

# The Application of MAP in DECT-Systems

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## **Abstract**

In Europe two digital mobile systems, DECT (Digital Enhanced Cordless Telecommunications) and GSM (Global System for Mobile Communication), has been standardised. They serve different purposes. The GSM-System is developed for public use, but it is not able to carry sufficient traffic in hot spots like inner-cities or airports, because of its large cell structure.

DECT is able to carry higher traffic because of its smaller cells. It has been developed for private or telepoint use. Because of growing traffic in the public systems and for protection of investment, it will be necessary to combine both of the existing mobile systems in the future. The mobility management methods of GSM are fully standardised. In contrast, the DECT mobility management has been left open for developers to interpret. With focus on interworking units, it is obvious that the mechanism of the GSM mobility management could be adopted for use in DECT. This paper presents a possible way to integrate the mobility management of both systems.

For the exchange of mobility information between the switching system and the databases, GSM uses the mobile application part (MAP). The MAP is located within the application layer of the OSI-model; the transport system is the signalling system (SS) No.7.

The DECT-system is used in private or business environments where SS No. 7 is not available because of its high costs. In this situation it is possible to use the ISDN-D-channel or the X.25-network.

To combine DECT and GSM and to use only one dual database it is necessary to adopt different signalling systems. In addition, the databases of both mobile systems need a similar structure. This paper presents the structure of a DECT-database and the application of MAP in DECT-systems.

## **1 System Description**

Both DECT and GSM are briefly described in the following text to ease the understanding of the procedures necessary for coupling [1] them.

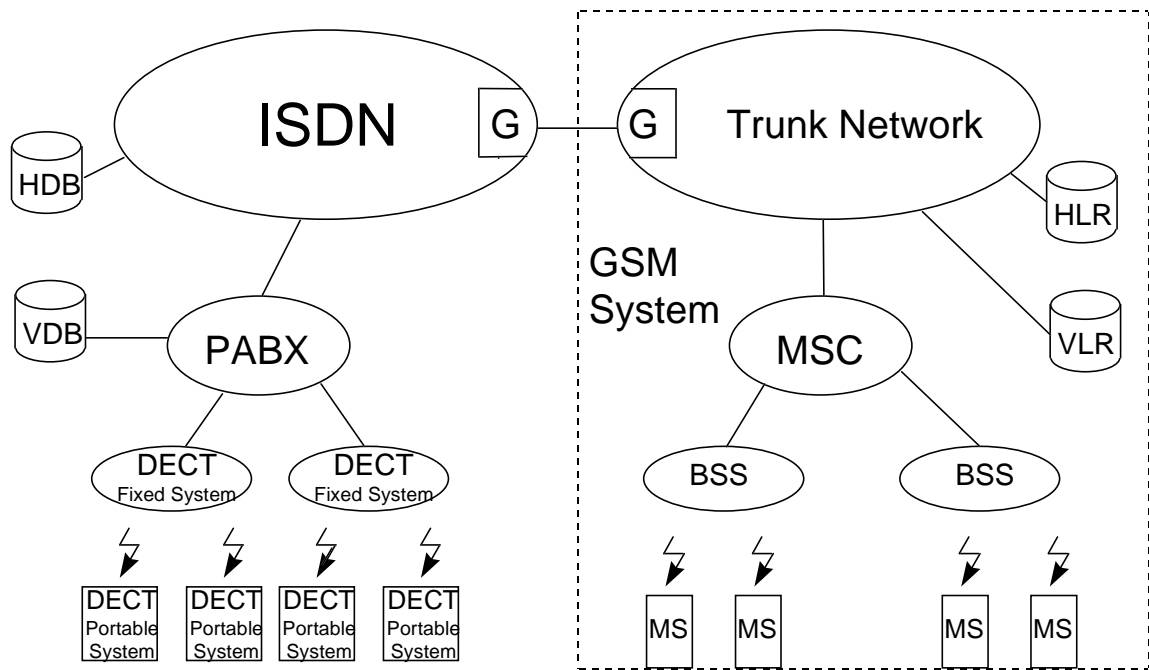


Figure 1: Interworking Concept

## 1.1 Interworking Concept

Figure 1 shows the basic configuration discussed in this paper. The two mobile systems are connected via gateways. The users need to be able to operate in both systems with dual-mode-handsets.

## 1.2 The GSM-System

Mobile systems in accordance with the GSM-Standard [2] can functionally be divided into two networks. These consist of the radio network with the customer access and the mobile switching network.

The radio network comprises the mobile stations (MS) and the base station subsystems (BSS). The radio networks task is to place the radio channels at the mobile stations disposal. The whole area of radio supply is divided into cells served from one base station transceiver. Because of the attenuation of the radio signal, the same carrier frequency can be reused in other cells having sufficient distance to the actual cell.

The mobile switching network connects the mobile switching centres (MSC) and interfaces to external networks such as the public switched telephone network (PSTN) or the integrated services digital network (ISDN). It includes an access network to connect the BSS and the MSC and a trunk network, connecting the MSCs with each other and with the gateways. The mobile-specific control functions are carried out by the MSC the BSS and special databases. The MSCs are ISDN-switching centres functionally expanded by procedures for mobility. Mobility functions serve to find the mobile station in case of mobile terminating calls. They determine the access to the databases and control functions supplying supplementary services.

### **1.3 The DECT-System**

The DECT-System [3] also falls into two parts, the radio network and the switching network. The only DECT-specific and standardised part of the DECT system is the radio network. The switching network is divided into the local network connected with the fixed parts and the global network connecting the local systems with each other and supplying gateways to other networks [4]. The mobile stations, called portable parts (PP), access the fixed parts and the local network via radio channels.

Local networks provide the switching functions for the DECT systems. Additionally they give the interworking functions between DECT networks and external global networks, being responsible for the necessary conversion of signalling. Possible realisations of local networks are analogue or digital private branch exchanges (PABX) or local networks on basis of the IEEE 802.x standards.

The global network connects local networks independent of their distance. It provides services for address translations, routing and data transfer. The global network usually covers international connections.

Possible global networks are the public switched telephone network, the ISDN or data networks such as X.25-networks or mobile communication networks, for instance the GSM network.

## **2 Databases**

### **2.1 DECT Databases**

The provision of mobility management functions in DECT systems with connection to public networks can be achieved using two databases [5]. The experience with the GSM concept suggests using home databases and visitor databases to provide the user mobility. The home database (HDB) is responsible for managing the quasi-static user data as in GSM, while the visitor database (VDB) stores the data dynamically in the case of user roaming and incoming calls [6].

The HDB contains data of two main types, the user information, such as billing records, service profile and subscriber data, and location information. The number of HDBs needs to be small to allow simpler maintenance of the database structure and routing of incoming calls. The security data are stored in the home database too, this strengthens the requirement of minimising the number of HDBs. Some disadvantages of minimising the number of HDBs are the increasing signalling traffic arising with centralising the databases and the problems caused by database failure and data loss. Both points of view are need considering carefully and chosen for each configuration to determine the most effective solution. In general there are two possibilities for locating the HDB. The first location is the local network with the associated problem of decentralising the data and the limited accessibility for network units of external networks. The second possibility is to place the HDB within the global network. The advantage here is the lower cost of maintenance, but at the same time the signalling traffic increases because of longer distances and possible additional protocol conversions. The effect is rising response times.

The VDB stores some of the data contained in the HDB to reduce the signalling traffic in the case of a moving subscriber. The data are transferred from the HDB to the VDB in the course of the registration procedure. Before this procedure there are no user data in the VDB. The user data are added dynamically to the database. The VDB supports the HDB in the case

Comparison	DECT	GSM
Directly Comparable	International Portable User Identity (IPUI) Temporary Portable User Identity (TPUI) International Portable Part Equipment Identity (IPEI) ISDN-Number  Portable Part Roaming Number (PPRN) Location Area Level (LAL) Security Keys	International Mobile Subscriber Identity (IMSI) Temporary Mobile Subscriber Identity (TMSI) International Mobile Equipment Identity (IMEI) Mobile Subscriber ISDN-Number (MSISDN) MS Roaming Number (MSRN)  Location Area Identity (LAI) Security Keys
Indirectly Comparable	Basic Services	Basic Services
Non Comparable	Portable Access Right Keys (PARK) Access Right Identities (ARI) Radio Fixed Part Number	No equivalents

**Table 1: Comparison of the Identities**

of a mobile terminating call by paging the mobile station. For purpose of protection of the radio transmission and for optimising the radio capacity, the VDB generates and manages a temporary identity called the temporary portable user identity. In general, one VDB supports more than one fixed part, reducing the number of maintained databases. The size of the VDB and the number of managed FPs depends on the average number of users in the assigned locations.

Besides the two databases mentioned, there is another smaller database called the fixed part database (FPDB). This additional database stores broadcast information such as radio fixed part identity and location area level (LAL). The data are general FP data only, and are not used for subscriber identification. For this reason the FPDB is static.

## 2.2 Database Contents

Both the mobile networks described use different parameters, so called identities, which are used for management and control of the mobile communications. In Table 1 the most important identities are listed in three groups. The parameters can be grouped into three categories: directly comparable, indirectly comparable and non comparable.

The user identities are used to identify the customer unambiguously. They serve to realise the user mobility. The roaming numbers and the location area level serve to find the subscriber at the current location. Security keys are used to authenticate the subscriber and to cipher the data. The service parameters permit the access to the subscribed services. In the DECT system, the access rights of a portable part are determined with the access rights keys and identities.

## 2.3 Signalling Protocols

The DECT standard defines only the radio interface. The connection to external networks and databases is provided by interworking units (IWUs). The IWUs are responsible for the necessary protocol conversions. Some IWUs have been standardised, e. g. GSM and ISDN

IWU. The standardised GSM IWU relates to the direct coupling of the GSM A-interface and a DECT fixed part. In this case, the DECT handsets are public without the possibility to make calls in private or business environments free of charge. This case is not discussed in this paper.

While developing the DECT standard, it was the intention to reach a maximum of flexibility. For this reason all the protocol conversion and interworking tasks are assigned to the interworking units. It is left to the developer to decide in what way the functions are implemented and how the necessary signalling is realised. DECT offers extensive features and an abundance of supplementary services with the necessity of large signalling procedures.

The signalling variants that can be considered are the following:

1. DECT individual signalling
2. DSS1+ (digital signalling system No. 1 plus, containing mobility functions)
3. MAP (mobile application part)

The first variant is possible where several DECT systems are interconnecting with each other. It is possible to use a protocol that supports all the DECT functions. Problems arise from connecting DECT systems with external networks e. g. the GSM system. The signalling system of the external system is not able to use all the DECT features and database access across the mobile systems is not possible. The individual solution makes it more difficult to connect different systems. It is better to use signalling standards. The following two variants are oriented towards international signalling standards.

The second possibility is to use the DSS1+ signalling system. This protocol is used to connect private automatic branch exchanges (PABX) with public switching centres [7]. The public switch takes on the mobility related functions completely. The DSS1+ protocol providing the mobility functions is currently in the standardisation phase.

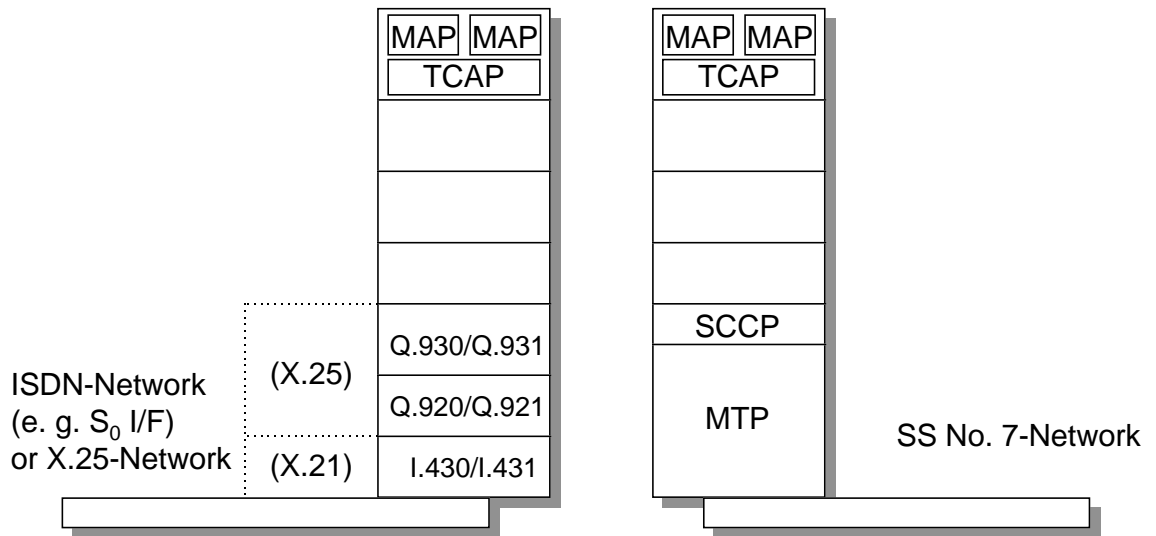
The third variant makes use of the signalling system number seven (SS No. 7), it is called the mobile application part (MAP) [8]. This protocol has been developed to handle the mobility related procedures and takes the signalling exchange with the databases into consideration. MAP represents the most flexible of the proposed alternatives and it is well tested in the GSM system. The advantages in using this protocol are the easy interworking with the GSM MAP, the existing implementations of MAP, this reduces development costs and the time to achieve standardisation. In the next chapter, the mobile application part is described to show that it is applicable to the DECT system and interworking between DECT and GSM.

### **3 The Mobile Application Part**

#### **3.1 MAP Services**

MAP provides intelligent network functions for mobile communication networks [9]. It consists mainly of functions to establish and release communication connections between two MAP peer entities, including functions to access the lower OSI layers

Manufacturer independent interfaces are defined to control the system functions, such as establishment and release of user data connections, control of supplementary services and access to centralised databases. The signalling in the SS No. 7 is handled in non associated signalling channels, which are used from several user connections. The channels are called central signalling channels, building a completely independent signalling network consisting of fixed connections between the switches and the signalling points.



**Figure 2: Transport Services for the MAP**

This approach leads to a structure of the mobile network which is similar to the intelligent network (IN) structure. This is a prerequisite to integrate the mobile network into the ISDN in the future [10][11].

The MAP uses TCAP (Transaction Capabilities Application Part) connections to transfer its control information. It provides elementary operations for mobile specific control procedures. The operations are divided into several groups. Each group contains its own MAP application entity. The groups are functionally distinguished according to their interface relation such as MSC-HLR or HLR-VLR interface.

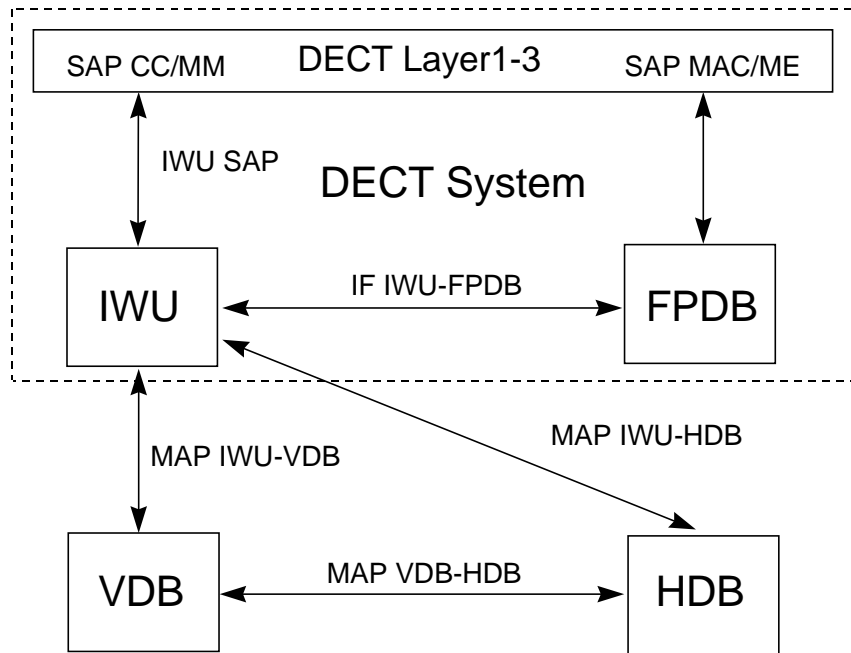
The TCAP provides user service elements for so called remote operations, they are necessary to access centralised databases. The transaction capabilities (TC) are defined as a general service for the end-to-end transfer of messages between two end systems. The application service elements are independent of the sort of information to transfer. TCAP uses the connectionless transfer service of the signal connection control part (SCCP) to handle a communication connection.

The message transfer part (MTP) serves as the transport protocol for all the higher layer protocols of the intelligent network concept. The overlying SCCP provides the possibility to transfer messages over logical signalling connections or connectionless between all nodes of the SS No. 7 network. The MTP and the SCCP supply the switching and transport service that functionally corresponds to the OSI layers 1-3.

### 3.2 Transport Services

The TCAP is standardised with the use of SS No. 7 as described, but the SS No. 7 is not available in all possible DECT local networks, especially in small PABXs. To enable the communication between databases and all involved entities, it is necessary to define additional transport protocols used by TCAP(Figure 2)..

Private or small PABXs are usually able to exchange signalling information in the ISDN D channel. Sometimes there is an X.25 connection. X.25 is used in the area of network management to transfer the information to the network elements and in public networks to transfer packet data. Both possibilities are to be taken into consideration for providing the signalling to non SS No. 7 systems. A database which fits all demands supplies connections to different signalling systems.



**Figure 3: Structure of the DECT System**

On the HDB level it is necessary to install SS no. 7, ISDN D channel signalling and connection to the X.25 network. This enables the communication with PABXs without SS no. 7 connection and with GSM-MSCs or other external networks using the signalling system number 7.

## 4 Simulation of the System

### 4.1 Specification with SDL

The realisation of the system discussed above has been done with the help of the specification and description language (SDL). Figure 3 shows the system structure of the developed database simulation. It consists of four blocks which communicate with the DECT layer 3. The DECT layer 3 is implemented as an SDL specification for testing the system. The interface to the standardised part of the DECT system includes two service access points (SAP). The SAP to the call control and mobility management functions (SAP CC/MM) connects the MAP-DECT IWU with the network layer of the DECT system, while the SAP to the media access control management entity (SAP MAC ME) provides the connection with the media access control layer (MAC). The block IWU provides the conversion function of the DECT messages into the MAP messages and vice versa. The interworking function is able to communicate with all the involved databases receiving the DECT messages and generating the corresponding MAP message.

It is not possible to adopt the signalling between FPDB and IWU from the MAP protocol. For this reason the chosen solution is a non standardised protocol which is only used between the MAC layer and the FPDB. The FPDB as mentioned contains DECT specific information which is used internally. The simulated FPDB includes access rights identifiers, number of the radio fixed part, the FP capabilities, multi frame number, the number of the location area and the numbers of the VDB and HDB the FP belongs to. The implemented message requests the data from the FPDB at system startup time and is sent from

<u>DECT message CC SETUP</u> Called Party Number	<u>MAP message MAP_SEND_ROUTING_INFO</u> <b>Request:</b> Invoke ID (MAP-connection identity) MSISDN (taken from CC_SETUP) <b>Response:</b> IPUI Temporary Number (PPRN)
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**Table 2: Content of Corresponding DECT and MAP Messages**

the IWU-Control process.

The communication between the IWU and the VDB is adopted from the MAP. The information flow serves to forward messages to the mobile subscribers HDB and to manage the local procedures. Local tasks are for example the attaching and detaching of the portable parts and the management of the temporary identity.

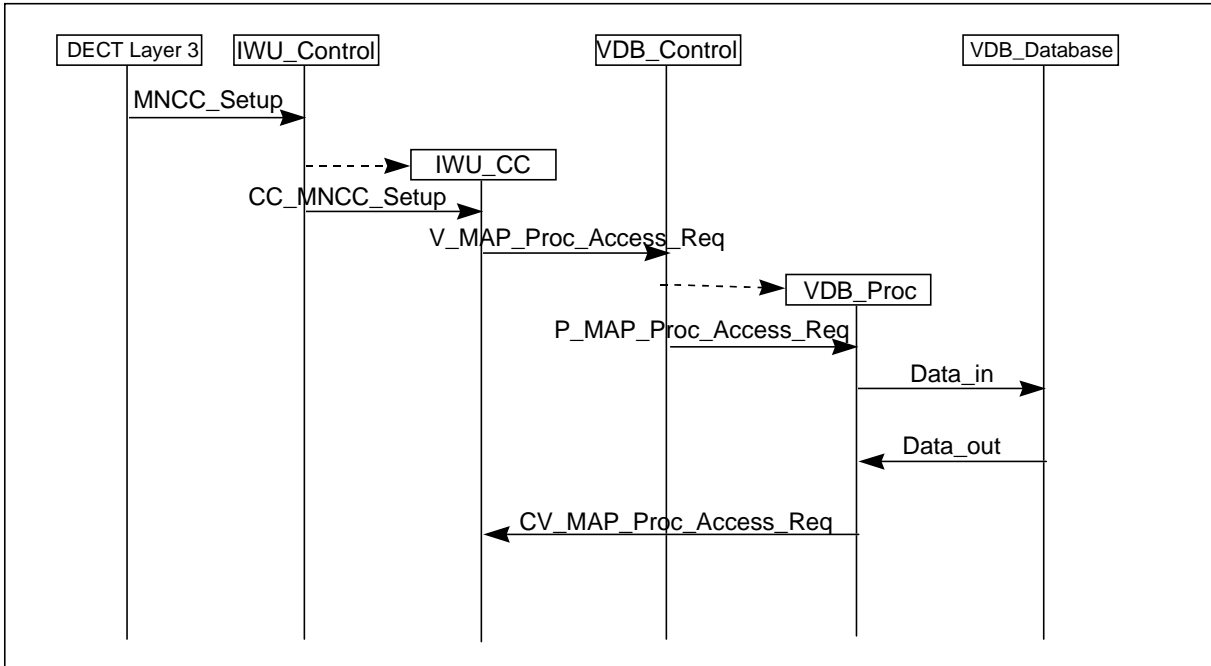
The protocol elements used for the communication between the VDB and the HDB are adopted from the MAP standard. The implemented messages serve to get user data such as authentication and actual location data. For example, the message MAP\_AUTHENTICATION\_INFO requests one authentication vector from the HDB. In the case of precalculated sets, the authentication vector consists of the expected result (RES) and two random variables (RAND, RS).

When an incoming call originates in the external network, the HDB provides the routing information. The routing information is called the portable part roaming number, in this paper. This number has the format of a standard ISDN number (ITU-T E.164) consisting of the ISDN number of the visited PABX and a temporary number to address the portable part in the PABX. Each PABX owns a visitor database to organise the temporary numbers and to page the portable part. Once a connection is in the establishment process, it is necessary to assign an unambiguous number to sort and manage the incoming and outgoing messages. The DECT standard assigns a number, called the endpoint identifier, to the primitives. This number can be used to identify a connection and to route the messages. For each connection several dynamic processes are created, this fact shows the necessity for separating the individual connections. Messages used to establish mobile terminating calls are to be marked with the unambiguous number before processing in the databases. For the internal signalling it is necessary to mark all primitives of the call control unit and the mobility management unit belonging to one connection with the same endpoint identifier.

The function of the IWU consists mainly of converting the messages between DECT and MAP. The expression „converting“ may be confusing in this context, because there is no direct conversion. The IWU generates the MAP message to get the information that is necessary to continue with the DECT procedures and vice versa. The processing of the messages is shown in the following example.

When a call originates from a DECT subscriber, a CC-SETUP (Table 2) message is sent from the portable part to the fixed part. The fixed part sends the message to the IWU. The





**Figure 4: message sequence chart**

IWU converts the message into the corresponding MAP message or messages. In this case a MAP\_SEND\_ROUTING\_INFO.request message which contains the called party address is generated and sent to the HDB. The HDB responds with a MAP\_SEND\_ROUTING\_INFO.request message containing the current ISDN number of the called party. This temporary number is called the portable part roaming number (PPRN). The IWU generates a CC-SETUP message with the response which contains the PPRN instead of the initial called party address and sends it to the network layer of the FP. The DECT network layer proceeds with the connection establishment process. The conversion function is processed similarly in all necessary cases.

## 4.2 Simulation with Message Sequence Charts

One test method for systems specified in SDL is the use of message sequence charts (MSC). MSCs are diagrams with process instances and the signal flow between them. One MSC of the simulated system is shown in Figure 4. The MSC is automatically generated at the time of simulating the system using an SDL development tool.

The example shows an incoming MNCC-SETUP message from the DECT layer 3. This is the case of a mobile originated call setup. The receiver of this message is the IWU control process. The IWU control creates an IWU\_CC process instance which is initiated for each active connection. The creation process is necessary to handle the messages belonging to one connection. The IWU control forwards the MNCC setup message to the new IWU\_CC process. The IWU\_CC process generates the corresponding MAP message, in this case the MAP\_PROCESS\_ACCESS\_REQUEST. This message is sent to the VDB\_Control to get the access confirmation for the portable part. The VDB\_Control process creates a new instance which requests the necessary data from the VDB. Finally, the VDB process returns the data to the IWU\_CC process.

## 5 Conclusions

DECT will be used extensively in private or business environments because of its lower costs and higher subscriber density in comparison to public land mobile networks (PLMN). The area of the databases is excluded from the DECT standardisation. There are only a few points in the standards mentioning the databases. For this reason exist different realisations with different features. All implementations are proprietary and the connection of different systems from different manufactures is not possible at the moment. In future, it will be necessary to develop a standard covering this area. This paper shows the suitability of mobile application part (MAP) for the purpose of DECT mobility and the interworking between different systems such as GSM and in future the ISDN with mobility functions. MAP is well tested and approved in the GSM system. This reason suggests the use of MAP to provide a global network-wide mobility in DECT and GSM systems.

A prototype realisation of the described database concept has been developed. The implementation uses the specification and description language SDL. For simulation, an SDL development tool was used. This enables the testing of the specified system. The implementation was limited to the most important messages because of the large scope of the MAP standard. All necessary DECT database elements such as handover, roaming and billing data elements are taken into account.

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