures.

11.3 Use of TLLI

After the SGSN has restarted but before the next authenticated radio contact the P-TMSI and TLLI known by the MS are invalid, as the P-TMSI was allocated before the SGSN restarted. The SGSN may request the MS to identify itself with the IMSI in order to make a relationship between the IMSI and the received old TLLI. The SGSN shall allocate a new P-TMSI for that MS.

If an MS identifies itself by a TLLI in an MS originating transmission, the SGSN proceeds as follows:

a) The SGSN checks the routing area identity (RAI) of the previous routing area sent by the MS. If this previous RAI belongs to a different SGSN, the request is handled in the normal way.

b) If the previous RAI belongs to the current SGSN, the status of the TLLI is checked.

   - If the P-TMSI derived from the TLLI was allocated after the SGSN restarted, and corresponds to a valid IMSI record, then the request is handled in the normal way.

   - If the P-TMSI derived from the TLLI was allocated before the SGSN restarted, or does not correspond to a valid IMSI record, then the SGSN requests the IMSI from the MS. If the MS returns an IMSI the SGSN proceeds in the normal way. If the MS does not return an IMSI the network aborts the originating transmission request or location registration procedure.

11.4 VLR associations

All associations with VLRs affected by the restart of an SGSN are marked as unreliable and may be deleted. Based on configuration data, "Reset" messages are sent on the Gs-interface to the VLRs served by the SGSN. The VLRs mark all associations with the SGSN as unreliable by setting the restoration indicator "Confirmed by radio contact" to "Not Confirmed" for the MSs served by that SGSN. The associations will be re-initiated one by one by the SGSN at the next Routing Area update, or combined RA/LA update from each MS.

12 Restoration of Data in an SMLC (GSM only)

12.1 Restart of an SMLC

When an SMLC restarts after a failure, it performs the following actions for those of its associated LMUs whose records have been affected by the fault:

- Reload all administered LMU data from non-volatile back-up;

- Reinitialize other temporary data for each LMU to indicate no ongoing measurement or diagnostic activities;

- Perform data restoration for each affected Type A and Type B LMU as described below.

12.2 Data Restoration for a Specific LMU

An SMLC may restore data for a specific LMU when the data in the SMLC or LMU is considered unreliable (e.g. if there is no communication between the SMLC and LMU for a long time or if messages received by the SMLC are inconsistent with the LMU state kept by the SMLC). To restore data for a specific LMU, the SMLC shall open a signalling connection to the LMU if this is Type A, as described in 3GPP TS 23.071. For both a Type A LMU and a Type B LMU, the SMLC shall then send an LLP Reset message to the LMU. On receiving an LLP Reset, an LMU shall cancel any LCS measurement and O&M tasks previously ordered by the SMLC and shall return an LLP Reset acknowledgement to the SMLC.

13 Restoration of Data in an LMU (GSM only)

When an LMU restarts following a failure, it shall reinitialize all data concerning LCS measurement and O&M tasks to indicate that no tasks ordered by an SMLC are active. A Type A LMU shall then perform an "IMSI Attach". A Type A LMU shall then open a signaling connection to its controlling SMLC as described in 3GPP TS 23.071. Both a Type A LMU and a Type B LMU shall send an LLP Status Update message to their controlling SMLC containing an indication that the LMU has restarted following a failure. The SMLC shall update its data regarding the state of the LMU and shall return an LLP Update Status acknowledgment to the LMU.

14 Restoration of data in the MME

14.1 Restart of the MME

14.1.1 Restoration Procedures

After an MME restart, the MME shall delete all MM Bearer contexts affected by the restart that it may have stored.

When an MME detects that a peer SGW or peer PGW has restarted (see clause 18 "GTP-C based restart procedures") it shall as a default delete all PDN connection table data/MM bearer contexts associated with the peer node that fails as well as freeing any internal MME resources associated with those PDN connections. The MME may optionally perform other implementation specific actions such as to clear external resources (e.g. S1-MME messages to clear RNC resources) or more advanced forms of restoration.

NOTE: The MME will have the identity of the PGW and SGW currently in use for a PDN connection available in the MME"s PDN connection table as part of existing EPC procedures as well as other peer state data.

The MME shall detect a peer SGW as currently unavailable by the MME sending a series of GTPv2 echo requests and not receiving a GTPv2 echo response within a period of time (see 3GPP TS 29.274 [13]).

Editor's Note: It is FFS if an unavailable node shall be treated in the same way as a restarting node.

14.1.2 Mobile originated Tracking Area Updating or E-UTRAN Attach

For attach, where the UE is unknown in the MME (i.e. the MME has no MM context for the UE) the MME shall create an MM context for the UE and shall set the indicators "Location Information Confirmed in HSS" and "Subscriber Data Confirmed by HSS" to "Not Confirmed". If authentication is required, the MME shall retrieve the authentication data. The MME then performs an "Update Location" to the HSS. If this is successful, the MME shall set the indicators "Location Information Confirmed in HSS" and "Subscriber Data Confirmed by HSS" to "Confirmed".

For tracking area update, where the UE is unknown in the MME (i.e. the MME has no MM context for the UE) or for inter-MME tracking area update, where the UE is unkown in the old MME, the MME shall reject the TA update with an appropriate cause. In order to remain attached, the UE shall then perform a new attach and should (re-)activate its EPS Bearer contexts.

If the MME has an MM context for the UE, and the indicator "Location Information Confirmed in HSS" or "Subscriber Data Confirmed by HSS" is set to "Not Confirmed" the MME shall perform an "Update Location" to the HSS. If this is

successful, the MME shall set the indicators "Location Information Confirmed in HSS" and "Subscriber Data Confirmed by HSS" to "Confirmed".

If the MME has an MM context for the UE with the indicator "Subscriber Data Confirmed by HSS" marked "Confirmed" the originated transmission shall be handled in the normal way.

The MME retrieves subscriber data from the HSS by sending an "Update Location" request, which triggers an "Update Location" answer which contains the subscriber data.

14.1.3 Mobile terminated services requested by the MSC/VLR

When the MME receives a request for CS paging from an MSC/VLR for an IMSI unknown by the MME, if the "MME-Reset" indicator is set to "true", the MME sends the paging request with the location information provided by the VLR. If no such location information is provided, the MME should page for the UE in all the tracking areas corresponding to that MME.

If the "MME-Reset" indicator is set to "false" and the IMSI is unknown or the UE is marked as EMM-DEREGISTERED by the MME, the paging request is rejected.

If the "MME-Reset" indicator is set to "false" and the IMSI is known and the UE is marked as EMM-REGISTERED by the MME, the paging request shall be sent to the UE.

14.2 VLR associations

All associations with VLRs affected by the restart of an MME are marked as unreliable and may be deleted. Based on configuration data, "Reset" messages are sent on the SGs interface to the VLRs served by the MME. The VLRs mark all associations with the MME as unreliable by setting the restoration indicator "Confirmed by radio contact" to "Not Confirmed" for the UEs served by that MME. The associations will be re-initiated one by one by the MME at the next Combined TA/LA update from each UE.

14.3 Partial Failure Handling at MME

14.3.1 General

A partial failure is where a hardware or software failure affects a significant number of PDN connections while a significant number of PDN connections are unaffected. When it is impossible to recover the affected PDN connections (for example, using implementation-specific session redundancy procedures), it is useful to inform the peer nodes about the affected PDN connections for recovery on the peer nodes. Such a notification could be performed using an identifier that represents a large set of PDN connections rather than on individual PDN connection basis.

NOTE 1: If a hardware or software failure happens to impact only an insignificant number of PDN connections the node experiencing the fault need not treat the failure as a partial fault but may tear down connections one by one.

For the purposes of partial fault handling the term "node" refers to an entity that takes the role of an MME, PGW or SGW as defined in a SAE network.

A PDN Connection Set Identifier (CSID) shall identify a set of PDN connections within a node that may belong to an arbitrary number of UEs. A CSID is an opaque parameter local to a node. Each node maintains a local mapping of CSID to its internal resources. When one or more of those resources fail, the corresponding one or more fully qualified CSIDs are signalled to the peer nodes.

The fully qualified CSID (FQ-CSID) is the combination of the node identity and the CSID assigned by the node which together globally identifies a set of PDN connections.

NOTE 2: The node identifier in the FQ-CSID is required since two different nodes may use the same CSID value. A partial fault in one node should not cause completely unrelated PDN connections to be removed accidentally.

The node identifier shall be globally unique across all 3GPP EPS networks. Its format is defined in 3GPP TS 29.274 [13]

For the purposes of partial fault handling the term peer is used as follows: For a particular PDN connection two nodes are peers if both nodes are used for that PDN connection. For a PDN Connection Set the nodes are peers if they have at least one PDN connection in the PDN Connection Set where both nodes are used for that PDN connection. In particular PGW and MME are generally peers for the purposes of partial fault handling.

An FQ-CSID is established in a node and stored in peer nodes in the PDN connection at the time of PDN connection establishment, or during a node relocation, and used later during partial failure handling in messages defined in 3GPP TS 29.274 [13] and 3GPP TS 29.275 [16]. Each node, including the MME and the PGW, should maintain the FQ-CSID provided by every other peer node for a PDN connection. The FQ-CSIDs stored by PDN connection are later used to find the matching PDN connections when a FQ-CSID is received from a node reporting a partial fault for that FQ-CSID. Implementations may choose to not store any CSID values in a received FQ-CSID and still be conformant. However, if there is a partial fault of a peer , the node that chooses not to store CSID values may experience hanging PDN connections until those connections are deleted by the GTP error handling mechanisms.

The SGW shall forward the FQ-CSID provided by the MME on S11 to the PGW on S5/S8. Similarly, the SGW shall forward the FQ-CSID provided by the PGW on S5/S8 to the MME on S11.

A node may choose not to generate CSIDs during a PDN connection establishment. However, all nodes (i.e., MME, SGW, and PGW) shall support the partial failure handling messages defined in 3GPP TS 29.274 [13] and 3GPP TS 29.275 [16].

With the exception of the GTPv2 Delete PDN Connection Set Request and PMIPv6 BRI messages, each MME, SGW or PGW assigns no more than one FQ-CSID for itself in messages and each FQ-CSID shall have exactly one CSID within the FQ-CSID.

These general procedures, identifiers and definitions apply to partial fault handling by the PGW and SGW unless otherwise stated.

14.3.2 Procedures during PDN Connection Establishment

During a PDN connection establishment, the MME may provide one FQ-CSID containing exactly one CSID for that particular PDN connection to the SGW. The MME should store the Node-ID and CSID values from the FQ-CSID provided by the SGW and the PGW in its PDN Connection table maintained as part of MME MM and EPS Bearer Contexts as specified in 3GPP TS 23.401 [15] in Table 5.6.2-15.7.2-1.

If the MME chooses not to store a received SGW FQ-CSID, the MME shall report an error with appropriate Cause value if a GTPv2 Delete Connection Set Request with any SGW FQ-CSID is received subsequently. Similarly, if the MME chooses not to store a received PGW FQ-CSID, the MME shall report an error with appropriate Cause value if a GTPv2 Delete Connection Set Request with any PGW FQ-CSID is received subsequently. This may also result at that time in hanging PDN connections on an MME that did not store that FQ-CSID, until those connections are deleted by the GTP error handling mechanisms.

14.3.3 Procedures during MME Partial Failure

When an MME detects that it has undergone a partial failure, it shall verify that one or more corresponding CSID(s) are present for the component(s) undergoing a partial fault. If there is no such CSID, then the following does not apply. When one or more CSIDs are currently assigned, the MME shall perform the following.

The MME may perform implementation-specific operations to clean up any residual state associated with the CSID(s).

The MME shall send a GTPv2 Delete PDN Connection Set Request containing all the MME CSID(s) of the component(s) failing in MME FQ-CSID(s) to every SGW peer.

Upon receiving a GTPv2 Delete PDN Connection Set Response message with Cause value "Success", the MME shall conclude that the SGW peer has initiated the internal deletion of the PDN connections corresponding to the FQ-CSID(s) present in the GTPv2 Delete PDN Connection Set Request message. The Cause value "Request Rejected" indicates that the SGW peer chose not to store the MME FQ-CSID.

Regardless of the "Cause" value in the response, the MME is not required to perform any further recovery actions towards SGW and PGW peers for PDN connections in the connection set identified by the MME FQ-CSID(s).

14.3.4 Procedures during a Peer"s Partial Failure

When an MME receives a GTPv2 Delete PDN Connection Set Request message from an SGW, the MME shall retrieve all the PDN connections corresponding to each of the FQ-CSID(s) present in the message. The MME shall delete all the retrieved PDN connections and the associated resources. Other implementation-specific actions may be performed.

As a response, the MME shall send a GTPv2 Delete PDN Connection Set Response message with appropriate Cause value (see sub-clause 14.3.2 for the cause value) immediately to the SGW.

14.3.5 Procedures during PDN Connection Removal or Modification

During a S11 procedure impacting an existing PDN connection (e.g. mobility management, bearer creation/deletion/update):

1) If the SGW is being relocated then the MME shall clear the currently stored SGW FQ-CSID value (if the MME stores SGW FQ-CSID).

2) Assuming the MME is employing a MME FQ-CSID for the PDN connection, if an MME relocation occurs (for example, TAU with MME service change), or if an SGW relocation occurs, (for example, TAU with SGW service change), the MME shall include its MME FQ-CSID in at least one S11 message of the procedure.

3) If the MME receives a FQ-CSID value of a SGW over S11 and assuming the MME stores SGW FQ-CSID then the MME shall overwrite the current stored SGW FQ-CSID value with the received value.

4) If the MME receives a FQ-CSID value of a PGW over S11 and assuming the MME stores PGW FQ-CSID then the MME shall overwrite the current stored PGW FQ-CSID value with the received value.

During a S11 procedure removing an existing PDN connection the MME simply removes the PDN data as well as any stored FQ-CSID values(s) of the PGW FQ-CSID and SGW FQ-CSID or pointers to such data. The same actions are done on the old MME if there is a MME relocation.

15 Restoration of data in GERAN/UTRAN

15.1 BSS Failure (A/Gb mode)

When a BSS fails, all its BSS contexts affected by the failure become invalid and shall be deleted. BSS storage of data is volatile.

15.2 RNC/BSC Failure (Iu mode)

When an RNC/BSC fails, all its RNC/BSC contexts affected by the failure become invalid and shall be deleted. RNC/BSC storage of data is volatile. An SGSN that recognises unavailability of an RNC/BSC or receives a Reset from an RNC/BSC, shall locally release the RABs for all affected PDP contexts. Any affected PDP contexts that use Direct Tunnel and have an invalid tunnel in GGSN will be recovered when the SGSN receives an Iu connection establishment request from the MS or when the GGSN informed the SGSN that the GGSN has received a GTP error indication from RNC.

When the RNC/BSC receives a GTP-U PDU for which no RAB context exists, the RNC/BSC shall discard the GTP-U PDU and return a GTP error indication to the originating node that may be SGSN or GGSN if Direct Tunnel is established.

If the SGSN receives a GTP error indication from the RNC it 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.

If the GGSN receives a GTP error indication for a PDP context that has the DTI flag set (i.e. from an RNC), the GGSN should not delete the associated PDP context but mark it as invalid. Any subsequent packets arriving for an invalid PDP context should be discarded. The GGSN shall inform the SGSN that the GGSN received a GTP error indication from RNC. The SGSN shall re-establish the tunnel between the SGSN and GGSN as specified in 3GPP TS 29.060 [8], which

sets the related PDP context as valid again in the GGSN. The GGSN then forwards any subsequent downlink packets to the SGSN.

The RNC should ensure as far as possible that previously used TEID values are not immediately reused after an RNC restart, in order to avoid inconsistent TEID allocation throughout the network.

15.3 RNC/BSC Failure (Iu mode) using S4

When an RNC/BSC fails, all its RNC/BSC contexts affected by the failure become invalid and shall be deleted. RNC/BSC storage of data is volatile. An SGSN that recognises unavailability of an RNC/BSC or receives a Reset from an RNC/BSC, shall locally release the RABs for all affected PDP contexts. The SGSN deactivates any affected Bearer Contexts using streaming or conversational traffic class in the Serving GW. Any affected interactive or background PDP contexts that use Direct Tunnel and have an invalid tunnel in Serving GW are recovered when the SGSN receives an Iu connection establishment request from the MSor when the Serving GW initiates the Network Triggered Service Request procedure as specified in 3GPP TS 23.060 [5].

When the RNC/BSC receives a GTP-U PDU for which no RAB Context exists, the RNC/BSC shall discard the GTP-U PDU and return a GTP Error Indication to the originating node that may be SGSN or Serving GW if Direct Tunnel is established.

If ISR is not activated on the network or UE is camped on UTRAN for ISR activated UE, when the Serving GW receives a GTP Error Indication for a Bearer Context that has the DTI flag set (i.e. from an RNC), the Serving GW should not delete the associated Bearer Context but delete all the RNC GTP-U tunnel TEIDs for this MS. The Serving GW starts buffering downlink packets received for this MS and sends a Downlink Data Notification message to the SGSN which triggers the re-establishment of the corresponding RABs as specified in 3GPP TS 23.060[5] if subsequent downlink packets arrive for the MS.

16 Restoration of data in the SGW

16.1 Restart of the SGW

16.1.1 Restoration Procedures

After an SGW restart, the SGW shall delete all MM Bearer contexts affected by the restart that it may have stored.

During or immediately after an SGW Restart the SGW shall place local SGW restart counter value in all GTPv2 Echo requests/responses messages and PMIPv6 heartbeat requests/responses the SGW sends.

The SGW will receive the MME restart counter in GTPv2 Echo requests and Echo response messages that the SGW receives from the MME.

The SGW will receive the PGW restart counter in GTPv2 Echo requests/ responses and PMIPv6 heartbeat requests/responses that the SGW receives from the PGW.

When an SGW detects that a peer MME or peer PGW has restarted (see clause 18 "GTP-C based restart procedures") it shall delete all PDN connection table data/MM bearer contexts associated with the peer node that fails as well as freeing any internal SGW resources associated with those PDN connections. The SGW shall not try to directly clear resources in the MME or PGW. The SGW may optionally perform other implementation specific actions such as messages to clear other external resources (e.g. PCC messages).

NOTE: The SGW will have the identity of the MME and PGW currently in use for a PDN connection available in the SGW"s PDN connection table as part of existing EPC procedure.

The SGW shall detect a peer MME as currently unavailable by the SGW sending a series of GTPv2 echo requests and not receiving a GTPv2 echo response within a period of time (see TS 29.274 [13]).

The SGW shall detect a peer PGW as currently unavailable by the SGW sending a series of GTPv2 echo requests, or PMIPv6 heartbeat requests, and not receiving within a period of time respectively a GTPv2 echo response, or a PMIPv6 heartbeat response (see TS 29.274 [13] or TS 29.275[16]).

Editor's Note: It is FFS if an unavailable node shall be treated in the same way as a restarting node.

16.2 Partial Failure Handling at SGW

16.2.1 General

See Section 14.3.1

In addition, the following applies. The SGW may receive Delete PDN Connection Set Request/Reply messages from MME or the PGW. The SGW shall forward such messages to the appropriate peer.

16.2.2 Procedures during PDN Connection Establishment

During a PDN connection establishment, the SGW may provide one FQ-CSID for that particular PDN connection to the PGW. Similarly, the SGW may provide one FQ-CSID for that particular PDN connection to the MME. The SGW should store the Node-ID and CSID from the FQ-CSID provided by the PGW and the MME respectively for that particular PDN connection in its PDN Connection table maintained as part of "EPS Bearer Contexts" table as specified in 3GPP TS 23.401 [15] in Table 5.7.3-1.

If a SGW chooses not to store a received MME FQ-CSID, then the SGW shall report an error if a GTPv2 Delete Connection Set Request is received later with any MME FQ-CSID. If a SGW chooses not to store a received PGW FQ-CSID the SGW shall report an error if a GTPv2 Delete Connection Set Request is received later with any PGW FQ-CSID (or in a PMIPv6 BRI). This may also result at that time in hanging PDN connections on an SGW that did not store that FQ-CSID, until those connections are deleted by the GTP error handling mechanisms.

The SGW shall forward the MME FQ-CSID provided by the MME on S11 to the PGW in the next S5/S8 message for that PDN connection. Similarly, the SGW shall forward the PGW FQ-CSID provided by the PGW on S5/S8 to the MME in the next S11 message for that PDN connection.

16.2.3 Procedures during SGW Partial Failure

When an SGW detects that it has undergone a partial failure, it shall verify that one or more corresponding CSID(s) are present for the component undergoing a partial fault. If there is no such CSID, then the following does not apply. When one or more CSIDs are currently assigned, the SGW shall perform the following.

The SGW may perform implementation-specific operations to clean up any residual state associated with the CSID(s).

The SGW shall send the GTPv2 Delete PDN Connection Set Request containing all the SGW CSIDs of the component(s) failing in SGW FQ-CSID every MME peer. The SGWshall send the GTPv2 Delete PDN Connection Set Request (or PMIP6 Bulk Binding Revocation Indication) message containing the equivalent SGW FQ-CSID(s) to every PGW peer.

Upon receiving a GTPv2 Delete PDN Connection Set Response message with Cause value "Success", the SGW shall conclude that the PGW (for GTPv2 S5/S8) or the MME (for S11) has initiated the internal deletion of the PDN connections corresponding to the FQ-CSID(s) present in the GTPv2 Delete PDN Connection Set Request message. Cause value "Request Rejected" indicates the PGW or MME peer chose not to store the SGW FQ-CSID. Similarly, upon receiving a successful PMIP6 Bulk Binding Revocation Acknowledgment message, the SGW shall conclude that the PGW has initiated the internal deletion of the the PDN connections corresponding to the CSID(s) present in the PMIP6 Binding Revocation Indication message.

Regardless of the "Cause" value in the response, the SGW is not required to perform any further recovery actions towards MME and PGW peers for PDN connections in the connection set identifed by the SGW FQ-CSID(s).

16.2.4 Procedures during a Peer"s Partial Failure

When an SGW receives a GTPv2 Delete PDN Connection Set Request message from an MME, the SGW shall retrieve all the PDN connections corresponding to each of the FQ-CSID(s) present in the message. The SGW shall send a GTPv2 Delete PDN Connection Set Request (or PMIP6 Bulk Binding Revocation Indication) message to every PGW peer containing the FQ-CSID(s) provided by the MME. The SGW shall delete all the retrieved PDN connections and the associated resources. Other implementation-specific actions may be performed.

As a response, the SGW shall send a GTPv2 Delete PDN Connection Set Response message with an appropriate Cause value (see sub-clause 14.3.2 for the cause value) immediately to the MME.

When an SGW receives a GTPv2 Delete PDN Connection Set Request (or PMIP6 Bulk Binding Revocation Indication) message from a PGW, the SGW shall retrieve all the PDN connections corresponding to each of the FQ-CSID(s) present in the message. The SGW shall send a GTPv2 Delete PDN Connection Set Request message to every MME peer containing the FQ-CSID(s) provided by the PGW. The SGW shall delete all the retrieved PDN connections and the associated resources. Other implementation-specific actions may be performed.

As a response, the SGW shall send a GTPv2 Delete PDN Connection Set Response message with an appropriate Cause value (see sub-clause 16.2.2 for the cause value) immediately to the PGW. On PMIP6-based S5/S8 interface, the SGW shall send a PMIP6 Bulk Binding Revocation Acknowledgment message.

16.2.5 Procedures during PDN Connection Removal or Modification

During a S11 or S5/S8 procedure impacting an existing PDN connection (e.g. mobility management, bearer creation/deletion/update):

1) If the MME is being relocated then the SGW shall clear the currently stored MME FQ-CSID value (if the SGW stores MME FQ-CSID).

2) Assuming the SGW is employing a SGW FQ-CSID for the PDN connection, if a SGW relocation occurs (for example TAU with SGW service change), or if a MME relocation occurs (for example TAU with MME service change) the SGW shall include its SGW FQ-CSID in at least one S11 message of the procedure and at least one S5/S8 message of the procedure.

3) If the SGW receives a FQ-CSID value of a PGW over S5/S8 and assuming the SGW stores PGW FQ-CSID then the SGW shall overwrite the current stored PGW FQ-CSID value with the received value. The SGW relays the PGW FQ-CSID value to the MME over S11 regardless of whether the SGW stores the value or not.

4) If the SGW receives a FQ-CSID value of a MME over S11 and assuming the SGW stores MME FQ-CSID then the SGW shall overwrite the current stored MME FQ-CSID value with the received value. The SGW relays the MME FQ-CSID value to the PGW over S5/S8 regardless of whether the SGW stores the value or not.

During a S11 or S5/S8 procedure removing an existing PDN connection the SGW simply removes the PDN data as well as any stored FQ-CSID values(s) of the PGW FQ-CSID and MME FQ-CSID or pointers to such data. The same actions are done on the old SGW if there is an SGW relocation.

17 Restoration of data in the PGW

17.1 Restart of the PGW

17.1.1 Restoration Procedures

After a PGW restart, the PGW shall delete all MM Bearer contexts affected by the restart that it may have stored.

During or immediately after a PGW Restart, the PGW shall place this PGW restart counter value in all GTPv2 echo requests/responses and PMIPv6 echo requests/responses the PGW sends.

The PGW will receive the SGW and MME restart counters in GTPv2 echo requests/responses and PMIPv6 heartbeat requests/responses that the PGW receives from the SGW.When a PGW detects that a peer MME or peer SGW has restarted it shall delete all PDN connection table data/MM bearer contexts associated with the peer node that fails as well as freeing any internal PGW resources associated with those PDN connections. The PGW does not try to directly clear resources in the MME or SGW. The PGW may optionally perform other implementation specific actions such as messages to clear other external resources (e.g. PCC messages).

NOTE: The PGW will have the identity of the MME and SGW currently in use for a PDN connection available in the PGW"s PDN connection table as part of existing EPC procedure.

Editor"s note: It is for FFS if the peer is identified by an explicit ID in the GTPv2 message or is derived from with an existing identifier in the PDN connection table and GTPv2 connection (i.e. GTPv2 control plane IP address or SGW PMIPv6 IP address for PMIPv6 S5/S8).

The PGW shall detect a peer SGW as currently unavailable by the PGW sending a series of GTPv2 echo requests, or PMIPv6 heartbeat requests, and not receiving within a period of time respectively a GTPv2 echo response, or a PMIPv6 heartbeat response (see TS 29.274 [13] or TS 29.275[16]).

Editor's Note: It is FFS if an unavailable node shall be treated in the same way as a restarting node.

17.2 Partial Failure Handling at PGW

17.2.1 General

See Section 14.3.1

17.2.2 Procedures during PDN Connection Establishment

During a PDN connection establishment, the PGW may provide one FQ-CSID containing exactly one CSID for that particular PDN connection to the SGW. The PGW should store the FQ-CSID provided by the SGW and the MME in the PDN Connection table maintained as part of P-GW Context as specified in 3GPP TS 23.401 [15] in Table 5.7.3-1.

If a PGW chooses not to store a received SGW FQ-CSID, then the PGW shall report an error if a GTPv2 Delete Connection Set Request is received later with any SGW FQ-CSID. If a PGW chooses not to store a received MME FQ-CSID, then the PGW shall report an error if a GTPv2 Delete Connection Set Request is received later with any MME FQ-CSID. This may also result in hanging PDN connections on a PGW that did not store the FQ-CSID, until those connections are deleted by the GTP error handling mechanisms.

17.2.3 Procedures during PGW Partial Failure

When a PGW detects that it has undergone a partial failure, it shall verify that one or more corresponding CSID(s) are present for the component(s) undergoing a partial fault. If there is no such CSID, then the following does not apply. When one or more CSIDs are currently assigned, the PGW shall perform the following:

The PGW may perform implementation-specific operations to clean up any residual state associated with the CSID(s).

The PGW shall send the GTPv2 Delete PDN Connection Set Request (or PMIP6 Bulk Binding Revocation Indication) message containing all the PGW FQ-CSID(s) of the component(s) failing to the SGW.

Upon receiving a GTPv2 Delete PDN Connection Set Response message with Cause value "Success", the PGW shall conclude that the SGW peer has initiated the internal deletion of the PDN connections corresponding to the FQ-CSID(s) present in the GTPv2 Delete PDN Connection Set Request message. Cause value "Request Rejected" indicates the SGW peer chose not to store the PGW FQ-CSID. Similarly, upon receiving a PMIP6 Bulk Binding Revocation Acknowledgment message, the PGW shall conclude that the SGW has initiated the internal deletion of the PDN connections corresponding to the CSID(s) present in the PMIP6 Bulk Binding Revocation Indication message.

The PGW is not required to perform any further recovery actions towards SGW and MME peers for PDN connections in the connection set identifed by the PGW FQ-CSID regardless of the "Cause" value in the response.

17.2.4 Procedures during a Peer"s Partial Failure

When a PGW receives a GTPv2 Delete PDN Connection Set Request (or PMIP6 Bulk Binding Revocation Indication) message from an SGW, the PGW shall retrieve all the PDN connections corresponding to each of the FQ-CSIDs present in the message. The PGW shall delete all the retrieved PDN connections and the associated resources. Other implementation-specific actions may be performed.

As a response, the PGW shall send a GTPv2 Delete PDN Connection Set Response message with appropriate Cause value (see sub-clause 17.2.2 for the cause value) this shall be sent back immediately. On PMIP6-based S5/S8 interface, the SGW shall send a PMIP6 Bulk Binding Revocation Acknowledgment message.

17.2.5 Procedures during PDN Connection Removal or Modification

During a S5/S8 procedure impacting an existing PDN connection (e.g. mobility management, bearer creation/deletion/update):

1) If the MME is being relocated or the SGW is being relocated then the PGW shall clear the currently stored MME FQ-CSID value (if the PGW stores MME FQ-CSID) and shall clear the currently stored SGW FQ-CSID value (if the PGW stores SGW FQ-CSID).

2) Assuming the PGW is employing a PGW FQ-CSID for the PDN connection then if an internal PGW relocation occurs (for example mobility/IRAT from Gn/Gp to S5/S8 on a collocated PGW/GGSN - note that this example might be viewed as PDN establishment), or if a SGW relocation occurs (for example TAU with SGW service change) or if a MME relocation occurs (for example TAU with MME service change), then the PGW shall include its PGW FQ-CSID in at least one S5/S8 message of the procedure.

3) If the PGW receives a SGW FQ-CSID value of a SGW over S5/S8 and assuming the PGW stores SGW FQ-CSID then the PGW shall overwrite the current stored SGW FQ-CSID value with the received value.

4) If the PGW receives a MME FQ-CSID value of a MME over S5/S8 and assuming the PGW stores MME FQ-CSID then the PGW shall overwrite the current stored MME FQ-CSID value with the received value.

During a S5/S8 procedure removing an existing PDN connection the PGW simply removes the PDN data as well as any stored FQ-CSID values(s) of the MME and SGW or pointers to such data.

For mobility/IRAT from S5/S8 to Gn/Gp on a collocated PGW/GGSN the MME FQ-CSID and SGW FQ-CSID are also removed from the PDN connection (it would be a PDP context after handover).

18 GTP-C based restart procedures

Across GTP-C based interfaces an SGSN, GGSN, SGW and PGW utilize either GTPv1-C or GTPv2-C Echo Request and Echo Response messages or GTP-C messages containing the Recovery Information Element to detect and handle a restart.

A GTP-C entity shall maintain two Restart counters:

- in volatile memory a remote Restart counter of a peer with which the entity is in contact;

- in non-volatile memory own, or local Restart counter that was sent to a peer.

After a GTP-C entity has restarted, it shall immediately increment all local Restart counters and shall clear all remote Restart counters.

A GTP-C entity may have a common local Restart counter for all peers, or it may have a separate local Restart counter for each peer.

A GTP-C entity may probe the liveliness of each peer with which it is in contact by sending an Echo Request message. The presence of the Restart counter in Echo Request or in a GTP-C message depends on the GTP-C version and therefore is specified in 3GPP TS 29.060 [8] and 3GPP TS 29.274 [13], respectively.

A GTP-C entity shall be prepared to receive an Echo Request message at any time and it shall reply with an Echo Response message. The Restart counter shall be included in an Echo Response message.

The GTP-C entity that receives an Echo Response or a Recovery Information Element in a GTP-C message from a peer shall compare the received remote Restart counter value with the previous Restart counter value stored for that peer entity.

- If no previous value was stored the Restart counter value received in the Echo Response or in the GTP-C message shall be stored for the peer.

- If the value of a Restart counter previously stored for a peer is smaller than the Restart counter value received in the Echo Response message or the GTP-C message, this indicates that the entity that sent the Echo Response or the GTP-C message has restarted. The received, new Restart counter value shall be stored by the receiving entity, replacing the value previously stored for the peer.

- If the value of a Restart counter previously stored for a peer is larger than the Restart counter value received in the Echo Response message or the GTP-C message, this indicates a possible race condition (newer message arriving before the older one). The received new Restart counter value shall be discarded and an error may be logged.

Annex A (informative): Change history

Change history						
TSG CN#	**Spec**	**Version**	**CR**	**<Phase>**	**New Version**	**Subject/Comment**
Apr 1999	GSM 03.07	6.1.0				Transferred to 3GPP CN1
CN#03	23.007				3.0.0	Approved at CN#03
CN#04	23.007	3.0.0	001	R99	3.1.0	GPRS restoration procedures
CN#06	23.007	3.1.0	002r2	R99	3.2.0	Authentication Enhancements
CN#06	23.007	3.1.0	003	R99	3.2.0	Support of VLR and HLR Data Restoration procedures with LCS
CN#07	23.007	3.2.0	004	R99	3.3.0	Support of VLR and HLR Data Restoration procedures with LCS
CN#08	23.007	3.3.0	005	R99	3.4.0	Clarifications on GSM vs. UMTS specific parts
CN#11	23.007	3.4.0		Rel-4	4.0.0	Release 4 after CN#11
CN#16	23.007	4.0.0	007	Rel-4	4.1.0	Removal of an optional IMSI paging after SGSN restart
CN#16	23.007	4.1.0		Rel-5	5.0.0	Release 5 after CN#16
CN#22	23.007	5.0.0	011r1	Rel-5	5.1.0	Restoration of data in RA update
CN#23	23.007	5.1.0	008r3	Rel-6	6.0.0	Change of Restart Counter definition for enhanced GTP
CN#25	23.007	6.0.0	012	Rel-6	6.1.0	Error Indication during an ongoing MBMS data transfer
CN#25	23.007	6.0.0	013	Rel-6	6.1.0	Restoration of GSNs in MBMS
CT#30	23.007	6.1.0	0014	Rel-6	6.2.0	Incorrect References
CT#32	23.007	6.2.0	0019r1	Rel-7	7.0.0	Correction for Usage of Cancel Location for Supercharger
CT#40	23.007	7.0.0	0020r2	Rel-8	8.0.0	EPS Restoration
CT#41	23.007	8.0.0	0021r3	Rel-8	8.1.0	Moving restoration procedures from TS 23.060 into TS 23.007
CT#41	23.007	8.0.0	0023r2	Rel-8	8.1.0	Node Restart Restoration Procedures for PGW, SGW and MME
CT#42	23.007	8.1.0	0027r2	Rel-8	8.2.0	RNC failure aligns with TS23.060
CT#42	23.007	8.1.0	0028	Rel-8	8.2.0	Restoration procedures for SGs interface
CT#42	23.007	8.1.0	0033r5	Rel-8	8.2.0	Partial Failure Handling
CT#42	23.007	8.1.0	0037r1	Rel-8	8.2.0	PMIP Path management / Restoration Clean-up
CT#43	23.007	8.2.0	0030r5	Rel-8	8.3.0	Moving the description of the restoration procedures (from 29.274) to 23.007
CT#43	23.007	8.2.0	0038r4	Rel-8	8.3.0	Partial fault handling finalization
CT#44	23.007	8.3.0	0043r1	Rel-8	8.4.0	FQ-CSID corrections
CT#44	23.007	8.3.0	0047r1	Rel-8	8.4.0	SGSN and SGW handling in case RNC/BSC Failure (Iu mode) using S4

History

Document history		
V8.2.0	January 2009	Publication
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