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FASCICLE VI.12

Recommendations Q.1000 to Q.1032

PUBLIC LAND MOBILE NETWORK

INTERWORKING WITH ISDN AND PSTN

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SECTION 1

PUBLIC LAND MOBILE NETWORK

Recommendation Q.1000

STRUCTURE OF THE Q.1000-SERIES RECOMMENDATIONS FOR PUBLIC LAND MOBILE NETWORKS

1 General

This Recommendation provides an overview of the Q.1000-Series Recommendations specifically aimed at specifying the requirements for the Public Land Mobile Network.

The purpose of the Q.1000-Series Recommendations is to provide smoothly:

1) realization of roaming and interworking between PLMNs,

2) portability of terminal equipments, and

3) independent evolution of each PLMN and terminal equipments.

In addition some Recommendations of other series are indicated in section 7 because of their interest to the Q.1000-Series.

2 General Recommendations on Public Land Mobile Networks

Q.1000: Structure of the Q.1000-Series Recommendations for Public Land Mobile Networks

This Recommendation gives an overview of the Q.1000-Series and some other Recommendations of interest to them.

Q.1001: General aspects of Public Land Mobile Networks

This Recommendation covers definitions, architectures and services in public land mobile networks.

Q.1002: Network functions

This Recommendation defines network functions requiring signalling on the radio path either as subscriber line signalling or as mobile management signalling necessary to support services and facilities provided by PLMNs.

Q.1003: Location registration procedures

This Recommendation identifies the procedures related to location registration, location cancellation, periodic registration and international mobile subscriber identity attach/detach operations.

Q.1004: Location register restoration procedures

This Recommendation describes methods that provide security of the data stored in the location registers and details procedures required to restore the location data and supplementary services data after a location register failure.

Q.1005: Handover

This Recommendation identifies the handling procedures between: radio channels of the same base station; base stations of the same MSC; base stations of different MSCs of the same PLMN; and base stations of MSCs in different PLMNs during handover operations.

3 Technical aspects of the services offered in the Public Land Mobile Networks

Q.1012: Handling of supplementary services

This Recommendation contains the stage 2 descriptions of the supplementary services which can be provided in a PLMN.

Note — This Recommendation is not published in the Blue Book. It will be finalized and brought into the accelerated procedure early in the next study period.

4 Interworking with ISDN/PSTN

Q.1031: General signalling requirements on interworking between ISDN or PSTN and a PLMN

This Recommendation specifies the general signalling requirements to be met in order to ensure a correct integration of the mobile service in the fixed networks.

Q.1032: Signalling requirements relating to routing of calls to mobile subscribers

This Recommendation specifies the signalling requirements that the fixed networks have to comply with, in order to route a mobile terminating call to the actual MSC.

5 Mobile application part

Q.1051: Mobile application part

This Recommendation describes network procedures and relevant protocols required to provide the functions listed in Recommendation Q.1002. The mobile application part is based on Signalling System No. 7.

6 Digital PLMN access interfaces

Q.1061: General aspects and principles relating to digital PLMN access signalling reference points

This Recommendation introduces the concept and definition of access signalling reference points which are used as the basis for the specification of signalling required at the Mobile Station and the Base Station.

Q.1062: Digital PLMN access signalling reference configurations

This Recommendation describes the reference configurations used to identify the various possible physical access arrangements to the digital PLMN.

Q.1063: Digital PLMN channel structures and access capabilities at the radio interface (Um reference point)

This Recommendation defines the set of channel types, access capabilities and channel configurations with respect to the radio interface.

7 Other Recommendations of interest to the Q.1000-Series

7.1 *Charging*

D.93: Charging and accounting in the international land mobile telephone service (provided via cellular radio systems)

This Recommendation covers principles for charging, accounting and settlements between PLMNs. An annex to the Recommendation gives examples of the practical use of the established principles.

7.2 *Numbering and Routing*

E.212: Identification plan for land mobile stations

This Recommendation covers definitions and mobile station identification plan principles. An annex to the Recommendation contains a list of mobile country or geographical area codes.

E.213: Telephone and ISDN numbering plan for land mobile stations in public land mobile networks (PLMN)

This Recommendation covers basic requirements for a numbering plan to be used for public land mobile networks.

E.214: The structure of the land mobile global title for the signalling connection control part (SCCP).

This Recommendation defines and describes the structure of the mobile global title.

Recommendation Q.1001

GENERAL ASPECTS OF PUBLIC LAND MOBILE NETWORKS

1 General

This Recommendation covers definitions, architectures and services in Public Land Mobile Networks.

The definition section is subdivided into basic, roaming and handover subheadings.

The architecture section covers examples of Public Land Mobile Network architecture in roaming and handover situations.

The services section covers introductory descriptions of basic and supplementary services that can be provided to the user.

2 Definitions

2.1 *Basic definitions*

2.1.1 **Public Land Mobile Services**

Telecommunications services provided to moving subscribers (terrestrial applications).

2.1.2 **Public Land Mobile Network**

A Public Land Mobile Network (PLMN) is established and operated by an administration or RPOA for the specific purpose of providing land mobile telecommunication services to the public. A PLMN may be regarded as an extension of a fixed network (e.g. PSTN) or as an integral part of the PSTN. In the first case, it can be considered as a collection of mobile services switching centre (MSC) areas within a common numbering plan (e.g. service access codes) and a common routing plan (e.g. definition of crossover point); in this case the MSCs are the functional interfaces between the fixed network and a PLMN for call set-up. In the second case, it can be considered as an assemblage of special logic in existing or future PSTN/ISDN stored program controlled digital local exchanges, conceptually integrated within a common numbering and routing plan.

Functionally the PLMNs may be regarded as independent telecommunications entities even though different PLMNs may be interconnected through the PSTN and PDNs for forwarding of calls or network information. A similar type of interconnection may exist for the interaction between the MSCs of one PLMN.

The location register system of a PLMN may be centralized, distributed or segmented. So long as we are concerned with functions of a PLMN, such as routing and interworking, the configuration and operation of the location register system have no influence on external networks.

The use of the concept PLMN is illustrated in Figure 1/Q.1001 where various PLMNs are shown with their interfaces to the fixed networks. It should be noted that a PLMN may have several interfaces with the fixed network (e.g. one for each MSC). Interworking between two PLMNs may be performed via an international gateway.

Figure 1/Q.1001 also shows the information paths between a PSTN and a PLMN and between two different PLMNs. The solid lines indicate a possible physical path between the PLMNs through the PSTN. The dotted line indicates that, for some interactions, an end-to-end information path (established through the physical path) may exist between the two PLMNs.

Figure 1/Q.1001, p.

2.1.3 Mobile Services Switching Centre

In an automatic system the Mobile Services Switching Centre (MSC) constitutes the interface between the radio system and the public switched telephone network. The MSC performs all necessary signalling functions in order to establish calls to and from mobile stations.

In order to obtain radio coverage of a given geographical area a number of base stations (radio transmittersB/Freceivers) are normally required; i.e. each MSC would thus have to interface several base stations. In addition several MSCs may be required in order to cover a country. The definition of the MSC may be prefixed by the terms ‘‘land’’ or ‘‘maritime’’ if that is more suitable in a specific application.

2.1.4 base station

The base station (BS) is the common name for all the radio equipment located at one and the same place used for serving one or several cells.

2.1.5 mobile station

The mobile station (MS) is the interface equipment used to terminate the radio path at the user side. It includes terminal functions required to provide services to the user, e.g. terminal equipment and terminal adaptors.

2.1.6 cell

The area covered by a base station, or by a sub-system (sector antenna) of that base station corresponding to a specific logical identification on the radio path, whichever is smaller.

Every mobile station in a cell may be reached by the corresponding radio equipment of the base station.

2.1.7 **base station area**

The area covered by all the cells served by a base station.

2.1.8 **location area**

The location area is defined as an area in which a mobile station may move freely without updating the location register. A location area may comprise several cells.

2.1.9 **MSC area**

The part of the network covered by an MSC. An MSC area may consist of several location areas.

2.1.10 **service area**

The service area is defined as an area in which a mobile station is obtainable by another PLMN, PSTN or ISDN subscriber without the subscriber's knowledge of the actual location of the mobile station within the area. A service area may consist of several PLMNs. One service area may consist of one country, be a part of a country or comprise several countries. The location registration system associated with each service area must thus contain a list of all mobile stations located within that service area.

Figure 2/Q.1001 shows an example of the composition of a service area.

Note — This definition does not take into account any constraints on routing imposed by the international telephone network.

Figure 2/Q.1001, p.

2.1.11 **system area**

The system area consists of one or more service areas with fully compatible MS-BS interfaces.

Note — The location registers of the individual service areas remain autonomous; updating of the location information is not performed when a roaming mobile station moves from one service area to another. The overall composition of the international land mobile system is shown in Figure 3/Q.1001.

Figure 3/Q.1001, p.

2.1.12 **Mobile Subscriber International ISDN Number**

The Mobile Subscriber International ISDN Number is defined as the number which has to be dialled in order to reach a mobile subscriber in a service area. See also Recommendations E.164 and E.213.

2.1.13 **international mobile station identity**

The mobile station's identification uniquely identifies the MS internationally. The identity is composed as defined in Recommendation E.212.

2.1.14 **radio traffic path**

The radio communication facility between a mobile station and a base station intended to carry a call and uniquely assigned to the mobile station during that call.

2.1.15 **radio control path**

The radio communication facility between a mobile station and a base station intended to carry all the information transfer between the mobile station and the MSC, in which area the mobile station currently is located, during the time that no radio traffic path between that base station and that mobile station is assigned.

2.2 *Roaming definitions*

2.2.1 **location register**

To establish a call to a mobile station the network must know where this mobile station is located. This information is stored in a function named location register. A mobile station is registered at one location register which functions as its home centre for charging and billing purposes and for administering its subscriber parameters.

2.2.2 **location information**

The location register should as a minimum contain the following information about a mobile station:

— international mobile station identity;

— actual location of the mobile station (e.g. PLMN, MSC area, location area, as required).

2.2.3 **home PLMN**

The PLMN in which a mobile station is permanently registered.

2.2.4 **home location register**

The location register to which a mobile station is assigned for record purposes such as subscriber information.

2.2.5 **home MSC**

The term home MSC (HMSC) may be used in cases where the home location register is implemented in an MSC.

2.2.6 **equipment Identity Register**

The register to which an international mobile equipment identity is assigned for record purposes.

2.2.7 **visited PLMN**

The PLMN, other than the home PLMN, in which a roaming subscriber is currently located.

2.2.8 **visitor location register**

The location register, other than the home location register used by an MSC to retrieve information for, for instance, handling of calls to or from a roaming mobile station, currently located in its area.

2.2.9 **visited MSC**

The term visited MSC (VMSC) may be used in cases where the visitor location register is implemented in an MSC.

2.2.10 **gateway PLMN**

The PLMN which receives a call from a fixed subscriber, via a public switched network, for extension to a mobile station. The gateway PLMN may vary for interconnection with different public networks.

The gateway PLMN could be the home PLMN or the visited PLMN or any other.

2.2.11 **gateway MSC**

The MSC which receives a call from a fixed subscriber, via a public switched network, for extension to a mobile station. The gateway MSC may vary for interconnection with different public networks.

The gateway MSC may be any MSC of the PLMN, including the HMSC or VMSC if the home and visited location registers are implemented in the MSC.

2.2.12 **designation method**

The calling subscriber must know the actual location area of any mobile station. The call is established according to the dialled information only, i.e. the call is not rerouted by the location register when the mobile station currently is in another location area.

2.2.13 **non-designation method**

The calling subscriber is not required to know the actual location area of the mobile station. The call is routed according to the dialled information and, if required, rerouted on additional information given by a location register.

2.2.14 **mobile station roaming number**

The network internal number used for routing of calls to the mobile station. See Recommendation E.213.

2.3 *Handover definitions*

2.3.1 **handover**

Handover is the action of switching a call in progress from one cell to another (or between radio channels in the same cell). Handover is used to allow established calls to continue when mobile stations move from one cell to another (or as a method to minimize co-channel interference).

2.3.2 **MSC-A (Controlling MSC)**

The MSC which first established the radio connection to or from a mobile station for mobile terminating or originating calls respectively. This MSC will be the call controlling MSC for the duration of the call also in cases where a call is handed over to another MSC.

2.3.3 **MSC-B**

The first MSC to which a call is handed over.

2.3.4 **MSC-B‘**

The second (or subsequent) MSC to which a call is handed over.

Note — After the handover is completed and the circuit between MSC-A and MSC-B has been released. MSC-B’ will look, from the point of view of MSC-A and the network, like MSC-B did before the handover.

2.3.5 **candidate MSC**

A Candidate MSC is an MSC which controls cells that could be candidates for receiving a call in case of a handover.

2.3.6 **target MSC**

The Target MSC is the MSC controlling the cell(s) selected as target(s) for a handover.

2.3.7 **serving MSC**

The Serving MSC is the MSC which handles the call at the moment.

2.3.8 **old serving MSC**

The old serving MSC is the MSC which was the serving MSC before a handover, other than MSC-A.

3 Architecture of the Public Land Mobile Network

3.1 *Configuration of a Public Land Mobile Network*

3.1.1 *General*

Figure 4/Q.1001 presents PLMN entities and the associated signalling interfaces. The specific implementation in each country (or PLMN, if more than one in each country) may be different; some of the functional entities may be combined in the same equipment and this may result in some interfaces becoming internal. The configuration of a PLMN must in any case have no impact on the relationship with other PLMNs. Example: PLMN entities and associated signalling interfaces are shown in Figure 5/Q.1001. To illustrate some implementation possibilities three examples of configurations are presented in Figures 6/Q.1001, 7/Q.1001 and 8/Q.1001. In addition, it can be mentioned that HLR and VLR can be physically implemented in the same equipment, as an integrated Location Register.

3.1.2 *Configuration example No. 1 (No co-location of functional entities)*

This configuration is presented in Figure 6/Q.1001. All functions are implemented in dedicated equipment. The interfaces within the PLMN are equipment external and therefore need the support of the Mobile Application Part (MAP) of Signalling System No. 7 to exchange the data necessary to provide the mobile service. All PLMN configurations can be deducted from this basic configuration. In instances where some functions are contained in the same equipment, the relevant interfaces become equipment internal to that equipment and the use of the MAP is not necessary. Some examples are given in §§ 3.1.3 and 3.1.4.

3.1.3 *Configuration example No. 2 (VLR co-located with VMSC)*

This configuration is presented in Figure 7/Q.1001. The Visited Location Register is co-located with or implemented in the VMSC for the following reasons. The main type of data stored in the VLR is the practical location information (i.e. location area) which has to be updated by the VMSC when the mobile station moves from one location area to another. The VMSC also has to interrogate the VLR at call set-up in order to know the relevant subscriber data (e.g. restrictions and supplementary services).

3.1.4 *Configuration example No. 3 (HLR and VLR co-located with a MSC)*

This configuration is presented in Figure 8/Q.1001. In cases where the HLR is implemented in the MSC, this MSC will become the HMSC for the subscribers managed by the Location Register. The two functions HLR and MSC are not of the same type: the HLR is a pure network data base function, interrogated when needed and the MSC is mainly in charge of call handling. The HMSC performs the call handling function for all its subscribers, as defined by their allocation to the HLR, when they are located in the HMSC area. Call set-up to mobile stations handled by the HMSC uses only the international mobile subscriber ISDN/PSTN number and no roaming number is allocated to these mobile stations.

3.2 *Interconnection between PLMNs*

As the configuration of a PLMN does not have any impact on other PLMNs, the specified signalling interfaces can be implemented between entities within a PLMN or between PLMNs, with or without intermediate interface equipment providing a gateway function at the application level.

A difference in the interface can be found at lower levels (SCCP), since different signalling networks can be involved in the exchange of messages and they are at least independent with respect to the signalling network addressing plan.

A specific interconnection with a PLMN gateway may be needed in cases where the organization and configuration of a PLMN does not meet the international specifications. The specific interconnection is used in this case to mask, from other PLMNs, a national configuration which is not in line with the international specifications.

Figure 4/Q.1001, p.4

Figure 5/Q.1001, p.5

Figure 6/Q.1001, p.6

Figure 7/Q.1001, p.7

Figure 8/Q.1001, p.8

3.3 *PLMN interfaces*

3.3.1 *General*

The implementation of the public land mobile service with international roaming and handover implies the exchange of mobile specific signalling information between the equipment involved in the service. The introduction of Signalling System No. 7 and its signalling network will be an opportunity to transfer the data needed to support the Public Land Mobile Service. Signalling System No. 7 should be used to convey the information, where applicable. In addition some parts of the equipment will have signalling interworking with the fixed network. The descriptions given below are limited to the mobile application. The Mobile Application Part will be supported by the Transaction Capabilities.

3.3.2 *Interface between MSC and base station (A interface)*

The exact definition of the interface between a base station and its MSC depends on the division of functions between BS and MSC. Call handling as well as mobile station management may be split between the two entities.

However, the BS-MSC interface will in any case carry information concerning:

— Call handling

— Mobility management

— BS management

— Mobile station management

3.3.3 *Interface between MSC and VLR (B interface)*

The VLR is the location and management data base for the mobile stations roaming in the area controlled by the associated MSC or MSCs. The MSC interrogates the VLR whenever it needs information relating to a given mobile station currently located in the MSC area. When a mobile station initiates a location updating procedure with an MSC, the MSC informs its VLR which stores the relevant information in its tables. This procedure occurs whenever a mobile station roams to another location area. The MSC also informs the VLR when a subscriber for instance activates a specific supplementary service or modifies some information related to a service. The VLR stores these modifications and updates the HLR, if required.

3.3.4 *Interface between MSC and HLR (C interface)*

This interface is used to exchange signalling information for administrative and routing purposes.

In cases where charging information is transferred from an MSC, using Signalling System No. 7, this interface will be used.

In cases where the fixed network is unable to interrogate the HLR, an interrogation from a gateway MSC will be necessary in order to get the call routing information from the HLR, for instance the roaming number (if the mobile station is roaming).

3.3.5 *Interface between HLR and VLR (D interface)*

This interface is used to exchange the signalling information related to the location of the mobile station and to the management of the subscriber. The main service provided to the mobile subscriber is the capability to set-up or to receive calls within the service area. To support this, the location registers must exchange signalling information. The VLR informs the HLR of the location of a mobile station managed by the HLR and provides the HLR with the roaming number of that mobile station. The HLR sends to the VLR information needed to support the service to the mobile station. The HLR also informs a VLR which previously served the mobile station to delete all relevant information regarding a mobile station, which has roamed to an MSC area served by another VLR. Exchange of signalling information can also occur for instance when the mobile subscriber activates a supplementary service, when the subscriber wants to change some information related to his subscription or when the administration modifies some parameter of the subscription.

3.3.6 *Interface between MSCs (E interface)*

This interface is used mainly for handover related information exchange between MSCs. A handover is required when a mobile station moves from one MSC area to another during a call in order to continue communication. The MSCs exchange signalling information as a part of the process to determine the best cell for handover and finally to perform the handover if the best cell is in another MSC than the Serving MSC.

3.3.7 *Interface between MSC and EIR (F interface)*

This interface is used for information transfer between an MSC and the equipment identity register, EIR, related to management of national and international mobile equipment identities.

3.3.8 *Interface between VLRs (G interface)*

This interface is used for information transfer between VLRs when a mobile station registers in a new VLR using a temporary mobile station identity, TMSI, assigned by another VLR. This interface is used to retrieve the international mobile subscriber identity, IMSI, from the VLR which assigned the TMSI.

3.3.9 *Interface between BS and MS (Um interface)*

The exact definitions of the interface between base station and mobile station are not part of this specification.

However, the BS-MS interface is characterized by the Um reference point:

— the Um reference point is the traditional over-the-air radio-interface that is RF technology dependent and includes the physical aspects of the interface to the Base Station.

3.3.10 *Interface between user and network*

The Digital PLMN User-Network interface provides:

a) flexibility of user terminals with respect to Digital PLMN network interconnection:

b) flexibility of separate user terminal evolution and PLMN technology evolution; and

c) flexibility of definition and provisioning for PLMN basic bearer services, teleservices and supplementary services.

The definition of the User-Network interface is for further study.

4 Services in the public land mobile network

The services to be provided in a public land mobile network can be described according to the ISDN service definition principles (see Recommendation I.210) as basic services and supplementary services. Examples of these two types of services are telephone service and call forwarding unconditional respectively.

The basic services to be provided in the PLMN includes teleservices and bearer services, e.g. telephone and data services (for further study) as well as most other services provided in the ISDN (for further study).

The supplementary services to be provided are additional to one or more basic services.

5 List of Acronyms (Additional acronyms will be included)

BS Base Station

EIR Equipment Identity Register

GMSC Gateway MSC

HLR Home Location Register

HPLMN Home PLMN

IMEI International Mobile Equipment Identity

IMSI International Mobile Station Identity

MAP Mobile Application Part

MCC Mobile Country Code

MNC Mobile Network Code

MS Mobile Station

MSC Mobile Services Switching Centre

MSC-A	MSC with call control at handover
MSC-B	MSC to which a handover is done
MSC-B'	MSC to which a subsequent handover is done
MSIN	Mobile Station Identity
MTP	Message Transfer Part
NMSI	National Mobile Station Identity
PLMN	Public Land Mobile Network
SCCP	Signalling Connection Control Part
SP	Signalling Point
TMSI	Temporary Mobile Station Identity
VLR	Visitor Location Register
VPLMN	Visited PLMN

Recommendation Q.1002

NETWORK FUNCTIONS

1 Introduction

This Recommendation defines network functions which may be necessary to support services and facilities provided by PLMNs. A summary of the network functions is given in Table 1/Q.1002. The table also indicates whether or not a function requires internetwork signalling between PLMNs (i.e., use of Mobile Application Part, Recommendation Q.1051).

H.T. [T1.1002]
TABLE 1/Q.1002
Overview of network functions

{
 Class of network function (NF)
 }
	Network function	Interworking with MAP

{
 NF needed for basic service provision
 }
 Call handling
 Subscriber authentication
 Emergency calls
 Supplementary services
 }
	{
	 X X — X	

{
 Additional NF needed for call handling
 }
 Queuing
 Call duration limitation
 OACSU
 Mobile station with priority
 Mobile station with preference
 Security related services
 }
	{
	 X — — — — X	

{
 NF needed for supporting cellular operation
 }
 Location registration
 Hand-over
 — in the same BS
 — in the same MSC
 — in the same PLMN
 — between PLMNs
 Power control
 Dynamic channel allocation
 }
	{
	 X — — — X X — (X)	

{
 Operation and maintenance oriented NF
 }
 Test loops
 Operation
 Maintenance
 Charging
 Traffic survey
 Malicious call identification
 Tracing of mobile stations
 }
	{
	 — X X X (X) — —	

Table 1/Q.1002 [T1.1002], p.

All functions require signalling on the radio path either as subscriber line signalling or as mobile management signalling.

2 Network functions for basic service provision

2.1 *Call handling*

This set of functions enables the establishment of communications between a mobile subscriber and another network subscriber in one of the following types of networks: PSTN, ISDN, PSPDN, CSPDN and other PLMNs.

2.1.1 *Call from MS registered in VLR*

This is the normal case where the call is routed according to the dialled number. After the call, the MSC shall send the charging information to the HLR, a billing entity and/or store the charging data on tapes or discs.

2.1.2 *Call from MS not registered in VLR*

When the VLR receives a request for call set-up parameters from an MSC for an MS originating call, where the MS is not registered in the VLR, the VLR shall initiate a location updating procedure toward the HLR and in response parameters are given concerning category, services and restrictions. The call is then set up as in § 2.1.1.

2.1.3 *Call to a mobile subscriber*

The call is routed (rerouted or forwarded) according to location data obtained from the HLR to the actual MSC.

2.1.4 *Call handling functions in HLR*

The HLR should accommodate call routing functions as described in § 2.1.3.

The HLR should also support control functions for handling of supplementary services.

2.1.5 *Call handling functions in VLR*

The VLR should provide subscriber parameters to the MSC as required for call handling.

The VLR should also support control functions for handling of supplementary services.

2.1.6 *Call handling functions in MSC*

The MSC should perform normal call routing and call control functions. The MSC will obtain subscriber parameters from its associated VLR.

The MSC should also be capable of performing handover as defined in § 3.2.

In some cases the MSC should be able to act as a gateway MSC.

2.2 *Subscriber authentication*

Authentication procedures should be implemented in order to protect the network from access by non-registered or fraudulent MSs. The authentication method is for further study.

A possible procedure could be as follows.

The procedure is based upon a challenge/signed response method which goes as follows:

— the fixed subsystem transmits a non-predictable number RAND (the challenge) to the MS;

— the MS calculates the signature SRES (the signed response) of RAND;

— the MS transmits the signature SRES to the fixed subsystem; and

— the fixed subsystem tests the signature for validity.

Authentication may take place in the following cases:

i) at location registration,

ii) at call set-up,

iii) when requesting operation of a supplementary service, or

iv) after handover.

2.3 *Emergency call*

2.3.1 *General*

The land mobile system should be capable of efficient handling of emergency calls from mobile stations. Signalling procedures on the radio path require further study.

2.3.2 The call should be routed automatically to an appropriate emergency centre based on the geographical location of the mobile station. For this purpose the accuracy of geographical location determination may be the cell serving the MS.

2.3.3 *Card operated stations*

It may be permissible to initiate emergency calls from card operated MSs also when the card is not inserted. This point is for further study.

2.4 *Supplementary services*

The support of supplementary services may require control procedures in HLRs, VLRs and MSCs in addition to the control procedures in the fixed network.

3 Network functions for supporting cellular operation

3.1 *Location registration*

3.1.1 *Definitions*

Location registration means that the PLMNs keep track of where mobile stations are located in the system area. The location information is stored in functional units called location registers. Functionally there are two types of location registers:

— the **home location register** where the current location and all subscriber parameters of a mobile station are permanently stored, and

— the **visitor location register** where all relevant parameters concerning a mobile station are stored so long as the station is within the area controlled by that visited location register.

See also Recommendation Q.1001 where the network architecture is described.

3.1.2 *Procedures*

Procedures related to location registration are specified in Recommendation Q.1003.

They comprise:

i) location register updating which enables the MS to inform the network that its location has to be updated, i.e. the MS has received a location area identity which is different from that contained in its memory. In order to avoid unnecessary updating, the current location area identity should be stored in a non-volatile memory in the MS;

ii) location cancellation which is used to delete an MS from a previous VLR;

iii) periodic location updating which enables the location of silent and stationary MSs to be updated at a reasonable rate; and

iv) as a network option, IMSI detach/attach operation which will enable MSs to inform the network that they have entered a power down/power up state.

The procedures also include mechanisms for restoration of location registers after failure. These procedures are defined in Recommendation Q.1004.

3.1.3 *Information stored in location registers*

Information to be stored in location registers is listed in Recommendation Q.1003.

3.2 *Handover*

3.2.1 *Definitions*

The following cases are considered:

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

Note — This capability 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 difference PLMNs.

For cases iii) and iv) two procedures are defined:

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 to a third MSC (MSC-B‘).

3.2.2 *Procedures*

The procedures are described in Recommendation Q.1005.

3.3 *Power control*

For further study.

3.4 *Dynamic channel allocation*

For further study.

4 Additional network functions for call handling facilities

4.1 *Queuing*

4.1.1 *General*

Queuing of calls from fixed and mobile subscribers may be offered as an optional facility. Calls should only be queued when there is congestion on the radio path when the call arrives. The queuing facility is accommodated in the MSC.

4.1.2 *Queuing of MS originating calls*

When an MS originated call is placed in a queue, a queuing indicator should be provided to the MS as display information. The maximum time that the call will be kept in the queue should also be indicated. This would enable timers to be set in the MS in accordance with the queuing arrangements of each PLMN.

The MS should be marked as busy when the call is placed in the queue.

The call is cancelled when:

— the MSC receives a clearing message from the MS;

— there is time-out on the queuing time; or

— the VLR receives a location cancellation message from the HLR.

Note — It is for further study whether or not this is practicable.

4.1.3 *Queuing of MS terminating calls*

Queuing facilities for MS terminating calls may also be provided in the MSC. If so, general PSTN/ISDN specifications on abnormal release conditions and post dialling delays should be taken into account. Further study is required on interworking with the fixed network.

The MS should be marked as busy when the call is placed in the queue.

MS terminating calls should be released if a location cancellation message is received while the call is being queued.

Note — It is for further study whether or not this is practicable.

4.1.4 *Queuing conditions*

Not more than one call should be queued for each MS.

Calls should be queued and serviced in the order they arrive at the MSC, except for calls subject to some priority condition, e.g. calls which are handed over should have priority over normal calls and emergency calls should have priority over any other call.

Calls arriving when all positions in the queue are occupied, should be rejected with a congestion indication provided to the calling party.

Calls which have been queued for a time longer than the maximum queuing time should be released from the queue. MS terminating calls should be cleared with a congestion indication provided to the calling party.

4.2 *Call duration limitation*

4.2.1 *General*

This is an optional facility.

PLMNs may support functions whereby the call duration is limited in order to increase the call handling capacity of the PLMN. Call duration limitation may apply independently to each cell depending on the current traffic load of the cell. If possible, an indication should be provided to the subscribers that a call is subject to call duration limitation. Procedures are for further study.

4.3 *Off-air-call-set-up (OACSU)*

4.3.1 *General*

OACSU may be implemented in PLMNs in order to increase the call handling capacity of the PLMN.

OACSU may be implemented in PLMNs on an optional basis subject to the following conditions:

i) OACSU should not be used for calls to an international number;

ii) OACSU should not be used for incoming international calls;

iii) foreign MSs not supporting the OACSU procedure should be allowed to access the PLMNs where OACSU is used;

iv) MSs supporting OACSU should be capable of operating in PLMNs where OACSU is not implemented;

v) OACSU must not be used for calls involving an ISDN or a PDN or for non-voice services in the PSTN.

4.3.2 *Signalling procedures*

Interworking requirements for supporting OACSU are described in Recommendation Q.1031.

4.4 *Mobile stations with priority*

This is an optional facility.

It may be possible to offer priority for certain subscribers for:

— incoming calls;

— outgoing calls; or

— all calls.

Priority could comprise priority in queuing systems, preemption of outgoing calls in order to service a call with priority, etc.

Procedures for handling MSs with priority are for further study.

4.5 *Mobile stations with preference*

This is an optional facility.

Preference means that in certain circumstances only MSs with preference are allowed to access the network. The condition may be controlled by the BS by inserting a preference indication in the messages sent on the common signalling channel on the radio interface.

Procedures for handling of MSs with preference is for further study.

It should be possible to set the preference condition individually in each cell.

4.6 *Security related supplementary services*

PLMNs may offer encryption of information sent on the radio path. Procedures for encryption and key distribution are for further study.

4.7 *Discontinuous reception*

Discontinuous reception is a technique used to reduce the average battery consumption of mobile stations. The operation of this function is for further study.

4.8 *Discontinuous transmission*

Discontinuous transmission is a technique used to reduce the battery consumption of mobile stations. The operation of this function is for further study.

5 **Operation and maintenance oriented network functions**

5.1 *Test facilities*

The public land mobile systems may contain test facilities which can perform tests similar to those defined for the ISDN subscriber line.

Further study is required.

5.2 *Operation*

5.2.1 *General*

In PLMNs tasks related to system operation are divided among several functional units:

— home location registers,

— visitor location registers,

— MSCs,

— BSs,

— national operation and maintenance centres,

— encryption key distribution centres, and

— centres for management of equipment identities.

It should be noted that several of these functional units may be co-located or even be accommodated in the same physical equipment.

In addition, other aspects concerning system operation will be the responsibility of subscribers, MS manufacturers, sales agents, etc.

Tasks allocated to each of the functional units are described below.

5.2.2 *Responsibilities of HLRs*

The main responsibilities of the HLRs are:

i) subscriber administration, i.e. management of all subscriber parameters of MSs registered in the HLR. Subscriber administration also includes the possibility of making changes to subscription conditions and subscriber parameters. It may also include additional administrative functions related to CUGs and MSs with preference;

ii) charging administration, e.g. relaying of charging information from a foreign PLMN to the charging point in the home PLMN; and

iii) updating of VLRs.

5.2.3 *Responsibilities of VLRs*

The main responsibilities of the VLRs are:

i) management of mobile station roaming numbers;

ii) management of temporary mobile station identities, if implemented;

iii) subscriber administration of visiting MSs;

iv) updating of HLRs;

v) management of MSC areas, location areas and BS areas; and

vi) radio channel management (e.g. channel allocation tables, dynamic channel allocation management, channel blocking status).

Note — Some or all of the functions in vi) may be in the MSC or the BS. This is for further study.

5.2.4 *Responsibilities of MSCs*

The main responsibilities of the MSCs are:

i) routing administration;

ii) charging and tariff administration;

iii) traffic administration, e.g. traffic monitoring; and

iv) sending of relevant traffic and charging information to the HLR (see § 5.4).

5.2.5 *Responsibilities of national 0 & M centres*

The operational responsibilities of national O & M centres could be remote control and monitoring of the operation of functional units, e.g. remote management of subscriber parameters.

5.2.6 *Responsibilities of BSs*

For further study.

5.2.7 *Responsibilities of encryption key distribution centres*

For further study.

5.2.8 *Responsibilities of centres for management of equipment identities*

For further study.

5.3 *Maintenance*

5.3.1 *General*

Maintenance of PLMNs may require activities in several functional units. Some maintenance activities are autonomous, i.e. within one functional unit, and others require cooperation between several functional units. Functional units which may be involved in cooperative maintenance activities are:

— mobile stations,

— base stations,

— MSCs,

— visitor location registers,

— home location registers, and

— national operation and maintenance centres.

In some cases maintenance activities may require international cooperation. In such cases the maintenance responsibilities, the information exchanges and the activities required for restoration of service should be in accordance with rules set down for the PSTN/ISDN (M-Series of Recommendations).

5.3.2 *Maintenance responsibilities of MSs*

To some degree the MS should be capable of detecting faulty operation. When faults are detected, the MS should initiate internal testing and prevent accidental transmission.

5.3.3 *Maintenance responsibilities of the BSs*

The BS should monitor the radio path. If faulty operation is detected, information should be sent to the MSC and/or to a national operation and maintenance centre.

The BS may also have facilities for blocking and unblocking of radio channels and BS-MSC circuits.

5.3.4 *Maintenance responsibilities of MSCs*

The MSC should include maintenance facilities and support maintenance functions as for exchanges of the PSTN/ISDN. These functions include:

i) maintenance of the MSC-BS circuits and signalling links, including:

— test, observation and measurement of MSC-BS (MSC-MS) protocols; and

— blocking and unblocking of MSC-BS circuits and radio channels.

ii) maintenance of circuits to exchanges of the PSTN/ISDN,

iii) maintenance of signalling links to a signalling network,

iv) fault reporting to operation and maintenance centres, and

v) maintenance of their own equipment.

5.3.5 *Maintenance responsibilities of location registers*

The location registers will be responsible for:

i) maintenance of signalling links; and

ii) restoration after restarts including information exchange with other location registers.

5.3.6 *Maintenance responsibilities of operation and maintenance centres*

For further study.

5.4 *Charging*

The MSC and the BS must be capable of obtaining all information required for determining call charges for MS originating calls.

For charging of MS originating calls information as follows may be required:

— address of called party,

— IMSI,

— time of the call,

— charging rate for the called destination,

— call duration and possibly also parameters such as traffic volume and radio channel resources used,

— additional charges, e.g. for use of supplementary services,

— charging conditions, e.g. normal charging, debit card, credit card, and

— location of MS (e.g. cell, location area, MSC area).

For calls within the same PLMN the information is directed to the relevant billing entity. How this is achieved is a national concern, however, examples could be:

i) by use of the Mobile Application Part;

ii) by use of a public data network;

iii) by use of dedicated links;

iv) by use of physical transfer of magnetic tapes containing the billing information; or

v) a combination of the above.

Case i) above is specified in Recommendation Q.1051.

The need for Recommendations covering the other alternatives is a matter for further study. They may be required to permit different manufacturers equipment to interwork.

It should be noted that the use of the Mobile Application Part will only allow charging data on a per call basis to be transferred, though not necessarily immediately after the call has been terminated. For instance if the Mobile Application Part signalling or network processing load is such that the transfer of billing information would compromise normal call set-up procedures, then the transfer of billing information should be delayed until the signalling load decreases (e.g. overnight transmission of stored billing data).

In the longer term it is not clear, even if overnight transfer of billing information is used, whether the Mobile Application Part will have sufficient capacity, therefore a move to another technique will be necessary.

For calls involving a roaming mobile in a visited PLMN, the same techniques as above can be applied by bilateral agreement. For instance the situation could be imagined where a roaming service is opened between two networks, but the level of roaming traffic does not justify either the use of a public data network, or physical transfer of magnetic tapes, therefore the Mobile Application Part is used initially.

The destination for international billing information should be the relevant billing entity of the home network, however, when using the Mobile Application Part, addressing difficulties may mean that only the HLR can be addressed.

The MSC may support facilities for debit card calls. The signalling procedure on the radio path should support this type of operation.

The MSC may also support facilities for credit card calls. This involves facilities and procedures for authentication of the credit card number and transfer of the required information to the billing authority. The procedures will not be specified for the Mobile Application Part. On a national basis Signalling System No. 7, public data networks or other networks convenient for the administration may be used for these purposes.

For MS terminating calls where part of or the whole charge is to be paid by the MS, the information to be stored would be similar to that of MS originating calls. Further study is required.

5.5 *Traffic survey*

For further study.

5.6 *Malicious call identification*

If required and regulatory and technical constraints permit, the MSC may support the malicious call identification (MCI) facility for MS originating and MS terminating calls. The exact implementation of this facility will depend upon national variations of the signalling system being used.

5.7 *Tracing of mobile stations*

For further study.

Recommendation Q.1003

LOCATION REGISTRATION PROCEDURES

1 Introduction

This Recommendation specifies the procedures related to location registration. They include:

— location registration;

— location cancellation;

— periodic registration; and

— IMSI attach/detach.

The procedures in the MS, MSC, VLR and HLR are also given. The procedures utilize the Mobile Application Part (MAP) and details concerning the exchange of information are contained in Recommendation Q.1051.

2 Definitions

2.1 *Location registration*

Location registration means that the PLMNs keep track of where mobile stations are located in the system area. The location information is stored in functional units called location registers. Functionally there are two types of location registers:

— the **home location register** where the current location and all subscriber parameters of a mobile station are permanently stored; and

— the **visitor location register** where all relevant parameters concerning a mobile station are stored so long as the station is within the area controlled by that visitor location register.

See also Recommendation Q.1001 where the network architecture is described.

The action taken by a mobile station in order to provide location information to the PLMN will be referred to as *location updating* .

2.2 *Location area and MSC area*

The MSC area is composed of the area covered by all base stations controlled by the MSC. An MSC area may consist of several location areas.

A location area is an area in which mobile stations may roam without updating the location registers. A location area consists of one or more base station areas.

Paging procedures will be required on the radio path if the location area consists of more than one base station area. The paging procedure is used to determine the base station area in which the MS is located.

For further details of the network architecture and for definitions, see Recommendation Q.1001.

2.3 *Location area identification*

The location area idenfication plan is part of the base station identification plan. The base stations should be identified uniquely and the base station identity should include mobile country code, mobile network (PLMN) code, location area code and base station code within the location area where the location area identification consists of the first three elements.

Furthermore, it is viewed that based on network considerations, the mobile country code and base station code may be optional in identifying where the location area identification is included in all messages sent on common signalling channels on the radio path.

2.4 *IMSI detach/attach operation*

IMSI detach operation is the action taken by an MS to indicate to the PLMN that the station has entered an inactive state (e.g. the station is powered down). IMSI attach operation is the action taken by an MS to indicate that the station has re-entered an active state (e.g. the station is powered up).

IMSI detach/attach operation is an optional facility in PLMNs.

2.5 *Use of the term mobile station (MS) in this Recommendation*

In order to simplify the text the term *mobile station (MS)* | s used in relation to location registration refers to the entity where the IMSI is stored, i.e., in the card operated MSs the term *mobile station (MS)* | efers to the card.

3 Procedures in the MS related to location registration

3.1 *Initiation of location register updating*

Automatic location updating should take place as follows.

The mobile station initiates location updating when it detects that it has entered into a new location area. The location area identification should be stored in a non-volatile memory in the MS so that the memory content does not disappear when the MS is turned off. This will avoid unnecessary location updating when the MS is still in the same location area when it is turned on again.

If the MS has lost the location information from memory, it will initiate location updating as soon as it is in an operational state and within radio coverage.

Location updating is also initiated on time-out of the timer T defined in § 3.2.

Location updating via manual intervention in the MS is for further study.

3.2 *Periodic location updating*

A timer T with the following characteristics could be optionally implemented in the MS:

i) timer T is reset to 0 and started when a signalling activity has taken place on the radio path;

ii) when the MS is powered down the current value of T is kept in memory, so that when the MS is powered up the timer starts running from the value thus contained in memory; and

iii) when timer T reaches its time-out value, the MS initiates a location updating.

Timer T thus measures the accumulated time between signalling activities in the MS while the MS is in the powered up state.

In order to ensure:

a) that the location of silent and stationary MSs are checked at a reasonable rate; and

b) that the timer T does not mature to time-out in the majority of cases.

The time-out value of timer T should be of the order of several hours (e.g. in the range of 12 to 24 hours). See also Recommendation Q.1004.

3.3 *Receiving acknowledgement from the PLMN*

The MS may receive either of the following acknowledgements from the PLMN.

i) *Location updated, roaming allowed* . In this case normal call handling operations will take place in the MS.

ii) *Location updated, roaming not allowed* . In this case, the MS will not be allowed to make calls. The MS should follow the procedure of §§ 3.1 and 3.2 above. The MS will resume normal operation if it receives a location updated, roaming allowed indication from the PLMN.

iii) *Updating failure* , indicating that the procedure in the PLMN failed. In this case, the MS should initiate a new updating after a given time. If this attempt fails, the MS should follow the normal procedures of §§ 3.1 and 3.2. When receiving the updating failure indication, the MS should be capable of normal call handling operation.

iv) *Insufficient identification* , indicating that the PLMN was not capable of identifying the MS. The MS should then initiate a new updating using the IMSI. The MS should follow the procedures of §§ 3.1 and 3.2 above.

v) *Not registered* , indicating that the MS is not known in the HLR. The MS should then reject any call attempts from the user. However, the MS should follow the normal procedures of §§ 3.1 and 3.2.

vi) *Illegal subscriber* , indicating that the MS is not allowed access to the system for authenticity reasons. The MS may follow the normal procedures of §§ 3.1 and 3.2.

3.4 *Procedure when acknowledgement is not received*

If the MS does not receive an acknowledgement (on layer 3) on an updating request, the MS may retransmit the message three times with at least ten seconds (see § 3.5) between consecutive attempts. If the procedure fails also for the third time, the general procedures of §§ 3.1 and 3.2 should be followed.

3.5 *Minimum time between location updatings*

The minimum time between consecutive location updatings should be ten seconds in order to avoid erroneous location information to be stored because of delays in the signalling network for information transfer via the mobile application part.

3.6 *IMSI detach/attach operation*

IMSI detach/attach operation is an optional facility in PLMNs. The facility is also optional in MSs.

The network should provide an indicator to the MS indicating whether or not IMSI detach/attach operation is allowed in a PLMN. MSs which are not equipped for IMSI detach/attach operation will ignore this indicator. MSs which are equipped for IMSI detach/attach operation shall operate in accordance with the received value of the indicator.

When IMSI detach/attach operation applies, an MS equipped for this type of operation and located in an area where roaming is allowed should send the IMSI detach signal to the MSC when the MS enters the inactive state (e.g. when the MS is powered down). When the MS again enters the active state,

the IMSI attach signal is sent to the PLMN, provided that the MS is still in the same location area. If the location area has changed, the normal location upating of § 3.1 shall take place.

The IMSI detach signal will not be acknowledged from the PLMN.

The IMSI attach signal will be acknowledged from the PLMN. If the acknowledgement indicates that the MS is not registered or that the identification is insufficient, the MS should initiate the normal location updating procedure of § 3.1.

If the acknowledgement is not received, the MS should retransmit the IMSI attach signal after a given time. If the second attempt fails, the MS should follow the procedure of § 3.2. However, in this state the MS is allowed to make calls.

3.7 *Location updating after handover*

See Recommendation Q.1005.

3.8 *SDL description of the procedures in the MS*

Figure 1/Q.1003 shows state transition diagrams for procedures in the MS related to location updating. The diagrams are intended for guidance.

Figure 1/Q.1003 (Feuillet 1/5), p.10

Figure 1/Q.1003 (Feuillet 2/5), p.11

Figure 1/Q.1003 (Feuillet 3/5), p.12

Figure 1/Q.1003 (Feuillet 4/5), p.13

Figure 1/Q.1003 (Feuillet 5/5), p.14

The following states are identified:

State 0: inactive

This state would in most cases correspond to the powered down state of an MS. The input signal IMSI attached may correspond to power up of the station.

State 1: Roaming allowed, updated

In this state the MS is fully operational.

State 2: Wait for updating

This is a transitional state where location updating takes place. In this state the MS cannot make or receive calls.

State 3: Wait for IMSI attached

This transitional state is only required in MSs which are designed for IMSI detach/attach operation. In this state the MS cannot make or receive calls.

State 4: Roaming not allowed

In this state the MS is not allowed to make calls (except emergency calls) and will not receive calls.

State 5: Not updated

This state is entered if the location updating or IMSI attach procedure fails. In this state the MS will not receive calls.

4 Procedures in the MSC/BS related to location updating

The MSC/BS will pass messages related to location updating between the MS and the VLR.

The MSC/BS will provide the location area identification and IMSI detach/attach supported information to the MS.

5 Procedures in the location registers

5.1 *Information to be stored in location registers*

The home and visitor location registers should contain information as defined in Annex A.

5.2 *Information transfer between MSCs/BSs and the associated visitor location register*

The procedures for information transfer between MSCs/BSs and the associated visitor location registers using Signalling System No. 7 are defined in Recommendation Q.1051.

5.2.1 *Normal location updating and IMSI detach/attach operation*

When receiving a location register updating message or an IMSI detach/attach message from an MS, the MSC/BS will convey the message to its associated visitor location register. The response from the location register will similarly be conveyed to the MS.

5.2.2 *Location updating as part of call set-up*

Location registration may also take place during call set-up if the request for call set-up comes from an MS which is not registered in the visited location register. This applies in particular to the case where a previous updating was unsuccessful. In such cases the MSC/BS should not establish the call until the location register updating has been completed.

Location register updating will also take place if the visitor location register receives signalling information from an unknown MS, e.g. a request for activation of a supplementary service.

5.3 *IMSI enquiry procedure*

The MS may either identify itself by the IMSI or the TMSI plus location area identification of the previous VLR. In the latter case the new VLR will enquire the IMSI from the previous VLR by methods defined in Recommendation Q.1051.

5.4 *Information transfer between visitor and home location registers*

5.4.1 *Interconnection of location registers*

Location registers may be interconnected by use of Signalling System No. 7 by procedures defined in Recommendation Q.1051. On a national basis other networks may be used for this purpose.

5.4.2 *Procedures for location registration*

Detailed procedures for exchange of location registration and location register updating information between visitor and home location

registers are given in Recommendation Q.1051. Below follows an overview of these procedures.

5.4.2.1 *Location updating procedure*

This procedure is used when an MS registers with a visitor location register. It will also be used if the visitor location register has to reallocate the mobile station roaming number for an MS (see Recommendation E.213).

The visitor location register provides routing information to the home location register. This information consists of the mobile station roaming number which is used for routing of calls to the MS.

The home location register will then convey the subscriber parameters of the MS which need to be known by the visitor location register for proper call handling.

5.4.2.2 *Location cancellation procedure*

The procedure is used by the home location register to remove a mobile station from a visitor location register. The procedure will normally be used when the MS has moved to an area controlled by a different location

register. The procedure can also be used in other cases, e.g. an MS ceases to be a subscriber of the home PLMN.

5.4.2.3 *Deregistration procedure*

If supported, the deregistration procedure is initiated by the VLR when it receives an IMSI detach request, see § 3.6. The corresponding IMSI is then deleted from the VLR tables. The HLR marks the subscriber as not registered and will reject all calls to that subscriber until a new updating procedure has taken place.

5.4.2.4 *Location information requested procedure*

This procedure enables a visitor register to enquire whether or not an MS is still to be kept in the register.

5.4.2.5 *Location information retrieval procedure*

By use of this procedure the home location register may obtain information on which of its MSs are registered with a visitor location register. The procedure may be used after a restart of the location register. The actual use of this procedure is for further study.

5.4.2.6 *Reset procedure*

The reset procedure is used for recovering from a restart of a home location register. A reset message is sent to visitor location registers so that recovery procedures can be initiated.

5.4.2.7 *Recovery procedure*

Recovery and restoration procedures for location registers are defined in Recommendations Q.1004 and Q.1051.

Recovery arrangements should be such that MSs with valid subscriptions are not deleted from the HLR as a result of HLR failure. The worst result of an HLR failure will thus be that some MSs are stored with errors in the temporary subscriber data.

5.5 *Overview state diagrams for location registers*

Figures 2/Q.1003 and 3/Q.1003 contain overview state transition diagrams for the home location register and the visitor location register, respectively, with regard to one MS. Reset procedures are not included in these diagrams, i.e. only the normal case is shown.

The state description is as follows.

i) *Home location register*

State 0: Null . In this state the MS has no subscription with the PLMN. Restart arrangements of the home location register should be such that this state is not reached for any MSs which have a subscription with the PLMN which is valid at the time of the restart.

State 1: MS not registered . In this state the location of the MS is not known. The MS is not offered any communication capabilities in this state.

State 2: MS in visitor location register (VLR), roaming allowed . In this state the MS is offered communication capabilities in the visitor location register in accordance with those established by the location updating procedure of § 5.4.2.1.

State 3: MS in visitor location register, roaming not allowed capabilities, except emergency calls, in the visitor location register. The home location register will contain an indication that the MS is in an area where the roaming not allowed condition applies. The visitor location register will not store any information concerning that MS.

ii) *Visitor location register*

State 0: Null . In this state the MS is not known to the visitor location register.

State 1: MS in visitor location register, roaming allowed . In this state the MS is offered communication capabilities in accordance with those established by the location updating procedure of § 5.4.2.1.

State 2: IMSI detached . In this state the MS is not offered communication capabilities.

5.6 *Additional updating procedures*

5.6.1 *Registration/erasure, activation/deactivation, invocation and interrogation of supplementary services*

The procedures defined in Recommendation Q.1051 enable MSs to register/erase, activate/deactivate, invoke or interrogate supplementary services in the visitor location register. The visitor location register conveys the necessary information to the home location register.

5.6.2 *Updating of other parameters*

Recommendation Q.1051 also contains procedures by which the home location register may update any set of subscriber parameters in a visitor location register if they are changed when the MS is in the area controlled by that visitor register. This may correspond to changes in subscription or of other parameters such as authentication parameters.

5.7 *Call handling functions of location registers*

5.7.1 *Retrieval of subscriber parameters on a per call basis*

All subscriber parameters are stored in the home location register. A subset of these parameters are stored in the visitor location register (see Annex A).

There are also cases where the visitor location register must obtain subscriber parameters on a per call basis from the home location register of the MS. The procedures are defined in Recommendation Q.1051.

5.7.2 *Interrogation procedures*

In fixed networks using the ISDN User Part of Signalling System No. 7 it may be possible for an exchange of the fixed network to

retrieve routing information from the home location register of an MS prior to establishing a physical connection for a call. If this is not possible, a gateway MSC will perform this interrogation.

Figure 2/Q.1003 (feuillet 1/3), p.15

Figure 2/Q.1003 (feuillet 2/3), p.16

Figure 2/Q.1003 (feuillet 3/3), p.17

Figure 3/Q.1003 (feuillet 1/2), p.18

Figure 3/Q.1003 (feuillet 2/2), p.19

ANNEX A
(to Recommendation Q.1003)

Organization of subscriber data

A.1 *Introduction*

A.1.1 *Definitions*

For the purpose of this Recommendation the following terms are used.

mobile station (MS) : either a physical equipment or a card for which subscriber data are stored.

subscriber data : all information concerning a specific MS which is required for service provisions, identification, authentication, routing, call handling, charging, operation and maintenance purposes. Some subscriber data are referred to as permanent subscriber data, i.e. they can only be changed by

administrative means. Other data are temporary subscriber data which may change as a result of normal operation of the system. Some data are referred to as flexible length data, i.e. further values than those listed may be required in the future.

A.1.2 *Storage facilities*

Subscriber data is stored in two types of functional units.

home location register (HLR) : which contains all permanent subscriber data and all relevant temporary subscriber data for all MSs permanently registered in the HLR.

visitor location register (VLR) : which contains all subscriber data required for call handling and other purposes for MSs currently located in the area controlled by the VLR.

Note — It is for further study whether other types of functional units containing MS parameters are to be included in this Recommendation or not. Such units could include encryption key distribution centres, maintenance centres, etc.

A.2 *Definition of subscriber data*

A.2.1 *Data related to identification and numbering*

A.2.1.1 **international mobile station identity (IMSI)** is defined in Recommendation E.212. It consists of three parts MCC, MNC and MSIN. The MCC consists of 3 digits and the MNC consists of 1 or 2 digits. The IMSI has variable length depending on national requirements. The maximum length is 15 digits.

Only numerical characters (0 through 9) are used in the IMSI.

The IMSI is permanent subscriber data, and is stored in both the HLR and the VLR.

Note — The IMSI for mobile PBXs is for further study.

A.2.1.2 **international mobile station number** is defined in Recommendation E.213. It is a PSTN/ISDN number and has a variable length which complies with the requirements of the PSTN/ISDN in each country.

The international mobile station number is permanent subscriber data.

The international mobile station number is stored in both the HLR and the VLR.

Note — Mobile station numbers for mobile PBXs are for further study.

A.2.1.3 **temporary mobile station identity (TMSI)** is assigned by the VLR and is used for identification of an MS within the area controlled by the VLR. The purpose of the TMSI is to support location confidentiality to mobile subscribers. TMSIs may not be allocated to all MSs, e.g. if the location confidentiality service is offered only on a subscription basis.

The TMSI is temporary subscriber data.

The TMSI is stored in the VLR.

A.2.2 *Data related to mobile station types*

A.2.2.1 *Mobile station category* | omprises the following categories:

For further study.

Only one category is assigned for each MS.

Mobile station category is permanent subscriber data.

The length of the parameter is one octet.

Mobile station category is stored in the HLR and the VLR.

A.2.2.2 **mode of operation** defines whether or not the MS is card operated. Only two possibilities exist:

— card operated; and

— not card operated.

Mode of operation is permanent subscriber data.

The mode of operation is stored in the HLR and the VLR.

Note — It is for further study whether this data is required or not.

A.2.2.3 **preference** indicates whether or not an MS is given preference access to the PLMN under certain circumstances. This point is for further study.

Preference is permanent subscriber data.

Preference is stored in the HLR and the VLR.

A.2.3 *Data related to authentication*

For further study.

A.2.4 *Data related to roaming*

A.2.4.1 **mobile station roaming number** is defined in Recommendation E.213. It is a PSTN/ISDN number and has a variable length which complies with the requirements of the PSTN/ISDN in each country.

The mobile station roaming number is temporary subscriber data.

The mobile station roaming number is stored in the HLR and the VLR.

A.2.4.2 **location area identification** consists of three parts: MCC, MNC and LAC, where MCC is the Mobile Country Code and MNC is the Mobile Network Code of Recommendation E.212 and LAC is a Location Area Code identifying a location area within a PLMN. MCC and MNC are composed of numerical characters (0 through 9). LAC may have a variable length and may be coded using full haxadecimal representation.

The overall length of the location area identification is for further study.

The location area identification is temporary subscriber data.

The location area identification is stored in the VLR. It may also be required in the HLR; this is for further study.

A.2.4.3 **VLR address** is a PSTN/ISDN number and has variable length which complies with the requirements of the PSTN/ISDN in each country.

The VLR address is temporary subscriber data.

The VLR address is stored in HLR.

A.2.5 *Data related to supplementary services*

For further study.

A.2.6 *Mobile station status data*

A.2.6.1 **MS registered/deregistered** is a parameter indicating whether the MS is in the registered or deregistered state. The parameter takes the following values:

— registered, or

— not registered.

The parameter is temporary subscriber data. The parameter is stored in the HLR.

A.2.7 *Other subscriber data*

This is for further study.

A.3 *Subscriber data stored in HLR*

The following information should be stored in the HLR for each MS:

i) international mobile station identity (§ A.2.1.1);

ii) international mobile station number (§ A.2.1.2);

iii) mobile station roaming number (§ A.2.4.1);

iv) mobile station category (§ A.2.2.1) and mode of operation (§ A.2.2.2);

v) preference (if implemented) (§ A.2.2.3);

vi) authentication parameters (§ A.2.3);

vii) VLR address (if received) (§ A.2.4.3);

viii) location area identification (if required) (§ A.2.4.2);

ix) supplementary service type (§ A.2.5.1.1);

x) mobile station status data (§ A.2.6); and

xi) other subscriber data, if required (§ A.2.7).

A.4 *Subscriber data stored in VLR*

The following information should be stored in the VLR for each visiting MS:

i) international mobile station identity (§ A.2.1.1);

ii) international mobile station number (§ A.2.1.2);

iii) mobile station roaming number (§ A.2.4.1);

iv) temporary mobile station identity (§ A.2.1.3);

v) mobile station category (§ A.2.2.1) and mode of operation (§ A.2.2.2.);

vi) preference (if implemented) (§ A.2.2.3);

vii) authentication parameters (§ A.2.3);

viii) location area identification (§ A.2.4.2); and

ix) other subscriber data, if required (§ A.2.7).

A.5 *Accessing subscriber data*

It should be possible to retrieve or store subscriber data concerning a specific MS from the HLR by use of each of the following references:

— international mobile station identity; or

— international mobile station number.

It should be possible to retrieve or store subscriber data concerning a specific MS from the VLR by use of each of the following references:

— international mobile station identity;

— mobile station roaming number; or

— temporary mobile station identity.