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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 categoryB/Fsupplementary 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.

Recommendation Q.1005

HANDOVER PROCEDURES

1 Introduction

This Recommendation contains a detailed description of handover procedures to be used in PLMNs.

The following cases are considered:

i) handover between radio channels of the same base station;

Note — This capability is mandatory and could be used in the following situations:

— when the radio channel carrying the call is subject to interference or other disturbances, and/or

— when a radio channel or channel equipment carrying a call has to be taken out of service for maintenance or other reasons;

ii) handover between base stations of the same MSC in order to ensure continuity of the connection when an MS moves from one BS area to another;

iii) handover between base stations of different MSCs of the same PLMN; and

iv) handover between base stations of MSCs in different PLMNs.

The same procedures can be used on the radio path for all four cases.

Cases i) and ii) involve only one MSC.

Note — Depending on the handover criteria, case ii) may involve measurements in other MSCs.

Cases iii) and iv) involve more than one MSC. For these cases, two procedures are defined requiring the use of the mobile application part:

a) **basic handover procedure** where the call is handed over from the controlling MSC (MSC-A) to another MSC (MSC-B); and

b) **subsequent handover procedure** where the call is handed over from MSC-B to MSC-A or from MSC-B to a third MSC (MSC-B‘).

In most respects case iv) is similar to case iii). However, any additional aspects of case iv) not covered by the specification of case iii) will not be included in this Recommendation for the time being.

The procedures in the mobile application part for supporting handover are specified in Recommendation Q.1051.

In the following, the controlling MSC will be referred to as MSC-A also when the handover only involves this MSC [cases i) and ii) above]. For cases iii) and iv), the controlling MSC (MSC-A) is the MSC on which the call was originally established.

All MSCs should be capable of acting as MSC-A and MSC-B.

2 Functional composition of MSCs and interfaces for handover

2.1 *MSC-A*

For handover the controlling MSC can be regarded as being composed of functional units as shown in Figure 1/Q.1005.

Signalling functions

1) The *BS/MSC (MS/BS) procedures MSC-A* | for signalling between the MSC and the BS and between the MSC and the MS. The functional unit interfaces the BSs through interfaces A‘ (to the previous BS) and, for case ii), also through interface A‘‘ (to the new BS). Interworking with other functional units takes place through the internal interface X.

2) The *call control procedures MSC-A* | for normal call control functions (interface B‘) and for signalling and call control of connections to other MSCs (interfaces B‘‘ and B‘‘‘). Interfaces B‘‘ and B‘‘‘ apply only to handover cases iii) and iv) where interface B‘‘‘ is required for subsequent handover.

3) The *handover control procedures MSC-A* | or overall control of the handover including interworking with other functional units (interfaces X, Y and Z).

4) The *MAP procedures MSC-A* | for information exchange with other MSCs and location registers. This function is required for handover cases iii) and iv). The external interface is interface c and the internal interface to the handover control functions is interface Z. Interface C represents the interface to all entities with which MSC-A is communicating during handover (other MSCs, location registers).

Note — This functional unit may also be required for cases i) and ii) if measurements have to be performed in other MSCs for determining the new BS (see below).

Figure 1/Q.1005, (N), p.1

Switching functions

5) The *switch and handover device MSC-A* | for connecting the new path. This function is additional to normal switching functions in the MSC. The handover device has interfaces to the previous BS (interface A‘) and the new BS (interface A‘‘) for handover case ii). Interface B‘ represents the original connection with the fixed network and interface B‘‘ represents the new connection to and MSC-B for handover between MSCs (cases iii) and iv)). Interface B‘‘‘ represents the connection to a third MSC (MSC-B‘) for subsequent handover from MSC-B to MSC-B‘. The connections which can exist in the handover device are shown in Figure 2/Q.1005.

Figure 2/Q.1005, (N), p.

The connection via interface A‘ is released after completion of a successful handover (Figures 2a and 2b/Q.1005).

For MS to MS calls in the same MSC the configuration in Figure 2b/Q.1005 applies. Then interface B‘‘ is not to another MSC but internal to MSC-A.

H.T. [T1.1005]

Case	Initial connection	Resulting connection
Figure 2a)/Q.1005	A‘ to B‘	A‘‘ to B‘
Figure 2b)/Q.1005	A‘ to B‘	B‘ to B‘‘
Figure 2c)/Q.1005	B‘ to B‘‘	B‘ to B‘‘‘

Tableau [T1.1005], p.

2.2 *MSC-B*

The functional composition of an MSC acting as MSC-B is essentially the same as that of MSC-A. However, there are some differences. The functional units are as follows (see Figure 3/Q.1005).

Figure 3/Q.1005, (N), p.

Signalling functions

1) The *BS/MSC (MS/BS) procedures MSC-B* | or signalling between the MSC and the new BS and between the MSC and the MS (interface A‘‘).

2) The *call control procedures MSC-B* | for normal call control functions and for signalling between MSC-A and MSC-B.

3) The *handover control procedures MSC-B* | for control of the handover in MSC-B.

4) The *MAP procedures MSC-B* | for information exchange with MSC-A and the VLR of MSC-B.

Switching functions

5) The *switch MSC-B* | for connecting the circuit from MSC-A (interface B‘‘) to the circuit to the BS (interface A‘‘).

MSC-B will also require a handover device for subsequent handovers to BSs (or to another channel of the same BS) in the MSC area of MSC-B. Subsequent handovers to other MSCs will not require switching in MSC-B (see below).

3 Initiation

The decision that a handover shall take place can be made by both the MS and the BS by monitoring the channel quality. If the decision is made by the MS, a handover request message should be provided to the BS.

Depending on the radio sub-system arrangement the new BS, to which the call is to be handed over, can either be determined by the MS or the MSC. If determined by the MS, the indication of the BS candidates will be providing to the MSC by signalling on the radio path.

If the new BS is to be determined by the MSC, this may require measurements on its own BSs and BSs in other MSCs. Procedures defined in Recommendation Q.1051 are used for initiating measurements on BSs in other MSCs.

The initiation procedures are for further study.

4 General description of the procedures for handover to another MSC

4.1 *Basic handover procedure*

The procedure which takes place after initiation, i.e. after the identity of the new BS has been determined, is shown in Figure 4/Q.1005 for a successful handover. The procedure makes use of messages of the Mobile Application Part (MAP) of Recommendation Q.1051.

Figure 4/Q.1005, (N), p.

Firstly, MSC-A sends a *radio channel request* | essage to MSC-B. The message will contain all parameters needed by MSC-B for allocating a radio channel (see Recommendation Q.1051). The message will also identify the BS to which the call is to be handed over. MSC-B will return the *radio channel acknowledge* | essage after having received the mobile station roaming number from its VLR (exchange of the messages *request for handover number*
| nd *handover number acknowledge*). The roaming number is to be used for routing the call from MSC-A to MSC-B. If a traffic channel is available in MSC-B the *radio channel acknowledge* | essage will contain the identity of the new radio channel and the mobile station roaming number. Other parameters may also be included (see Recommendation Q.1051).

If there is no free traffic channel in MSC-B, this will be indicated to MSC-A and MSC-A will terminate the handover procedure. The existing connection to the MS will not be cleared.

At this point, MSC-A establishes a connection between MSC-A and MSC-B by signalling procedures supported by the network to which MSC-A is connected. In Figure 4/Q.1005 this is illustrated by the messages IAM (Initial Address Message) and the ACM (Address Complete Message) of Signalling System No. 7. MSC-B initiates the handover procedure on the radio path when the ACM is sent and MSC-B initiates the procedure when the ACM is received (illustrated by HB- and HA-INDICATION, respectively).

The connection is through-connected in MSC-A by use of a handover device. The through-connection is done and the old radio channel is released when MSC-A receives an acknowledgement from the MS (HA-CONFIRM) or when the *successful handover* message is received from MSC-B. MSC-B sends this message when it receives an acknowledgement from the MS (HB-CONFIRM).

In order not to conflict with the PSTN/ISDN signalling system(s) used between MSC-A and MSC-B, MSC-B must generate an answer signal when HB-CONFIRM is received.

If the connection between MSC-A and MSC-B cannot be established (e.g. an unsuccessful backward message is received instead of the ACM), MSC-A terminates the procedure without clearing the radio path.

MSC-A will have the overall call control until the call is cleared by the fixed subscriber or the MS and there are no further call control functions to be performed (e.g. servicing waiting calls). MSC-A then releases the connection to MSC-B and also sends an *end signal* message which terminates the MAP procedure. When receiving this message MSC-B will release all call control functions and send the message *remove handover number* to its VLR.

MSC-A may terminate the procedure at any time by sending the MAP message *handover cancellation* | to MSC-B. If establishment of the physical connection between MSC-A and MSC-B has been initiated, the physical connection must also be cleared by procedures defined for the signalling system used between MSC-A and the fixed network. The VLR of MSC-B is also informed by using the *remove handover number* message.

The *handover cancellation* | essage is sent when MSC-A detects clearing or interruption of the radio path before the call has been established on MSC-B. The message is also sent in order to terminate the MAP procedure in MSC-B when it is not possible to establish a connection between MSC-A and MSC-B.

4.2 *Procedure for subsequent handover*

When an MS, after the call has been handed over from MSC-A to MSC-B, leaves the area of MSC-B during the same call, subsequent handover is necessary in order to continue the connection.

The following cases are identified:

i) the MS moves back to the area of MSC-A, and

ii) the MS moves into the area of a third MSC (MSC-B‘).

In both cases the call is redirected in MSC-A using the handover device; the connection between MSC-A and MSC-B can be released after a successful subsequent handover has been performed.

4.2.1 *Description of subsequent handover procedure*

i) *MSC-B to MSC-A*

The procedure which takes place after the initiation procedure has indicated that a handover has to be made back to MSC-A is shown in Figure 5/Q.1005 for the case of successful handover.

Figure 5/Q.1005, (N), p.

The procedure is as follows.

MSC-B sends the *subsequent handover request* | essage to MSC-A indicating that the new MSC is MSC-A. Because MSC-A is the call controlling MSC, this MSC needs no roaming number for routing purposes; MSC-A can directly search for a free radio channel at the desired BS.

When a radio channel can be assigned in time, MSC-A will return the *subsequent handover acknowledgement* | essage containing the new radio channel number and possibly other information to MSC-B. If a radio channel cannot be assigned, a no channel available indication will be given to MSC-B and MSC-B has to maintain the connection with the MS as long as possible.

If a radio channel has been reserved in MSC-A, both MSC-A and MSC-B can start the handover procedure on the radio path (in Figure 5/Q.1005 indicated by the interworking messages HB-INDICATION and HA-INDICATION respectively).

After handover, MSC-A has to release the connection with MSC-B by the procedures relevant to the PSTN/ISDN signalling system(s) used between MSC-A and MSC-B.

MSC-A must also terminate the MAP procedure for the basic handover between MSC-A and MSC-B. This is done by MSC-A by sending the *end signal*
| essage to MSC-B. When receiving this signal, MSC-B sends the *remove handover number* | essage to its VLR.

4.2.2 *Description of the subsequent handover procedure*

ii) *MSC-B to MSC-B‘*

The procedure which takes place after the initiation procedure has indicated that the call has to be handed over to MSC-B‘ is shown in Figure 6/Q.1005 in the case of successful handover.

The procedure consists of two parts:

— subsequent handover as described in § 4.2.1 between MSC-A and MSC-B, and

— a basic handover procedure as described in § 4.1 between MSC-A and MSC-B‘.

MSC-B sends the *subsequent handover request* | essage to MSC-A indicating a new MSC which is not MSC-A. The message contains the identity of MSC-B‘ and of the new BS. MSC-A then starts a basic handover procedure towards MSC-B‘.

When MSC-A receives the ACM from MSC-B‘, MSC-A informs MSC-B that MSC-B‘ has started the handover procedure on the radio path by sending the *subsequent handover acknowledgement* message to MSC-B containing the new radio channel number. Now MSC-B can start the procedure on the radio path.

Figure 6/Q.1005, (N), p.7

For MSC-A the handover is completed when it has received the *successful handover* | essage from MSC-B‘. The connection between MSC-A and MSC-B is released by normal clearing procedures applicable for the PSTN/ISDN signalling system(s) on the connection between MSC-A and MSC-B. MSC-A also sends the *end signal* message to MSC-B in order to terminate the original handover procedure between MSC-A and MSC-B. Receiving this message, MSC-B releases the radio path.

In case no radio channel can be allocated in time or the connection between MSC-A and MSC-B‘ cannot be established, MSC-A informs MSC-B by a *congestion* message. MSC-B has then to maintain the existing connection with the MS as long as possible. When necessary, MSC-A sends the *handover cancellation* message to MSC-B‘.

When the MS again passes the MSC boundary, MSC-B‘ is considered as an MSC-B so that the subsequent handover procedures given above are applicable for any series of handover between MSCs.

4.3 *Handover procedure using subscriber information transfer (optional procedures)*

This procedure is a handover procedure with subscriber information transfer during handover. To realize this handover procedure, only the following additional procedure will be needed.

4.3.1 *Basic handover procedure (optional)*

In addition to the basic handover procedure, described in § 4.1, this optional procedure is illustrated in Figure 7/Q.1005. MSC-A sends a handover completion message which contains subscriber information as soon as MSC-A receives the successful handover message. MSC-B informs its VLR to send a roaming number to the HLR to support supplementary services (e.g., call waiting), after receiving the handover completion message.

Figure 7/Q.1005, (N), p.

4.3.2 *Subsequent handover procedure (optional)*

4.3.2.1 *Description of the subsequent handover procedure (optional)*

i) *MSC-B to MSC-A*

In addition to the subsequent handover procedure, described in § 4.2.1, this optional procedure is illustrated in Figure 8/Q.1005. When receiving the end signal, MSC-B sends the remove handover number message to its VLR and the handover completion message to MSC-A. MSC-A informs its VLR to send a roaming number to the HLR, after receiving the handover completion message.

Figure 8/Q.1005, (N), p.

4.3.3.2 *Description of the subsequent handover procedure (optional)*

ii) *MSC-B to MSC-B‘*

In addition to the subsequent handover procedure, described in § 4.2.2, this optional procedure is illustrated in Figure 9/Q.1005. After receiving the end signal, MSC-B releases the radio path and sends handover completion message to MSC-B‘. MSC-B‘ informs its VLR to send a roaming number to the HLR, after receiving the handover completion message.

Figure 9/Q.1005, (N), p.

Note — Implementation of this procedure requires careful consideration of the handling of some supplementary services (e.g., call waiting, conference calling or call completion to busy subscriber) at handover, since these aspects have not been studied in detail. The procedure is not included in the current version of the MAP (Recommendation Q.1051).

5 Detailed procedures in MSC-A

5.1 *BS/MSC (MS/BS) procedures MSC-A (functional unit 1)*

The handover procedures in this functional unit consist of:

i) signalling between the MS and the MSC; and

ii) signalling between the BS and the MSC for

— initiation of quality measurements, and

— access management.

Signals sent to and received from functional unit 3 (handover control procedures MSC-A) are indicated in § 5.3 below.

5.2 *Call control procedures MSC-A (functional unit 2)*

Related to handover the call control procedures in MSC-A can be divided into two functional entities.

The first entity is the call control procedure as part of the normal interworking between the PSTN/ISDN and the PLMN; for an MS originating call MSC-A is the originating exchange, for an MS terminating call MSC-A is the destination exchange.

The second entity is the call control procedure for the connection between MSC-A and MSC-B in case of a handover from MSC-A to MSC-B. For the latter call control procedure the following applies.

Call set-up

The connection to MSC-B is set up by procedures relevant to the signalling system used in the PSTN/ISDN to which MSC-A is connected. The call is set up by using the MS roaming number received from MSC-B as part of the MAP procedures.

The call set-up direction will always be from MSC-A to MSC-B, i.e. also when the call was originally established by the MS. Functional unit 2 should therefore keep information on call set-up direction in order to be able to correctly interpret any clearing signals (see below).

The unit should indicate the address-complete condition to functional unit 3 and through connect without waiting for the answer signal from MSC-B. This applies also to signalling systems where address-complete signals are not supported. In such cases, an artificial address complete is established by functional unit 2.

Call clearing

The call clearing consists of two parts after inter MSC handover, clearing of the BS-MS connection and clearing of the inter MSC connection.

The MAP is used to transfer information between MSC-B and MSC-A in order to maintain full control with MSC-A. MSC-A determines, based on information received from MSC-B, the appropriate signals to be sent to the MS, and sends this information to MSC-B.

MSC-A shall initiate inter MSC connection release and send the *end signal* | o release any resource attached to the call.

The clearing of the connection is by procedures relevant to the signalling system in the PSTN/ISDN to which MSC-A is connected.

When the Signalling System No. 7-ISDN User Part is used, the normal symmetric release procedures apply on both the connection to the fixed network and to MSC-B.

When a signalling system is used with a symmetric release possibility, some notice should be given to the clear-forward and clear-back procedures.

For *MS terminating calls* | he following conditions apply on clear-forward and clear-back:

— when a clear-forward signal is received on interface B‘ (see Figure 1/Q.1005), MSC-A clears the circuit to MSC-B by normal clear-forward procedures; and

— when a clear-back signal is received from MSC-B, MSC-A starts normal clear-back procedures towards the fixed network (interface B‘) and sends the clear-forward signal on interface B‘‘ in order to clear the connection with MSC-B.

Note — This case corresponds to a fault situation. O&M actions are for further study.

For *MS originated calls* | he following applies:

— when an MSC-A receives a clear-back signal from MSC-B, this signal must be interpreted as indicating clear-forward condition. MSC-A then clears both the connection on interface B‘ (see Figure 1/Q.1005) and to MSC-B by normal clear-forward procedures; and

Note — This case corresponds to a fault situation. O&M actions are for further study.

— when MSC-A receives a clear-back signal on interface B‘, MSC-A should distinguish between national and international connections:

— for *international* | onnections MSC-A sends a clear-forward signal on both interface B‘ to the fixed network and interface B‘‘ to MSC-B; and

— for *national* | connections a timer is started according to national practice for clear-back supervision and MSC-A proceeds as follows:

i) if a clear-back signal is received from MSC-B, MSC-A interprets this as indicating a clear-forward condition and proceeds by clearing the connections on interface B‘ and to MSC-B by normal clear-forward procedures, or

ii) if the timer expires, MSC-A proceeds by normal clear-forward of the connections on interface B‘ to MSC-B.

5.3 *Handover control procedures MSC-A (functional unit 3)*

The procedures of functional unit 3 are given in terms of SDL diagrams in Figure 10/Q.1005. For all signals sent to or received from another functional unit the source or sink of the signal is indicated (e.g. from 4, to 2, etc.).

The procedures of functional unit 3 include the following:

i) Initiation (states 1, 2 and 3). The initiation condition is shown by the signal HA-REQUEST. This may either be generated by the MS or the BS depending on the initiation condition (see § 3). The diagram includes all possibilities described in § 3, i.e. the MS identifies the new BS, or the new BS is identified by the MSC by measurements in adjacent BSs. These may include BSs in other MSCs.

The diagram also includes queuing when there is no channel available. Calls for which handover had been initiated should be queued with priority higher than normal calls. They should have lower priority than emergency calls.

ii) Handover of calls within the area of MSC-A, i.e. handover cases i) and ii) (states 1, 2, 3 and 4). MSC-A controls the procedures on both the previous and the new radio channel. Both signals HA-INDICATION and HB-INDICATION are required. The handover procedure is completed when HB-CONFIRM is received. If this signal is not received, the radio path and the connection on interface B‘ are either released or the original connection is maintained depending on national choice.

The handover device is first set up so that all interfaces A‘, A‘‘ and B‘ are connected (illustrated by the signal *set up handover device*). This is done when HA-INDICATION is sent. The device is connected in its final position (i.e. A‘‘ to B‘ for case ii)) (illustrated by the signal *connect handover device*) either when HA-CONFIRM is received or when HB-CONFIRM is received.

iii) Handover to MSC-B (states 1, 2, 5, 6 and 7). This procedure is the one described in § 4.1. The handover device is set up when MSC-A send the HA-INDICATION, i.e. the interfaces A‘, B‘ and B‘‘ are connected. The device is connected in its final position (i.e. B‘ to B‘‘) when either the HA-CONFIRM signal is received from the MS or the successful procedure indication is received from functional unit 4.

iv) Subsequent handover to MSC-A (states 7 and 9). This procedure is described in § 4.2. When a handover to MSC-A indication is received from functional unit 4, the handover device is set up so that interfaces B‘, B‘‘ and A‘ are connected. When HB-CONFIRM is received, the device is connected in its final position (i.e. B‘ to A‘).

If HB-CONFIRM is not received (expiry of timer T104), the handover device releases interface A‘ and returns to a position where B‘ and B‘‘ are connected. A congestion indication is returned via functional unit 4 to MSC-B.

v) Subsequent handover to a third MSC (MSC-B‘) (states 7 and 8). The procedure is described in § 4.2. The handover device is set up in its initial position, i.e. interconnection of interfaces B‘, B‘‘ and B‘‘‘, when the connection to MSC-B‘ has been established (indicate by the signal connection established from functional unit 2). MSC-B is informed via functional unit 4 (send acknowledge) that the connection has been established and that the procedure on the radio path can be initiated. The device is connected in its final position (i.e. B‘ to B‘‘‘) when a successful procedure indication in received from functional unit 4. MSC-B is informed that all procedures in MSC-B can be terminated (illustrated by the send-end signal indication). The device returns to the state where B‘ and B‘‘ are connected if the subsequent handover procedure fails.

Figure 10/Q.1005 (1/9), (N), p.11

Figure 10/Q.1005 (2/9), (N), p.12

Figure 10/Q.1005 (3/9), (N), p.13

Figure 10/Q.1005 (4/9), (N), p.14

Figure 10/Q.1005 (5/9), (N), p.15

Figure 10/Q.1005 (6/9), (N), p.16

Figure 10/Q.1005 (7/9), (N), p.17

Figure 10/Q.1005 (8/9), (N), p.18

Figure 10/Q.1005 (9/9), (N), p.19

Timers in MSC-A

The procedures are supervised by timers in order to avoid deadlock when responses are not received or the procedures fail. The following timers are defined:

T100: This timer supervises the time between sending a request for measurements to a BS or an MSC and the receipt of the results. Results received after time out are ignored. T100 = (FS)

T101: This timer supervises the queuing time for a free channel. If T101 expires, a no channel indication is generated. T101 = (FS)

T102: This timer supervises the time for handover completion for handover between BSs in MSC-A. If T102 expires, the radio path and the connection on interface B‘ are released. T102 = (FS)

T103: This timer supervises the time between issuing a HA-INDICATION in MSC-A and receiving a successful procedure indication from MSC-B. If T103 expires, the handover procedure is cancelled and either the radio channel is released (if HA-CONFIRM has been received) or it continues on the old channel (if HA-CONFIRM has not been received). T103 = (FS)

T104: This timer supervises the time between sending an HB-INDICATION and receiving the HB-CONFIRM for a subsequent handover from MSC-B to MSC-A. If T104 expires, the new radio channel is released and the existing handover device connection to MSC-B is maintained. T104 = (FS)

5.4 *MAP procedures in MSC-A (functional unit 4)*

The MAP procedures for handover are defined in Recommendation Q.1051. They include:

— requesting measurements in other MSCs;

— procedures for basic handover; and

— procedures for subsequent handover.

These procedures are as outlined in § 4.

6 Detailed procedures in MSC-B

6.1 *BS/MSC (MS/BS) procedures MSC-B (functional unit 1)*

The handover procedures in this functional unit consist of:

i) signalling between the MS and the MSC; and

ii) signalling between the BS and the MSC for

— initiation of quality measurements, and

— access management.

Signals exchanged with functional unit 3 are indicated in § 6.3 below.

6.2 *Call control procedures MSC-B (functional unit 2)*

These procedures relate to the call control in MSC-B of the ‘‘handover’’ connection with MSC-A. For these procedures the following apply.

Call set-up

The connection is set-up by MSC-A. MSC-B should provide, if possible, the following backward signals:

— signals indicating unsuccessful call set-up and, if possible, the cause of call failure;

— address complete signal; and

— answer signal (see note).

Note — The answer signal is not related to answering by the MS and it has no meaning in the handover procedure between MSC-A and MSC-B. But after successful handover this signal is needed for bringing the connection in the answered state in the intermediate PSTN/ISDN exchanges.

There will be no indication that the call applies to a handover. This information has to be derived from the MS roaming number received during call set-up in relation to the earlier radio channel request/radio channel acknowledgement procedure between MSC-A and MSC-B (MAP-procedure).

When the connection has been established an indication should be given to functional unit 3 (illustrated by the signal ‘‘connection established’’ in Figure 11/Q.1005).

Figure 11/Q.1005 (1/8), (N), p.20

Figure 11/Q.1005 (2/8), (N), p.21

Figure 11/Q.1005 (3/8), (N), p.22

Figure 11/Q.1005 (4/8), (N), p.23

Figure 11/Q.1005 (5/8), (N), p.24

Figure 11/Q.1005 (6/8), (N), p.25

Figure 11/Q.1005 (7/8), (N), p.26

Figure 11/Q.1005 (8/8), (N), p.27

Call clearing

The call clearing consists of two parts after inter MSC handover, clearing of the BS-MS connection and clearing of the inter MSC connection.

The MAP is used to transfer information between MSC-B and MSC-A in order to make it possible for MSC-B to send the appropriate signals and still leave the call control to MSC-A.

MSC-A initiates release of the connection between MSC-A and MSC-B.

MSC-B is only allowed to initiate inter MSC connection release after the *end signal* | s received.

When the Signalling System No. 7-ISDN User Part is used, the normal symmetric release procedures apply.

When a signalling system is used without a symmetric release possibility, the following applies.

— When MSC-B receives a clear-forward signal from MSC-A, it shall release the radio path.

— In fault situations, e.g. machine malfunction or loss of the connection on interface A, MSC-B may send a clear-back signal to MSC-A.

6.3 *Handover control procedures MSC-B (functional unit 3)*

The procedures of functional unit 3 are given in the form of SDL diagrams in Figure 11/Q.1005. For all signals sent to or received from another functional unit the source or sink of the signal is indicated (e.g. from 4, to 2, etc.).

The procedures in functional unit 3 include the following.

i) Handover from MSC-A (states 1, 2, 3 and 4). This case includes initiation by MSC-A (indicated by the allocate radio channel signal received from functional unit 4) and allocation and establishment of the new radio channel. The procedure is outlined in § 4.1.

ii) Subsequent handover within the area controlled by MSC-B (states 4, 5, 6 and 7). This procedure is essentially the same as that of ii) of § 5.3.

iii) Subsequent handover to another MSC (MSC-A or MSC-B‘) (states 4, 8 and 9). The initiation procedure is essentially the same as that of i) of § 5.3. The HA-INDICATION is now generated by MSC-B after a subsequent handover accepted indication is received from MSC-A (via functional unit 4). The procedure is terminated in MSC-B when MSC-B receives a terminate procedure indication from functional unit 4.

Timers in MSC-B

The procedures are supervised by timers in order to avoid deadlock when responses are not received or the procedures fail. The following timers are defined.

T200: This timer is the same as T100 (§ 5.3).

T201: This timer is the same as T101 (§ 5.3).

T202: This timer is the same as T102 (§ 5.3).

T204: This timer is the same as T104 (§ 5.3).

T210: This timer is used to supervise the time for establishing a connection from MSC-A to MSC-B after an allocate radio channel request has been received. When T210 expires, the allocated channel in MSC-B is released. T210 = (FS)

T211: This timer is used to control the time between requesting a subsequent handover and receiving the response from MSC-A. If T211 expires, the existing connection with the MS is maintained. T211 = (FS)

6.4 *MAP procedures MSC-B (functional unit 4)*

The MAP procedures for handover are defined in Recommendation Q.1051. They include:

— requesting measurements in other MSCs,

— procedures for basic handover,

— procedures for subsequent handover, and

— procedures for obtaining and releasing MS roaming number for handover from the VLR.

These procedures are outlined in § 4.

7 Authentication

Authentication will be performed after handover (for further study).

8 Handling of supplementary services

This is for further study. MAP procedures for supporting such functions are contained in Recommendation Q.1051.

MSC-A will maintain call control until all operations, i.e. the existing call and any supplementary service operation have been terminated. At this instant, MSC-B is informed by the *end signal* message of the MAP that all functions in MSC-B can be released.

If the call waiting service is provided for the called MS, and there are calls waiting at the time of a handover to another MSC, these calls should be established by MSC-A using normal call forwarding to MSC-B. If the MS requests holding of the existing call and connection of a waiting call, the MAP is used to provide the necessary exchange of information between MSC-A and the MS.

9 Location updating after handover

MSC-B (or VLR-B) should not initiate automatic updating of the HLR at the end of the call. The procedures in the MS should be such that the MS should initiate updating after the call has been completed and the MS has tuned to a common control channel.

Automatic updating by MSC-B (or VLR-B) is for further study.

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SECTION 3

INTERWORKING WITH ISDN AND PSTN

Recommendation Q.1031

GENERAL SIGNALLING REQUIREMENTS ON INTERWORKING

BETWEEN THE ISDN OR PSTN AND THE PLMN

1 Introduction

The purpose of this Recommendation is to present the general requirements for the PSTN and the ISDN as well as for the mobile network to be met in order to ensure a correct integration of the mobile service in the fixed network.

This Recommendation covers only the signalling aspects of the interworking between the mobile service and fixed network.

2 General requirements

2.1 *Requirements for the mobile system*

In order to be integrated in the fixed network the PLMN must comply with the following requirements:

a) The MAP which supports information exchanges between the nodes of the mobile service uses the facilities of Transactions Capabilities of Signalling System No. 7. Therefore the equipment of the mobile network must comply with the specification of the interface between TCAP and the application user. If TCAP functions are integrated in the mobile network equipment, the latter must comply with the relevant specifications (Recommendations Q.771 to Q.774).

b) FOR MAP messages routing purpose, the mobile nodes must provide the SCCP via TCAP with an address complying with the relevant specifications (Recommendations Q.711 to Q.714).

c) For call set-up, the MSCs must interface with the fixed exchanges. In the detailed interworking Recommendations, the fixed network signalling considered are Signalling System No. 7 and its User Parts (TUP or ISUP). The MSCs must comply with the same signalling interface specifications as the fixed exchanges.

d) The PLMN and the signalling on the radio path must provide the information needed to ensure a correct interworking with the fixed network. The interworking in the MCSs must occur with a minimum loss of information.

e) The PLMN nodes must interface with the No. 7 signalling network. For that, they must comply with the MTP specifications (Recommendations Q.701 to Q.707).

2.2 *Requirements for the fixed network*

The adaptations of the fixed network needed for the integration of the mobile service have to be minimized. However, some facilities foreseen for other services will also facilitate the access to the mobile service or the operation of the PLMN.

a) The implementation of the No. 7 signalling network could be useful for the mobile service. Before the No. 7 Signalling System is implemented, a dedicated signalling network, using a subset of Signalling System No. 7, could be used as an interim solution for transporting the data between functional units of PLMNs.

b) It will be useful that, in addition to the signalling network, the SCCP facilities be available in order to avoid a specific implementation of such a service in the PLMN equipments.

c) The interrogation procedure based on TCAP prior to connection set up to a mobile would save circuits resources in the network and would increase the service quality provided to the fixed calling subscriber by e.g., reducing the post dialling delay in such kinds of calls. From a signalling point of view the best way is to introduce this procedure as near as possible to the local originating exchanges (see Recommendation Q.1032).

3 Interworking with the PSTN for call set-up

The interworking with the Telephone User Part of Signalling System No. 7 is the only case considered here.

Particular aspects :

a) The fixed telephone network provides an end-to-end transparent link at least for speech use. It is then possible to have a data transmission communication on a telephone call. This would not be the case with a mobile subscriber: the radio path would not be transparent. Therefore, if a calling subscriber wishes to have a data transmission call with a mobile it would be necessary to inform the network concerning the precise characteristics of this transmission: the mobile system will then be able to replace the speech coder by a data coder adapted to the type of transmission modem used. One solution could be that the mobile station has one telephone number per type of data transmission service it can use.

b) The usual routing of a call to a mobile includes a re-routing according to the roaming number allocated to that mobile. This number is temporarily allocated and difficulties could appear in some cases such as a failure of a register. It would then be useful that the number dialled by the calling subscriber appears in the Initial Address Message received by the VMSC. This transmission can be used as a solution to avoid the allocation of one roaming number for each telephone number in the case of data transmission to a mobile station.

4 Interworking with the ISDN for call set-up

Since the radio path cannot economically provide a transparent 64 kbB/Fs channel to mobile subscribers all the time, all the ISDN services foreseen in the fixed network will not be available to the mobile subscribers. The Quality of Service in land mobile networks may also in some cases not meet the Quality of Service requirement for certain ISDN services. Therefore some service limitations need to be introduced in the access to mobile stations.

Different methods may be foreseen to implement this limitation:

a) The interrogation is used also to check the service capabilities of the mobile access. This procedure can also be used to perform a compatibility check between the parties. But this test is only possible if the HLR knows the relevant characteristics of the mobile station and cannot be used with card operated stations; in that case a mobile subscriber can use different stations.

b) The simplest solution is that normal mobile call set-up be processed and controlled by the incoming MSC. As such the incoming MSC can also provide a compatibility check for card operated stations.

c) The call setup is normally performed up to the mobile. The IAM contains the characteristics of the service requested and on the terminal needed by the calling party. The network, MSC included, is transparent in the compatibility check. This method is the same as that defined in the ISDN.

5 Impact of the off-air call set-up on the interworking

The use of the off-air call set-up in the PLMN has an impact on the interworking with the fixed network. Both outgoing and incoming calls have to be considered: the consequences are not the same.

As it was stated before, the use of the Off-Air Call Set-Up procedure is optional and must be limited to national telephone calls only (see Recommendation Q.1002).

5.1 *Definition of the off-air call set-up*

To save the radio resources the radio traffic channel may be allocated to the communication only when both calling and called parties are present i.e., at the answer instant. This method called ‘‘Off-Air Call Set-Up’’ (OACSU) has some implication on the interworking with the fixed network. The consequences are not the same whether the mobile subscriber is the calling or the called party.

5.2 *Outgoing call from a mobile station*

Upon initiation of an outgoing call, a traffic channel is allocated to the communication when the called subscriber answer is received in the MSC. In some cases, no idle traffic channel may be available when necessary. Therefore, an appropriate announcement must be given to the called party when no idle traffic channel is available within a certain interval upon receipt of the called party’s answer.

Whenever the announcement is used, it must always be played through in its entirety, even if a traffic channel becomes available before it is completed.

If the ADDRESS COMPLETE message indicates that there will possibly be no ANSWER message upon the connection of the called party (e.g., ADC without any information), the radio path must be established immediately upon receipt of the ADC.

Due to interworking constraints coming from the characteristics of the different signalling systems used in countries, the OACSU technique should only be used for national calls.

5.3 *Incoming call to a mobile station*

For incoming calls, the impact is not so important, but some rules must be applied in order to limit the influence on the service quality.

Concerning the sending instant of the answer message, the normal operating rules apply. If the call is successfully set-up to the mobile station, the answer message must be sent to the originating exchange only when the traffic channel is established upon recognition of the called party connection.

6 Special arrangements

6.1 *Control of speech processing and echo control devices*

For further study.

6.2 *Interworking for non-voice calls*

For further study.

Recommendation Q.1032

SIGNALLING REQUIREMENTS RELATING TO ROUTING OF CALLS TO MOBILE SUBSCRIBERS

1 Introduction

When a subscriber wants to call a mobile subscriber, the fixed network needs to know the actual location of the MS in order to route the connection to the relevant Mobile Services Switching Centre (see Recommendation Q.1003 on location registration). This contribution tries to present the signalling requirements the fixed network has to comply with for that purpose. The document considers the different assumptions concerning the capabilities of the fixed exchanges to perform some signalling procedures prior to call set-up.

This Recommendation assumes that the routing analysis requirements specified in Recommendation Q.107*bis* | are fulfilled.

This Recommendation assumes that the ISDN number of the mobile contains a specific National Destination Code. The cases where the mobile numbering plan is fully integrated in the fixed numbering plan are for further study.

2 General routing rules

The number dialled by the calling subscriber contains no indication concerning the actual location of the called MS. Therefore, to set up the complete connection, it is necessary to know the location of the MS and the routing address to be used, i.e. the Mobile Station Roaming Number. The only equipment able to provide this information is the Home Location Register. Therefore to route the call to the Mobile Services Switching Centre where the MS is located, it is necessary to interrogate the HLR.

The preferred procedure with regard to signalling is the following:

1) When a subscriber wants to call a mobile station he dials the ISDN number of that station.

2) The local exchange (or a transit exchange) analyzes the number dialled and recognizes the mobile service National Destination Code indicating that the call is destined to a mobile subscriber. In general this complete routing analysis can be made for the national calls only: when the outgoing exchange recognizes that the calling subscriber dialled the international prefix, it routes the call directly to the outgoing International Switching Centre (ISC) without any further analysis. This ISC can then recognize the mobile national destination code.

3) If the result of routing analysis shows that it is necessary to get additional information to set up the complete connection to the MSC where the called station is located, then this information must be obtained from the HLR in charge of the mobile subscriber. If the interrogation procedure is implemented in an exchange referred to in 2) above, this exchange then performs the interrogation of the Home Location Register. The HLR sends back the roaming number of the called MS. This procedure is supported by the Transaction Capabilities of Signalling System No. 7.

4) The connection is then set up in the fixed network to the MSC according to the roaming number of the MS.

3 General requirements for the fixed network

To route a call up to a mobile subscriber, an interrogation of the HLR must be performed in order to get the roaming number allocated to that MS. This interrogation procedure is supported by the Transaction Capabilities of Signalling System No. 7. The preferred solution is that the local exchanges be adapted to TC, and able to perform this interrogation: then they can route the call directly to the called mobile according to the roaming number they obtain from their interrogation of the HLR. The following section of this document shows possible solutions if this assumption is not fulfilled.

As it is described below, in the case where there are no interrogation facilities in the fixed network, on recognition that a call is destined to a mobile subscriber, the routing is first performed to a Gateway MSC. The interrogation of the HLR is then performed by the MSC and the call proceeds according to the Roaming Number received.

Section 5 deals with the routing of calls to foreign mobile stations: usually, in this case, the local exchange does not analyze the national part of the called address and routes directly to the outgoing International Switching Centre which then performs the correct routing of the call.

4 *Signalling aspects on routing a call to a mobile managed by a home PLMN situated in the same country*

4.1 *The originating exchange is adapted to the interrogation procedure* | (Figure 1/Q.1032)

If the originating local exchange is able to perform the interrogation procedure, the call set-up occurs as it is specified in section 2 of this document.

4.2 *The originating exchange is not adapted to the interrogation procedure*

If the originating exchange is unable to use TCAP, the following cases can be considered:

— the interrogation procedure is performed by a transit exchange;

— the call is re-routed by a Gateway MSC.

Figure 1/Q.1032, (N), p.28

4.2.1 *The interrogation is performed by a transit exchange* | (Figure 2/Q.1032)

If the originating exchange is unable to perform the interrogation of the HLR, the connection is set up to a transit exchange. This exchange analyzes the address received (the ISDN number of the subscriber) and notices that the call is destined to a mobile subscriber. It then performs the interrogation of the HLR and routes the call as it is described in section 2.

4.2.2 *The call is re-routed by a Gateway MSC* | (Figure 3/Q.1032)

If the fixed network is unable to interrogate the HLR in order to route the call to the actual location of the MS, the connection is set up to a Gateway MSC.

The Gateway MSC interrogates the HLR of the called MS (using MAP in general cases). It receives back the roaming number of the subscriber. With this address, the GMSC set up a connection via the telephone (or ISDN) network to the MSC where the mobile is located. If the called subscriber is abroad, the connection is normally set up via the international network.

5 Routing a call to a foreign mobile subscriber

As for a normal telephone call, the calling subscriber, when he wants to join a foreign mobile subscriber, dials the international access prefix first. His local exchange, according to this prefix, routes the call directly to the outgoing International Switching Centre without any further analysis of the number dialled.

The routing of the call is then performed by the outgoing international Switching Centre. Two assumptions can be envisaged:

— the outgoing International Switching Centre recognizes that the called party is a mobile subscriber and can perform the interrogation of the HLR;

— the outgoing International Switching Centre is unable to perform the interrogation of the HLR.

Figure 2/Q.1032, (N), p.29

Figure 3/Q.1032, (N), p.30

5.1 *The outgoing ISC can perform the interrogation of the HLR* | (Figure 4/Q.1032)

When the outgoing International Switching Centre receives the call, for routing purposes it analyzes the digits of the country code and the first digits of the national significant number of the called party address. It can then notice that the call is destined to a mobile subscriber and needs a preliminary interrogation transaction prior to setting up the connection.

With the roaming number, the ISC then routes the call to the MSC where the mobile is actually located. The connection is set up via the international network if the MS is not in the same country as the calling subscriber.

Figure 4/Q.1032, (N), p.

5.2 *The outgoing International Switching Centre is unable to perform the interrogation of the HLR* | (Figure 5/Q.1032)

If the outgoing International Switching Centre is unable to perform the interrogation procedure, it routes the call to the incoming ISC of the country where the Home PLMN of the called mobile is situated according to the telephone (or the ISDN) number dialled by the calling subscriber.

The incoming ISC receiving the call notices that it is destined to a mobile. The following assumptions can be envisaged:

— this ISC can perform the interrogation;

— this ISC is unable to perform the interrogation: therefore the interrogation has to be made either by a national transit exchange or by a Gateway MSC.

In this assumption where the actual routing has to be made in the home country of the mobile, the connection may comprise two international links in tandem if the subscriber is roaming abroad. Therefore it would be better that the interrogation is performed in the outgoing country; this method would limit the length of the complete connection. The worst case will appear when the called mobile is roaming in the country of the calling subscriber: the complete connection comprises two international links in tandem instead of a simple national routing.

Figure 5/Q.1032, (N), p.

5.3 *The International Switching Centre recognizes that it is a call to an MS but cannot perform the interrogation*

In this case, the International Switching Centre routes the call to a Gateway MSC which performs the interrogation:

— if the GMSC is accessed by the outgoing ISC, see Figure 6/Q.1032.

— if the GMSC is accessed by the incoming ISC, see Figure 7/Q.1032.

6 Alternative solution: re-routing of the call after clearing the previous connection | (Figure 8/Q.1032)

The ISUP provides a backward message to indicate that the call should be re-routed and containing the new address. This facility may be used in the case where a foreign MS is called and no interrogation functions are available in the fixed network to get the Roaming Number from the HLR. A long international connection may be established before the location of the MS is determined but this facility could allow the call to be ‘‘dropped back’’ to the suitable MSC.

Figure 6/Q.1032, (N), p.33

Figure 7/Q.1032, (N), p.34

Figure 8/Q.1032, (N), p.35

7 Unsuccessful call set-up

7.1 *Roaming not allowed*

If the MS is roaming in an area where it is not allowed to have calls, the location is not stored in the HLR and an indication is set. When a call is set up to this subscriber, the HLR will return an unsuccessful indication to the originating exchange.

7.2 *Restart of the HLR*

After a restart, the HLR considers that the information coming from the back up is still valid. If an interrogation is related to a subscriber whose information is not yet restored, the HLR gives back the Roaming Number it has in its tables. If there is a mistake, the restoration procedure specified in Recommendation Q.1004 will re-establish the correct information.

7.3 *Mobile station roaming number unallocated*

If the incoming MSC receives a call which roaming number is declared unallocated by the VLR, it sends back an unsuccessful call set-up indication to the outgoing exchange. This situation may occur after a restart of the HLR or of the VLR (see Recommendation Q.1004).