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PREFATORY NOTE

ETSI has constituted stable and consistent documents which give specifications for the implementation of the European Cellular Telecommunications System. Historically, these documents have been identified as "GSM recommendations".

Some of these recommendations may subsequently become Interim European Telecommunications Standards (I-ETTs) or European Telecommunications Standards (ETTs), whilst some continue with the status of ETSI-GSM Technical Specifications. These ETSI-GSM Technical Specifications are for editorial reasons still referred to as GSM recommendations in some current GSM documents.

The numbering and version control system is the same for ETSI-GSM Technical Specifications as for "GSM recommendations".

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1. INTRODUCTION

The data stored in the location registers are automatically updated; the main information is related to the location of the mobile station. These data are updated when the MS moves from one area to another. The loss of this information would have an important impact on the service provided to the relevant mobile subscribers. It is therefore necessary to define solutions to limit the perturbations following a register failure and to restore automatically these tables.

This Recommendation specifies procedures to be performed to restore the location data after a location register failure.

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

The problem has to be solved for the supplementary services parameters, as well even though the impact on the service is not so sensitive.

Procedures for supporting these functions are contained in Recommendation GSM 09.02.

2. DESIGN OBJECTIVES

To avoid a loss of all the data stored in a location register when a failure occurs, it is necessary to implement a periodic backup of the memories. This would avoid an overload of the signalling network at the restart and limit the disturbances for the subscribers. This method is normally used in the telephone exchanges where a copy of the tables is made periodically in order to allow a restart if a control unit failure occurs, e.g. on a disc device or a magnetic tape.

The reliability objectives of location registration are listed in Recommendations GSM 03.05 and 12.07.

3. RESTORATION OF THE LOCATION DATA

The perturbations due to a deterioration of the location tables and the restoration procedures are different if the equipment affected is a Home or a Visitor Location Register.

3.1 The Visitor Location Register

3.1.1 Status of the data after a failure

When a Visitor Location Register failure occurs, some discrepancies between the actual location of the MS and the location information stored may appear in the following cases:

- i) since the last backup, the MS moved to another location area in the same MSC area: if allocated, the roaming number remains correct but the location area information is wrong;
- ii) the MS appeared in the MSC area since the last backup: this MS is then unknown by the Visitor Location Register while the Home Location Register has stored information corresponding to this new location;
- iii) the MS left the MSC area: the MS is still registered in the Visitor Location Register but the update was made in the Home Location Register;
- iv) the MS left the MSC area and then came back: for the Visitor Location Register, the MS did not leave the MSC area. If allocated, then the previous roaming number remains stored by the Visitor Location Register while the Home Location Register stored another roaming number given during the last updating made before the failure. In general, the location area information saved is not the relevant one.

3.1.2 Restoration procedures

When a restoration procedure of the VLR is requested, the VLR will perform the following actions:

- reload all data from the back-up memory and sets the state of each subscriber as "not confirmed by radio contact" and "not confirmed by the HLR" (see note 1);
- a reset message is sent as soon as possible to the HLRs to which the roaming number is sent at location updating. On receiving this reset message, the HLR marks "to be checked" all the subscriber records concerned;
- starts to handle the interrogation procedures

Note 1: As an option, the VLR could erase all data. It should however be noted that this method of operation may generate an increase signalling load, depending on frequency of making back-ups, subscriber movements and areas served by the VLR, compared to use of back-up in VLR.

Procedures during restoration:

a) incoming calls

■ Messages to VLR:

i) Provide Roaming number

- Irrespective of whether the VLR has any data stored, it returns an MSRN. The subscriber data are also updated (using the 09.02 procedures). Upon reception of the subscriber data from HLR, VLR turns off the indicator "not confirmed by the HLR". The indicator on confirmation by radio contact remains as "not confirmed".

ii) send information for I/C call set-up

- if the subscriber record has not been checked yet with the HLR, a negative result is sent (e.g system failure).
- if the subscriber record has been checked with the HLR, the VLR handles the message according to the normal procedure, using "search MS" operation.

■ Message to HLR:

i) send routing data info:

- if the HLR contains the MSRN and the subscriber record has to be checked, it sends to VLR the enquiry message. (The MSRN is updated in the HLR and the record is turned to "checked" only after the next location updating)
- if the HLR does not contain the MSRN, it sends in any case the enquiry to VLR. (The LMSId is updated in the HLR, if required, after the next location updating.)
- validation of VLR record is performed as indicated above.

b) outgoing MS request

When the restart occurs, each outgoing request (call, supplementary service request, IMSI attach request) from a MS will initiate the checking operation of its location information.

- If the MS is already registered in the MSC area, the location area information is updated if necessary and the indicator "not confirmed by radio contact" is removed. The location updating procedure is then initiated with the HLR to remove the indicator turned there and have the subscriber data update. The indicator "not confirmed by the HLR" is then removed in the VLR.
- If the MS is unknown in this MSC area, a normal location updating procedure is started with the station (see Recommendation GSM 03.12). The location updating removes the indicator in the HLR.

c) location updating

A location area updating coming from an MS already registered causes the removal of the VLR indicator "not confirmed by radio contact". A normal location updating procedure is then initiated with the HLR to remove its indicator and have the subscriber data updated. The indicator "not confirmed by the HLR" is then removed in the VLR.

d) application of TMSI

Since there may be a discrepancy between the TMSI known by the MS and this one stored in the VLR, the first contact with an MS after a restart is performed with the IMSI.

e) IMSI attach/detach

When it restarts, the VLR erases all the IMSI detach flags.

f) restoration phase time-out

In case iii), as the MS left the area, no traffic is received for or generated by that MS; the restoration is then impossible and a roaming number is frozen for nothing. To solve this problem, if the validation of the location information does not occur after a certain delay (in the order of several hours or one day), the VLR erases the MS from its tables.

3.2 The Home Location Register

The deterioration of the data contained in the Home Location Register is of concern not only for the PLMN but also for the whole service. The Home Location Register needs the help of all the visitor registers in charge of the MSC areas where its MSs are located.

3.2.1 restart of the HLR

When a restoration procedure of the HLR is requested, the HLR will perform the following actions:

- reload all data from the back-up memory and sets the state of each subscriber record as "to be checked".
- sends a reset message as soon as possible to the VLRs to inform them about the failure. The VLR marks all the concerned subscriber record and starts a timer.
- starts to handle interrogation procedures.

3.2.2 procedures during restoration

When the HLR receives a "send routing data info" message:

- If the MSRN is available and the subscriber record has to be checked, it sends a "roaming number enquiry" to the relevant VLR according to the VLR address contained in subscriber record and sends also MSRN with the indication that the data should be checked. If the mobile is registered in VLR, the latter returns the MSRN and removes the indicator. The HLR registers the new MSRN and removes its indicator. If the mobile is not registered in VLR, the latter returns a negative answer (unknown subscriber) and the HLR deregisters the MS and waits for a location updating for this MS.
- If the MSRN is not available and the subscriber record has to be checked, it sends to the relevant VLR a "provide roaming number" containing the LMSId, if applicable, with the indication that the data should be checked. If the mobile is registered in VLR, the latter returns the LMSId and removes the indicator. The HLR registers the new LMSId and removes its indicator. If the mobile is not registered in VLR, the latter returns a negative answer (unknown subscriber) and the HLR deregisters the MS and waits for a location updating for this MS.

When the VLR receives a message from an MSC initiated by an outgoing request (call, supplementary service request, IMSI attach request, location area updating) from a mobile concerned by the failure, the VLR removes the indicator and initiates a location updating procedure with the HLR. At this time the HLR updates its table, removing the indicator.

3.2.3 restoration phase time-out

If after a certain delay, the location information stored in the VLR is not confirmed for some MSs, the VLR erases then the concerned records. The timer used to supervise this phase could be the same as started for VLR restoration: see 3.1.2 f).

3.3 Periodic location updating

The delay to confirm the location of a subscriber after a failure depends on the traffic of this MS. If a MS is silent for a long time, it would be difficult to know if the location information stored is correct or not during this period.

A solution to reduce this delay is to force the MS to send a message when it remains still during a long time. For that purpose a time-out is reinitiated at each message sent by the MS. When this time-out expires, the MS sends a location updating message to the base station. With this method, the delay during which the MS can be lost is, in most cases, less than the duration of this time-out. In order to avoid a control channel overload in the morning, this time-out runs only when the MS is switched on. The interruption of the time-out when the MS is switched off is not a problem because the latter is then unable to receive any call: therefore the service provided to that subscriber is not degraded. If the IMSI detach procedure is used, the first message sent by the MS when it is switched on is the registration: in that case the interruption of the time-out is not very useful but does not raise any difficulty. A rough estimate of this time-out value may be a few hours: this value is to be fixed according to traffic simulations and it seems that it could be comprised between 6 minutes and 25.5 hours. (see Recommendation GSM 03.12)

4. RESTORATION OF THE SUPPLEMENTARY SERVICES PARAMETERS

As well as the location data, the supplementary services parameters may be disturbed when a register failure occurs. Therefore, it is necessary to define methods to restore them.

4.1 VLR fault recovery

After a failure, the VLR recovers the subscriber data from a previous internal back-up (see also note 1 to 3.1.2). However, inconsistencies about activation status of the supplementary services may appear between the tables of the VLR and of the HLR (e.g. the MS may have recently modified activation status of call forwarding services).

In any case, the whole information related to supplementary services status is available in the HLR. Then the retrieval of SS-information should be performed only between the VLR and the HLR. There is no need to give any indication to the subscriber. The procedures described in para. 3.1.2 apply.

4.2 HLR fault recovery

After a failure, the HLR recovers the subscriber data from a previous internal back-up. However, the subscriber may have modified recently the status of supplementary services.

Then the following procedures are performed:

- a) After recovery, the restarting HLR sends a reset message to the VLRs known. This message has to be considered by the VLR as an implicit request to initiate a location updating procedure as soon as a MS concerned by the failure sends a radio message (see section 3 above).
- b) The HLR may not be able to restore its data for all supplementary services. To complete this restoration, it is then necessary to inform the subscribers about these possible discrepancies. Therefore, if some service parameters have not been restored, the HLR should request the VLR to alert the subscriber on this failure with a message "check SS". This message is sent when the HLR receives a location updating for this station, after a radio contact (see 3.2 above). The message is then sent to the MSC. When the MSC receives this message it informs the station and an indication is given to the subscriber. With this method every mobile is individually informed even if it is e.g. switched-off at the time of the failure. In addition, signalling overload can be avoided on the radio path and in the network by subscribers trying to check their supplementary service status at the same time.

4.3 MSC fault recovery

If the MSC fails, the location registers cannot help the MSC to recover the contexts of the calls in progress. There is no difference with a normal fixed exchange.

5. STAND-ALONE OPERATION

5.1 VLR In stand-alone situation

With this is meant that the VLR does not succeed to communicate with one or several HLRs. The principle here is that calls from the concerned mobile subscribers may still be possible. The reason being that the VLR has already data stored about the MS.

The VLR may accept a location updating order from an MS even if the HLR is not updated, since the MS cannot perform call set-up if it has not stored the location area. This can only be done if authentication is successfully performed. In case VLR does not update HLR in the location updating, it shall store the LAI only, and mark that HLR has not been updated. In the next radio contact with the MS, location updating with HLR is initiated. If successful, the mark to update HLR for this MS is removed.