Mobility management modeling with the use of an object-oriented approach

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Abstract - **The paper presents an object-oriented approach to modeling mobility management (MM) procedures in cellular networks. MM procedures are offered as services on Intelligent network (IN) platform. GSM mobility procedures incorporate common signaling blocks like authentication, new TMSI assignment, ciphering and database updating. Defining these blocks as Service Independent Building Blocks (SIBs) it is possible to offer MM services composed by an appropriate set of SIBs. Furthermore comparing MM procedures in GSM with those in GPRS and UMTS, it is possible to use almost the same SIBs in mobility services creation. Of course some of the SIBs defined for GSM have to be modified for GPRS and UMTS and some new ones have to be defined.**

Keywords – **Intelligent network services, SIBs, objects, mobility management**

I. Introduction

An intelligent network (IN) is "a communication network that is controlled by a software services layer enabling new services to be developed without the need to modify the network switching nodes".

ITU standardized IN in a continuous process and froze the standards at regular intervals, called capability sets (CSs). IN was initially designed for fixed voice telephony networks. CS-1 standard was powerful and simple, but it was disabled to meet the requirements for mobile communications. The mobile networks incorporate some kind of intelligence like mobility management and in-call mobility. In case of a mobile terminating call the network has to contact with the subscriber and therefore to keep track of where his telephone is at that time. During a call, it is possible that a subscriber will move out of reach of the antenna to which he or she is connected. The network must be able to reconnect the subscriber as quickly as possible to the closest available new antenna without breaking the call. So to lift some of the limitations of CS-1, CS-2 was defined. CS-2 allows user interactions to take place outside the context of a call. CS-2 allows call-related and call-unrelated interactions to use out-channel signaling connections. So new mobility management services (MM) can be offered on the IN platform.

IN recognizes the need for efficient creation of new services. It defines services as composition of features, which in turn are composed out of elementary building blocks, SIBs. There is commonality or a "red thread" in all the scenarios the mobile telephone is involved. Some individual blocks in signaling procedure are applied to all: mobile originating, mobile terminating and location updating. Defining these individual blocks as SIBs it is possible to offer MM services composed by an appropriate set of SIBs.

Furthermore comparing MM procedures in GSM with those in GPRS and UMTS, it is possible to use almost the same SIBs in mobility services creation. Of course some of the SIBs defined for GSM have to be modified for UMTS and some new ones have to be defined. The paper investigates the common parts in MM procedures in GSM, GPRS and UMTS and presents an object-oriented approach to defining SIBs that can be used in mobility services creation.

II. Service creation in a mobile IN network

Before presenting details on how IN mobility services can be defined, some signaling procedures for MM in GSM, GPRS and UMTS are considered in brief. In order to simplify the descriptions we will restrict the MM procedures to location area update (LAU) and routing area update (RAU). Nevertheless the identified steps are common for all: IMSI attach, LAU, RAU, mobile originating call and mobile terminating call.

In a possible architecture of an IN structured mobile network the MSC implements the service switching function (SSF) and the call-unrelated service function (CUSF); the HLR is integrated with the service data function (SDF) and in addition to mobile subscriber data it contains an information about IN services; the SCP resides the logic of the services and implements the service control function (SCF).

Let us assume that there is a signaling link between the mobile telephone (MT) and the radio access network. Before providing the required service the MSC requests authentication data. Receiving the necessary information the MSC starts authentication procedure. If authentication succeeds the MSC activates ciphering, which is followed by new TMSI assignment. The next step depends on the requested service.

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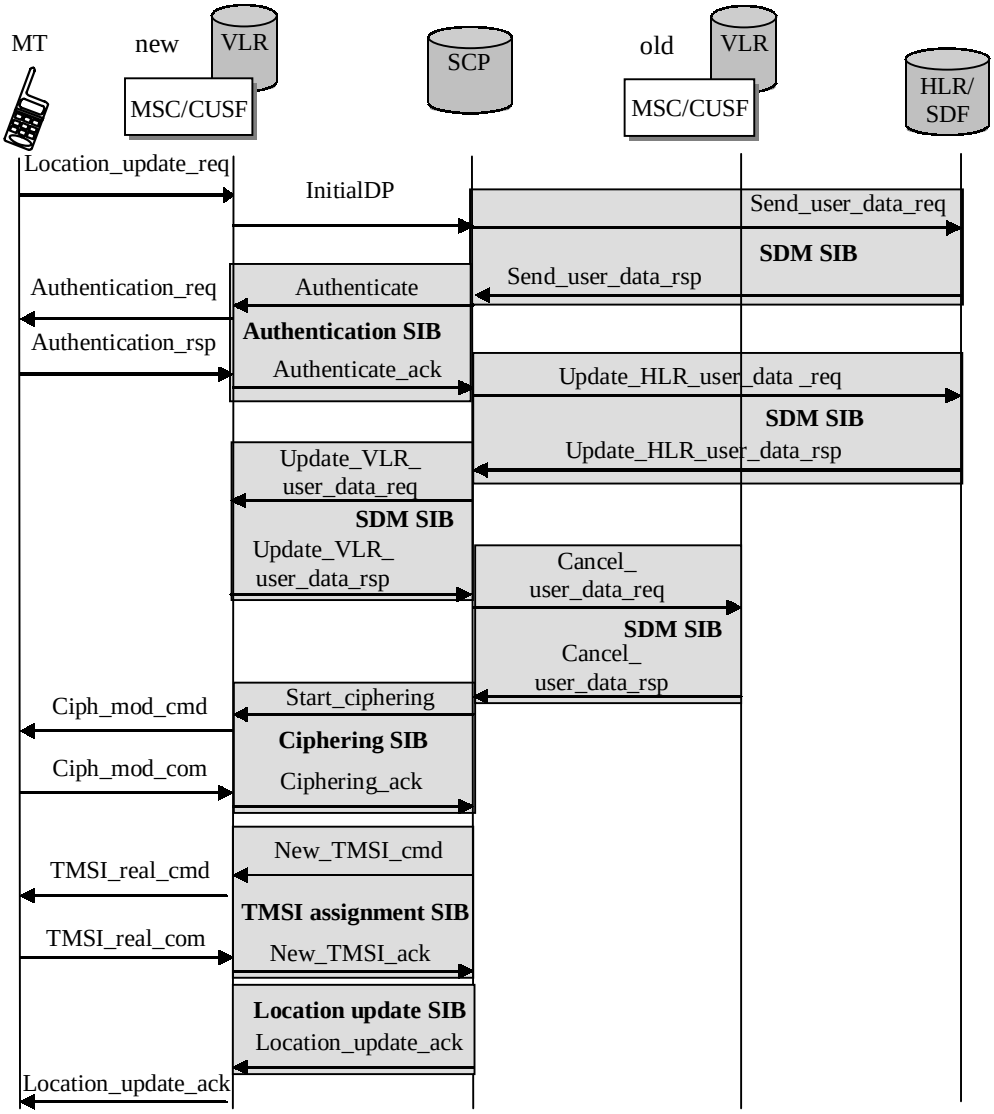

Figure 1 Inter-MSC LAU service with the use of SIBs

By modularizing the MM procedures in this way we can define SIBs corresponding to the identified common blocks. So, the following SIBs are necessary to offer GSM/GPRS/ UMTS mobility functionality:

- Authentication SIB – generates data required for authentication and checks the calculated value against the returned value.
- Ciphering SIB – instructs the radio access network to cipher a channel to the MT.
- TMSI assignment SIB – issues a new TMSI to the MT.
- Service data management SIB – used for creating, updating and deleting records on database. This SIB is defined in CS-1 and can be adapted for mobile subscriber data management.

In order to define service specific parts some more SIBs have to be defined.

- Location update SIB – if LAU procedure is successful, then the user is informed accordingly or else the SIB is used to process any errors that may have been occurred during the procedure.
- Mobile originating SIB – checks the compatibility service requested by the user with the subscription for the user. Instructs the MSC capture a radio channel to the MT and forwards instructions on call completion to SSF.
- Mobile terminating SIB – instructs the SSF to check compatibility of incoming call with the mobile terminal and capture a radio channel to the MT;
- Paging SIB – instructs radio access network to page a MT in a specified area.

Figure 1 illustrates the inter-MSC LAU provided as IN service using the defined SIBs.

The MT detects that coverage is provided by a new location area and initiates the location update procedure. It transmits a *Location_update_req* message. The MSC/CUSF treats the message as an IN service trigger and requests instructions from the SCP how to proceed. The SCP invokes LAU service and requests authentication data for the subscriber from the

HLR/SDF (SDM SIB). The HLR/SDF returns authentication data for the user. The SCP invokes Authentication SIB and instructs MSC to send the *Authentication_req* message to the MT. The MT returns the authentication result. If authentication succeeds the SCP invokes the SDM SIB to update user location data in the HLR. In order to create a new user record on the new VLR the MSC initiates the SDM SIB. The SDM SIB is also used to delete the user record on the old VLR. Ciphering is activated with the use of the Ciphering SIB. The SCP invokes the TMSI assignment SIB to issue new TMSI to the MT. The service ends with the Location update SIB to inform the MT that LAU update is accepted.

III. An object-oriented approach to SIB definition

The described services cover the main steps in LAU procedure in GSM, GPRS and UMTS as a whole. However the Authentication sub-procedure in UMTS is more complicated than that in GSM (not discussed here) and there are some differences in massage parameters for the three systems. The SIB functionality, which is common, can be defined as an object type. The specific message parameters require redefinition of the corresponding SIB.

The object type for the generic Inter-MSC LAU service is presented in Figure 2 using the object-oriented concepts in SDL[3]. The common SIBs are defined by virtual SDL services. To adapt this generic service to GSM or GPRS the virtual SDL services have to be redefined. Following the object orientation the identified SIBs can be used for example in combined RAU/LAU in case of intra-SGSN RA update or in case of inter-SGSN RA update.

Figure 3 shows the specialization of the generic Inter-MSC LAU service for the combined RA/LA update in case of intra-SGSN RA update. The service is triggered by SGSN/ CUSF when the *RA_update_req* message is received. The message parameters indicate if the location area is changed with the routing area updating. The redefined start makes some settings specific for the GPRS MM procedure. As in this scenario the SGSN is involved, the SDM virtual services which requests authentication data and the Authentication virtual service have to be redefined. A new SDM virtual service associated with the SDM SIB is defined to update user data in the SGSN. A new RA update SIB is identified. If the RAU procedure is successful then the user is informed accordingly or else the SIB is used to process any errors that may have been occurred during the procedure. The RA update SIB is presented by the RA_update virtual service.

To apply the defined object types to combined RAU/LAU in case of inter-SGSN routing area update procedure new SIBs have to be defined, for example:

- SGSN context SIB – provides MM and PDP contexts for the subscriber;
- Update PDP context SIB – updates the existing PDP contexts for the subscriber in GGSN.

As in the former cases some of the SIBs have to be redefined.

[3] Specification and description language

Following the same approach common parts in GSM IMSI attach procedure and in GPRS/IMSI attach procedure can be identified and the corresponding SIBs can be defined.

- Attach SIB - informs the user about the successful IMSI attach procedure otherwise the SIB is used to process an exception situation during the procedure;
- Delete PDP context SIB – deletes the PDP contexts. This SIB may be used also in detach procedures.

IV. Conclusion

By modularizing the GSM mobility procedures it is possible to identify commonality within the various procedures. These common parts are defined as SIBs. The SIBs can be combined to create IN mobility service. Furthermore following the resemblance between the mobility management procedures in GSM, GPRS and UMTS it is possible to redefine the generic SIBs and to define some new ones. An object-oriented approach is used to define SIBs for generic mobility services and to redefine the SIBs according to the specifics in GSM, GPRS and UMTS. As object-oriented programming has become the industrial standard and the envisaged architecture of the future telecommunication networks is IN structured this approach can provide an elegant way in defining mobility services for next generation networks.

Reference

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Virtual process type

<<block type LA_service>> Updating

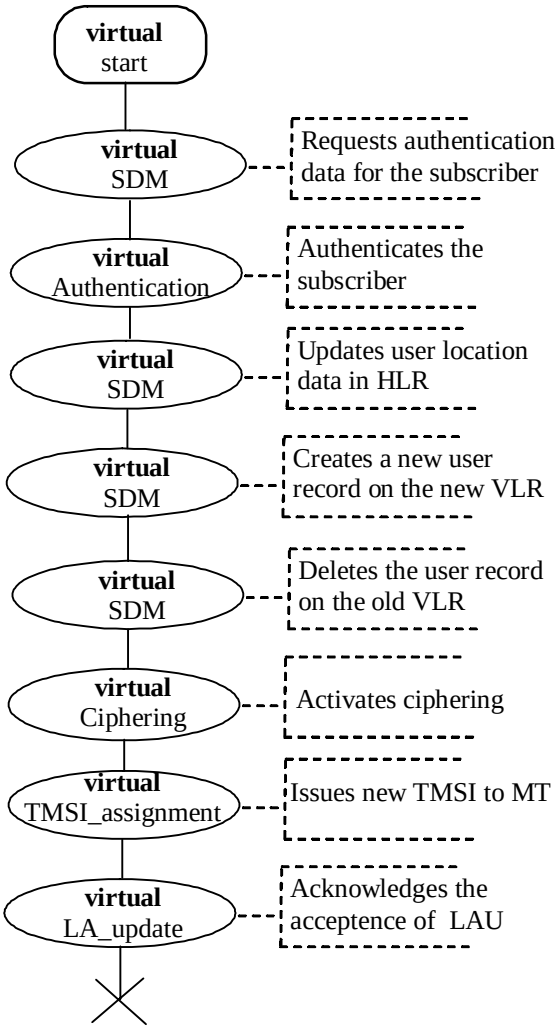

Figure 2 Generic inter_MSC Location update service, presented as SDL virtual process type

Redefined process type

<<block type RA_LA_service>> Updating inherits <<block type LA_service>> Updating adding

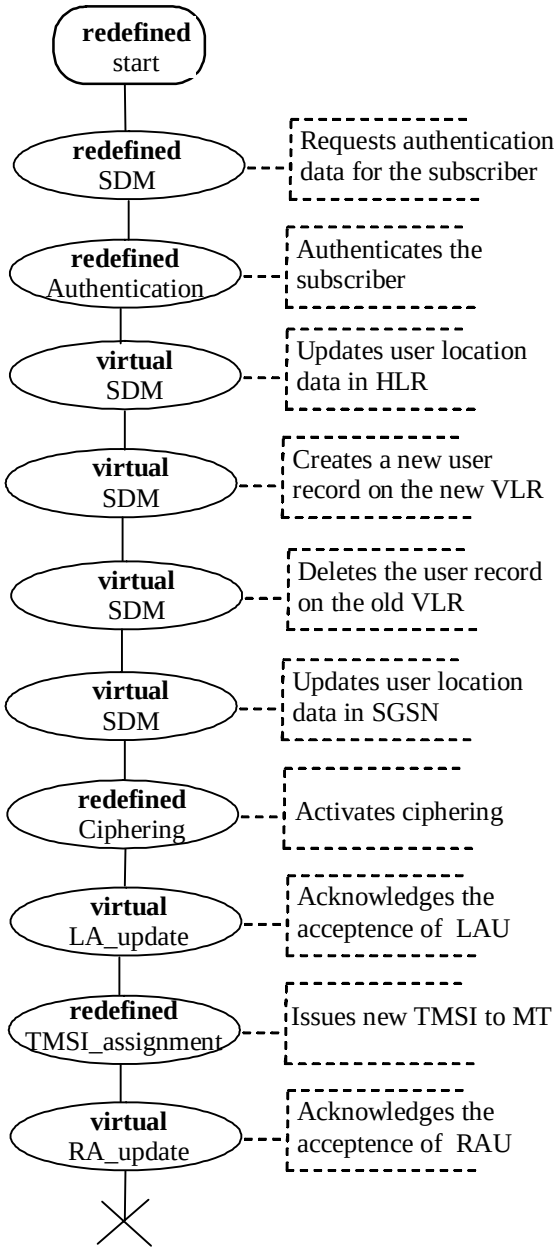

Figure 3 Specialised combined RA/LA update service in case of intra SGSN RA update prosedure, presented as SDL virtual process type