

ETSI TS 123 007 V3.4.0 (2000-06)

Technical Specification

**Digital cellular telecommunications system (Phase 2+) (GSM);
Universal Mobile Telecommunications System (UMTS);
Restoration procedures
(3G TS 23.007 version 3.4.0 Release 1999)**



Reference

RTS/TSGN-0423007UR2

Keywords

GSM, UMTS

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

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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:

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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 GSM 09.02 and 09.60.

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.

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.

[1] 3G TS 21.905: "3G Vocabulary".

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

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

- [4] 3G TS 23.040: "Technical realisation of SMS Point to Point".
- [5] 3G TS 23.060: "General Packet Radio Service (GPRS) Service description; Stage 2".
- [6] 3G TS 29.002: "Mobile Application Part (MAP) specification".
- [7] 3G TS 29.018: "Serving GPRS Support Node (SGSN) - Visitors Location Register (VLR); Gs interface layer 3 specification".
- [8] 3G TS 29.060: "GPRS Tunneling Protocol (GTP) across the Gn and Gp Interface".
- [9] GSM 03.05: "Digital cellular telecommunication system (Phase 2+): Technical performance objectives".
- [10] GSM 03.71: "Digital cellular telecommunications system (Phase 2+); Location Services (LCS); Functional Description; Stage 2".
- [11] GSM 12.07: "Digital cellular telecommunications system (Phase 2); Operations and performance management".

1.2 Abbreviations

For the purposes of the present document, the abbreviations listed in GSM 01.04 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 GSM 03.05 and GSM 12.07.

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 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 targeted 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 each 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 HLR's 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 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 routing area update timer value used by the MSs.

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.

4.1 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 GSM 03.40 and GSM 09.02.
- 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. The SGSNs mark all associations with the VLR as unreliable by setting the restoration indicator "VLR-Reliable" to "False" for the MSs 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 MS.

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

When an HLR restarts after failure it performs 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".

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 updating 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 GSM 03.22.

7 Periodic routing 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 routing area update is described in GSM 03.60.

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.

10 Restoration of data in the GGSN

10.1 Restart of the GGSN

After a GGSN restart, all the PDP contexts stored in the GGSN and affected by the restart become invalid and may be deleted. GGSN storage of data is volatile except as specified in this subclause. The GGSN maintains in volatile memory an SGSN Restart counter for each SGSN with which the GGSN is in contact, and in non-volatile memory a GGSN Restart counter. The GGSN Restart counter shall be incremented and all the SGSN Restart counters cleared immediately after the GGSN has restarted. The SGSN performs a polling function (echo request and echo response) towards the GGSN's with which the SGSN is in contact. The GGSN Restart counter shall be included in the echo response. If the value received in the SGSN differs from the one stored for that GGSN, the SGSN will consider that the GGSN has restarted (see GSM 09.60). The SGSN Restart counters shall be updated in the GGSN to the value received in the first echo message coming from each SGSN after the GGSN has restarted.

When the SGSN detects a restart in a GGSN with which it has one or more PDP contexts activated, it shall deactivate all these PDP contexts and request the MS to reactivate them. Also, the new value of the GGSN Restart counter received in the echo response from the GGSN restarted shall be updated in the SGSN.

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 GSM 03.60).

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

11.1 Restart of the SGSN

After an SGSN restart, the SGSN deletes all MM and PDP contexts affected by the restart. SGSN storage of data is volatile except as specified in this subclause. The SGSN maintains in volatile memory a GGSN Restart counter for each GGSN with which the SGSN is in contact, and in non-volatile memory an SGSN Restart counter. The SGSN Restart counter shall be incremented and all the GGSN Restart counters cleared immediately after the SGSN has restarted.

The GGSN performs a polling function (echo request and echo response) towards the SGSNs with which the GGSN is in contact. The SGSN Restart counter shall be included in the echo response. If the value received in the GGSN differs from the one stored for that SGSN, the GGSN will consider that the SGSN has restarted (see GSM 09.60). The GGSN Restart counters shall be updated in the SGSN to the value received in the first echo message coming from each GGSN after the SGSN has restarted.

When the GGSN detects a restart in an SGSN with which it has any PDP context activated, it shall delete all these PDP contexts. Also, the new value of the SGSN Restart counter received in the echo response from the SGSN restarted shall be updated in the GGSN.

11.2 Restoration Procedures

11.2.1 Mobile terminated user data transmission

When the SGSN receives a tunnel PDU for which no PDP context exists it discards the tunnel PDU and sends an Error indication message to the originating GGSN. The SGSN may search for the MS by paging with the IMSI in the SGSN area if there is no MM context for the MS. An MS that is paged with the IMSI performs a GPRS attach procedure.

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 routing 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 Specifications GSM 03.40 and GSM 09.02.
- 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

If 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".

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 signaling connection to the LMU if this is Type A, as described in GSM 03.71. For both a Type A LMU and 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 acknowledgment 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 GSM 03.71. 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.

Annex A: 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

History

Document history		
V3.2.0	January 2000	Publication
V3.3.0	March 2000	Publication
V3.4.0	June 2000	Publication