INTERNATIONAL TELECOMMUNICATION UNION

ITU-T Q.1004

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

PUBLIC LAND MOBILE NETWORKS

LOCATION REGISTER RESTORATION PROCEDURES

ITU-T Recommendation Q.1004

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation Q.1004 was published in Fascicle VI.12 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Recommendation Q.1004

LOCATION REGISTER RESTORATION PROCEDURES

1 Introduction

The data stored in the location registers are automatically updated and the main information is related to the location of the mobile station. The data is updated when the mobile station 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 describes some methods that could be implemented in order to provide a good security of the data stored in the location registers and procedures that could be performed to restore the location data and supplementary services data after a location register failure.

However, the implementation of these methods and procedures are not mandatory and are open to technical innovation.

2 Technical realizations to achieve the 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 safeguard of the memories. 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. This back-up can be made on either a disc device or a magnetic tape.

3 Restoration of the location register memories

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 mobile station and the location information stored may appear in the following cases:

i) since the last safeguard, the mobile moved to another location area in the same MSC area; the allocated roaming number remains correct but the location area information is wrong;

ii) the mobile appeared in the MSC area after the last safeguard; this mobile is then unknown by the visited location register while the home location register stored a roaming number corresponding to this new location;

iii) the mobile left the MSC area; a roaming number is allocated in the visitor register but the updating was made in the home register;

iv) the mobile left the MSC area and then came back; for the visitor register, the mobile did not leave the MSC area and the previous roaming number is considered as correct by the visitor register while the home register stored another roaming number given during the last updating made before the failure. The location area information saved may not be the relevant one.

3.1.2 *Restoration procedures*

When a failure occurs, the data concerning only a small part of the mobiles located in the relevant area are lost. Therefore, it seems that a systematic restoration method such as a general interrogation of the home location registers would load the network and the equipments for so small a result.

The restoration process is then the following:

At the restart of the register each element of the memory is pointed out by an indicator. This indicator is turned out when the relevant location information has been checked.

a) *Outgoing calls*

When the restart occurs, each outgoing call from a mobile will initiate the checking operation of its location information:

- if the mobile is already registered in the MSC area, the location area information is updated, if necessary, but the location updating procedure is not initiated with the home register (case i) solved);
- if the mobile is unknown in this MSC area, a roaming number is allocated to that station and a location updating procedure is started with the home register (case ii) solved).

b) *Incoming calls*

Concerning the incoming calls, in the cases ii) and iv) described above, the roaming number received by the MSC in the IAM does not correspond to the right mobile station. In some cases, it is not allocated or it may be allocated to another mobile; this depends on the method used to allocate this number. The normal solution (see also note) to detect this difficulty is that the Initial Address Message received by the MSC during the call set-up contains also the international ISDN number of the called subscriber. If this is the case, the visitor location register can check the couple to detect a possible mistake. If an inconsistency is noticed, the MSC sends then an Unsuccessful Backward Message to inform the originating exchange that it is unable to complete the call. The VLR interrogates the relevant HLRs (the mobiles may be attached to two different HLRs) to correct its tables. Two interrogations have to be performed:

- one about the mobile station to which the VLR allocated this wrong roaming number (MS 1);
- the other about the station to which the call was destined (MS 2).

i) The MS 1 left its MSC area; the VLR erases it from its table and updates it by allocating the roaming number to MS 2 which is introduced in the VLR tables. The data attached to that station are requested from its HLR;

ii) The MS 1 is still in the MSC area:

- the VLR allocates a new roaming number to that station and then updates the relevant HLR;
- the MS 2 is introduced in the VLR table and the parameters attached to that station are requested from its HLR.

If the mobile station left its location area since the last safeguard, the paging message sent will remain unanswered and the mobile will be considered as lost or out of service. To improve the service, the call message may be sent in all the location areas controlled by the MSC. If the mobile answers, the location information is then updated. If not, the mobile is considered out of reach and the appropriate unsuccessful end-of-selection message is sent backwards.

If the mobile is switched off when it is called, the result is the same as the above.

Note - As a national option, the HLR may use the "send parameter from VLR" operation of MAP to obtain the MSRN from the VLR on a per call basis. This is normally allowed only within a PLMN.

c) Particular cases

In case iii), as the mobile leaves the area, no traffic is related to that mobile; 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 one day or more), the VLR may then interrogate the HLR to know if this station is still located in its area. This method can also solve cases ii) and iv) if the corresponding mobiles have a very low traffic.

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 mobiles are located.

When a restart of the home location register occurs, a specific reset message is sent to all the visitor location registers to inform them about the failure. As the home register is unable to know the addresses of all the visitor registers in service, the only solution is to send the message only to the registers known. The list is extracted from the tables saved previously; of course some modifications occurring since the last back-up are lost and therefore some visitor registers involved in the control of mobiles managed by this home register will not be contacted. But the number of registers forgotten will be very low. Another solution could be that the reset message is sent only to the "neighbour" VLRs; a specific table giving the addresses of these VLRs is then contained in the HLR memories. The content of that table is defined by the operating people according to the roaming traffic of the mobile managed by this HLR. In that case too, the number of forgotten registers will be very low.

After receiving this reset message, when a mobile concerned by the failure sends a radio message, to update its location, to set up an outgoing call, to answer an incoming call or a request coming from the MSC or to activate or request a supplementary service, the relevant visitor location register will initiate a location updating procedure with the home location register. The latter then updates its tables and validates the relevant data.

If, after a certain delay, the location of some mobiles is not confirmed, the home register interrogates the relevant visitor registers. If a positive answer can be obtained, the location information is validated. If not, because the mobile left the MSC area between the back-up and the failure, an alarm message may be given to the technical staff in order to inform them about the loss of the location of this subscriber.

3.3 *Periodic registration*

The delay to confirm the location of a subscriber after a failure depends on the traffic of this station. If a station 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 mobile 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 mobile. When this time-out expires, the station sends a location updating message to the base station. 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 12 and 24 hours); if the IMSI detach procedure when switched off is not used, to avoid an overload of the control channel in the morning, this time-out runs only when the station is switched on. With this method, the delay during which the mobile can be lost is less than the duration of this time-out. The interruption of the time-out when the station is switched off is not a problem because it 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 mobile when it is switched on is the IMSI attach; in that case the interruption of the time-out may or may not be implemented.

4 Restoration of the supplementary service parameters

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

4.1 *VLR fault recovery*

a) When the VLR fails, the HLR is able to retrieve the activation status of the supplementary services. However, if the visitor location register does not require any information from the home location register in order to comply with a MS supplementary services activation request, the involved data are not available in the HLR when the VLR fails. This situation cannot appear if the location area is the only information in the VLR which is unknown from the HLR. Otherwise, it would be necessary to include in the deregistration request and in the location cancellation acknowledge messages sent by the VLR to HLR the parameters of activations which would be only known from the VLR.

b) After the restart of a VLR, risks of inconsistency appear between the tables of the VLR and of the HLR:

- relating to incoming calls, the mobile may have recently modified activation status of supplementary services; reverse charging acceptance, diversion call on no reply, connect when free ... ;
- relating to outgoing calls, this method allows checking of other parameters; conditional barring of outgoing calls, preferential closer used group...

Two few mobiles are involved in this situation to justify the systematic interrogation of the HLR by the VLR so it is suggested that the VLR sends an information request message to the HLR if, and only if, one SS at least was registered in the saved tables of the VLR. This message must request from the HLR all parameters of supplementary services that are related to the mobile. Moreover, as soon as the data of supplementary services are validated in the tables of the VLR, an

indicator has to be turned out.

The retrieval procedures are not influenced by handover.

4.2 *HLR fault recovery*

When the restart of a home location register occurs, the loading of a previously saved state is useful. However, the mobile may have changed its parameters of registration or activation since the last back-up of the HLR; these cases are presented here.

4.2.1 *Retrieval of SS-registration status*

If the mobile station changed recently, by administrative means, the list of the supplementary services for which it contracts a subscription, the operation can be lost by the system when the HLR fails. It seems important to avoid this situation with a high security.

When the MS requests, by signalling means, the HLR to provide a registration for a specific supplementary service, this capability being additional to that of providing subscriptions by administrative means, the HLR has to save this command with a high level of security, against an eventual HLR failure. After that, the HLR can send back a category/supplementary services information acknowledge message to the VLR.

4.2.2 *Retrieval of SS-activation status*

After the HLR failure, the information which is related to the activations of supplementary services by a not-registered station are available in no VLR.

Therefore, the reset message which is sent by the reinitialized HLR to all VLRs should contain implicitly an information request about the current activation status of the supplementary services. Since in some cases the VLR may not know these data, the relevant parameters should be held in the mobile equipment. To recover them, two possibilities are available:

- to include this request into a "search" message, from the VLR towards the MSC, and then to send a category/supplementary services information message to the HLR; however, the HLR cannot recover by this method the data associated with the non-registered mobiles;
- to wait for the next mobile originating message and to indicate to the mobile the loss of supplementary services status in the system; the simplest solution is that the information is only given after a status request message from the mobile; but the quality of the service would be improved if the information was introduced into a field of any originating mobile message acknowledgement. It may be envisaged, too, that the mobile station equipment or the subscriber card contain the description of all supplementary service parameters.

4.3 *MSC fault recovery*

No information is stored in the home or visitor location register for the following services:

- charging information (different forms of facilities);
- credit card call;
- debit card call;
- reverse charging, MS originating call;
- completion of calls to busy subscriber, MS orig. and term. calls.

All these services are invoked on a call per call basis; if the VMSC fails, the location registers cannot help the MSC to recover the contexts of the established calls. There is no difference with a normal fixed exchange.