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.

The VLR address is stored in HLR.

A.2.5Data related to supplementary services

For further study.

A.2.6Mobile station status data

A.2.6.1MS 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.2.7Other subscriber data

This is for further study.

A.3Subscriber 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);

- 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.2.3Data related to authentication

For further study.

A.2.4Data related to roaming

A.2.4.1Mobile 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 thePSTN/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.2.4.2Location 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.2.4.3VLR 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.

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.2.1.2International 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.2.1.3Temporary 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.2.2Data related to mobile station types

A.2.2.1Mobile station category comprises 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.2.2.2Mode of operation defines whether or not the MS is card operated. Only two possibilities exist:

- card operated; and

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.

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 3/Q.1003 (Sheet 2 of 2)

State diagram for visitor location register

FIGURE 3/Q.1003 (Sheet 1 of 2)

State diagram for visitor location register

FIGURE 2/Q.1003 (Sheet 1 of 2)

State diagram for home location register

those established by the location updating procedure of § 5.4.2.1.

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. In this state the MS is not offered any communication 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

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.

5.4.2.7Recovery procedure

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

FIGURE 1/Q.1003 (Sheet 5 of 5)

Logic procedures in the MS for location updating

FIGURE 1/Q.1003 (Sheet 4 of 5)
Logic procedures in the MS for location updating

FIGURE 1/Q.1003 (Sheet 3 of 5)

Logic procedures in the MS for location updating

FIGURE 1/Q.1003 (Sheet 2 of 5)

Logic procedures in the MS for location updating

FIGURE 1/Q.1003 (Sheet 1 of 5)

Logic procedures in the MS for location updating

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.

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 shouldfollow 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.

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

ii) 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 udating 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.

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

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

In order to simplify the text the term mobile station (MS) as 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) refers to the card.

3.Procedures in the MS related to location registration

3.1Initiation 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.

3.2Periodic 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:

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

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).

Contents of Recommendation Q.1003

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Annex A - Organization of the subscriber data

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

2.1Location registration