SIEMENS

Information

System

System Description D900/D1800

A30808-X3231-X45-1-7618

Important Notice on Product Safety

Elevated voltages are inevitably present at specific points in this electrical equipment. Some of the parts can also have elevated operating temperatures.

Non-observance of these conditions and the safety instructions can result in personal injury or in property damage.

Therefore only trained and qualified personnel may install and maintain the system.

The system complies with the standard EN 60950. All equipment connected has to comply with the applicable safety standards.

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Technical modifications possible.
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1 Introduction

A growing number of customers of the telecommunication administrations and operators would like to have modern communication facilities at their disposal wherever and whenever they need them. In order to meet this demand on an international scale, the European Telecommunication Standards Institute (ETSI) has specified the GSM (Global System for Mobile Communication).

1.1 GSM900/GSM1800 PLMN for GSM900/GSM1800 Mobile Subscribers

GSM900/GSM1800 defines a standard for a public land mobile network (PLMN). The GSM900 primary band will be operated in the 900 MHz frequency range (890-915 MHz uplink or 935-960 MHz downlink) and the GSM900 extension band G1 in the frequency range (880-915 MHz uplink or 925-960 MHz downlink). The GSM1800 will be operated in the 1800 MHz frequency range (1710-1785 MHz uplink or 1805-1880 MHz downlink).

The GSM900/GSM1800 standard is the first international standard which allows the mobile subscriber full access to the networks of the different PLMN operators in all the countries that have chosen the GSM900/GSM1800 as standard. The GSM900/GSM1800 standard represents a second generation mobile communication system.

Phase 1 of this GSM900/GSM1800 standard was finalized by ETSI in 1990. The second stage (**Phase 2**) was approved in 1995 and the appropriate features will be introduced into the networks from 1996 onwards. An extension of the second step (**Phase 2+**) meets the needs which have also arisen from practical operation since the introduction of the GSM900/GSM1800 standard.
Phase 1 comprised basic PLMN functions plus telecommunications services and full-rate channel calls. Phase 2 contains supplementary telecommunications services (such as conference calls, etc.) and support of half-rate channel calls. Phase 2+ involves new services and technical precautions for new applications based on the GSM900/GSM1800 standard. Examples of such include: Call completion to busy subscriber (CCBS), call transfer (CT), handover at extremely high speeds, access to DECT networks, to satellite networks and to IN/CAMEL services, etc.

Siemens' digital cellular mobile communication system D900/D1800 implements the GSM900/GSM1800 standard to Phase 1 and Phase 2/2+ for a PLMN and uses the very latest technologies in order to meet all the requirements of this international communication system. D900/D1800 is the first system to exploit the potential for innovation made possible by digital voice transmission for cellular telephones. In addition to the enhanced connection quality, a number of other improvements has been made, such as efficient utilization of the frequency spectrum.

The advantages of D900/D1800:

Spectrum efficiency

The radio-frequency channel spacing, i.e. the width of the frequency band allocated to one radio-frequency channel should be wide enough to ensure good voice transmission quality, yet simultaneously narrow enough to permit good spectrum efficiency. Time-division multiple access operation, i.e. utilizing a radio-frequency channel by more than one traffic or control channel, is an excellent means of expanding spectrum efficiency.

Efficient utilization of the radio-frequency channels is achieved by splitting a carrier into time slots, which are used as the physical channel for various types of logical channels.

Cost-effectiveness

In analog systems a separate transmitter and receiver are needed for each connection. In contrast, a D900/D1800 base station system with one transmitter and one receiver can carry up to eight traffic channels simultaneously. This is due to the application of the time division multiple access (TDMA) principle.

As a consequence, equipment costs, space requirements and energy consumption are all considerably reduced. In addition, a series of further technical features add to the high cost-effectiveness of the D900/D1800, such as digital voice transmission, highest spectrum efficiency for the maximum number of subscribers, maximum use of the trunks between mobile-services switching center (MSC) and base station system (BSS), and extensive central and local operation possibilities.

Improved transmission quality for voice and data

The transmission quality of the D900/D1800 is better than that of any other cellular system. This is due to the method of transmission developed and optimized specially for D900/D1800.

For voice transmission, the analog electrical voice signal generated by the microphone is converted in a specific voice coding process in the case of full-rate or enhanced full-rate channels into a 13 kbit/s bit stream (supplemented with 3 kbit/s associated signaling to form a 16 kbit/s traffic signal) and then transmitted digitally over radio at a rate of 22.8 kbit/s.

This increased radio transmission rate results from additional protection procedures that increase immunity to radio-frequency interference. The connection quality is thus to a great extent independent of the radio link quality.

Furthermore the D900/D1800 supports a half-rate channel operation or a dual-rate/triple-mode operation with parallel full-rate/enhanced full-rate and half-rate channels.

For half-rate channels, half the data rate is correspondingly obtained for voice transmission, i.e. a 6.5 kbit/s bit-stream after voice conversion, or 11.4 kbit/s as the radio transmission rate. The sub-multiplex traffic signal remains unchanged, as for the16-kbit/s full-rate channels.

For data transmission (asynchronous, circuit-oriented or packet-oriented) the digital data signal is fed via a special interworking function (IWF). The IWF performs functions such as rate matching, modem and codec, to permit matching to the network conditions of the communication partner in the stationary network.

Protection against interception by means of ciphering

Because of the use of digital voice transmission it is possible for the first time with the D900/D1800 to cipher all messages in such a way that even experts are not capable of intercepting the calls. This is done by an ciphering process similar to those which, up to now, have been used exclusively for military purposes.

Protection against unauthorized network access by authentication

A special network access check ensures that only authorized mobile users obtain access to the GSM900/GSM1800 network. This is achieved by comparing the authentication parameters of the mobile user side and of the network side in the D900/D1800.

New GSM900/GSM1800 basic telecommunication services

The system D900/D1800 was optimized principally with its most common application, GSM900/GSM1800 teleservice telephony, in mind. But access to non-voice services was also taken into consideration at the beginning of the design stage, in contrast to conventional systems. The GSM900/GSM1800 mobile subscriber has at his disposal for a connection many bearer services and teleservices, such as data transmission services via PSTN/ISDN (asynchronous, circuit-switched) or via PSDN (packet-oriented) as well as fax and short message service, including short message cell broadcast.

New GSM900/GSM1800 supplementary services

The D900/D1800 offers the mobile subscriber numerous GSM900/GSM1800 supplementary services, all of which are usable on the teleservice telephony and partly also on the other basic telecommunication services. Examples of supplementary services in accordance with the GSM900/GSM1800 standard are call forwarding, call restriction services, advice of charge, calling line identification presentation, closed user groups, call transfer or call completion to busy subscriber. In addition to the GSM900/GSM1800 supplementary services it is also possible to implement on a project-specific basis also non-GSM900/GSM1800 supplementary services in a national PLMN.

High system availability and cost-effectiveness in operation

D900/D1800 has a very high system availability due to the duplication of all important functional units and to additional safeguarding functions in hardware and software. In addition, decentralized supervision in the functional units reduces repair times by locating faults precisely.

To a large extent, operation and maintenance are carried out from central operation and maintenance centers (O&M centers) by remote control. Of course, on-site operation and maintenance is also possible via local or mobile O&M terminals. D900/D1800 can in most areas be adapted to the operating company's own operation and maintenance concepts.

The mobile station, your constant companion

The mobile stations of cellular systems are becoming smaller and smaller. On the one hand this is a result of technological progress, especially in the field of large-scale integration, and on the other hand the result of the subscriber's desire to be able to telephone everywhere using a handy device not larger than a pocket calculator.

D900/D1800 fulfils these requirements. Smaller handsets are possible for the simple reason that the transmit/receive control still required by analog systems is not necessary here. A further great improvement has been made with the specific energy-saving technology of the D900/D1800 system.

In order to be always ready to receive a call, the mobile stations must scan the signaling transmitted by the base station systems at all times, also without connection operation. With the D900/D1800, calls to the mobile stations are transmitted at certain times controlled by clock pulses. This means that the mobile stations only need to switch on their receivers at these times, thus requiring only a fraction of the battery power. The handsets can therefore manage with smaller and lighter batteries. Furthermore, they can operate for longer without a change of battery or recharging.

Use of frequency hopping and antenna diversity provides greater range at lower transmission power and improves transmission quality.

Total mobility with the ID chip card

All GSM900/GSM1800 mobile subscribers are issued with an ID chip card (SIM, subscriber identity module) for their mobile stations which offers absolute protection against misuse. With this ID chip card, which has the same format as a credit card, the GSM900/GSM1800 mobile subscribers can use mobile stations (or the portable phone) e.g. in a rented car as if it were their own: calls are directed to the mobile station in which the GSM900/GSM1800 mobile subscribers have checked in their ID chip card. The call charges are billed to the card owner. Even the personal telephone number index for abbreviated dialing can be stored on the ID chip card and used at other mobile stations.

Product maintenance

Teams of highly qualified developers, equipped with the latest development tools, continue to provide product maintenance. Research groups ensure that innovation possibilities of advantage to technology and application are recognized at an early stage and implemented at the right time. Numerous proven methods of quality assurance guarantee high quality.

Product support for the customer

For the lifetime of the system, D900/D1800 is accompanied by extensive product support. Among others, the following features are offered: documentation, training, network planning, installation planning, assembly, a range of spare parts, repair services, the implementation of new features, handling of turnkey projects. If required, Siemens can therefore relieve the operating company of a large number of tasks.

1.2 Combined Switching Center (CSC)

In addition to implementing a GSM900/GSM1800-PLMN for classical GSM900/GSM1800 mobile subscribers the D900/D1800 allows for provision of conventional non-GSM900/GSM1800 mobile subscribers within a PLMN. Access and administration is handled by what is known as a combined switching center (CSC), which is integrated into the PLMN instead of a mobile switching center (MSC) for example.

In a CSC following types of subscribers can be administered and connected:

- GSM900/GSM1800 subscribers following the GSM900/GSM1800 standard
  - GSM900/GSM1800 mobile subscribers
  - GSM900/GSM1800-RITL subscribers (radio-in-the-loop subscribers, which are supported via the GSM900/GSM1800 radio interface too)
- fixed network subscribers
  - ISDN/analog subscribers, either as main station or basic access or via private automatic branch exchanges (PABX),

Both GSM900/GSM1800-RITL subscribers and ISDN/analog subscribers at the CSC are administered with respect to their directory numbers as subscribers of the local network area belonging to the CSC - similar to the subscribers of a stand-alone local exchange (LE).
The fixed network subscribers of the CSC (ISDN/analog subscribers) are connected by wireline to the CSC.

In the following sections of the System Description, the GSM900/GSM1800 notation is reduced to the abbreviated GSM notation, whereby all the statements about GSM900 also apply in GSM1800 PLMN. This gives rise to the following equivalents, for example:

GSM900/GSM1800 subscriber = GSM subscriber
GSM900/GSM1800 mobile subscriber = GSM mobile subscriber
GSM900/GSM1800-RITL subscriber = GSM-RITL subscriber
GSM900/GSM1800 radio interface = GSM radio interface
GSM900/GSM1800 mobile station = GSM mobile station
GSM900/GSM1800 standard = GSM standard
GSM900/GSM1800 PLMN = GSM PLMN

1.3 IN/CAMEL Functions in the PLMN and CSC

All GSM mobile subscribers of a PLMN can be provided with Intelligent Network (IN) services or Customized Application for Mobile network Enhanced Logic (CAMEL) services.

The fixed network subscribers and GSM-RITL subscriber of a CSC can be provided with Intelligent Network (IN) services.

1.4 Mobile Internet Access (MIA)

Incredible growth of the Internet and a concurrent growth in demand for cellular telecommunications services has led to increased market demand for mobile access to the Internet. Current technical limitations require that mobile Internet access (MIA) be routed over PSTN/ISDN, resulting in lengthy and costly communications access requirements for mobile access to the Internet.

PLMN operators should be able to offer their mobile customers direct mobile internet access to reduce the required access time to data services and limit their reliance on PSTN, thereby enhancing the usage of mobile data communication to the Internet. While increasing airtime usage operators can tap into a new source of revenue by themselves becoming mobile Internet service providers (ISP). The PLMN operator can thereby leverage the huge resources of Internet protocol (IP) based applications, by differentiating himself from other competitors.

This section describes the Siemens mobile Internet strategy. Siemens plans to offer an evolutionary approach to mobile Internet access (MIA):

1. Step 1: Stand alone solution (realized in the current software version)
   The PLMN operator will be offered an Internet protocol (IP) based value added service (VAS) platform, necessary to become an internet service provider. The platform is based on Siemens tested third party (OEM) products, but in accordance with the Siemens internet strategy. Thus the costly routing through the PSTN to access the Internet is obsoleted for the PLMN operator as he is now able to directly access the Internet.
2. Step 2: Integration and voice over Internet protocol (VoIP)
   Functionality's of the VAS platform will be integrated by Siemens into the PLMN , additionally in accordance with the Siemens Internet strategy new services like VoIP will be offered.

3. Step 3: Introduction of high speed circuit switched data (HSCSD)service and General packet radio (GPRS) service
   New data services will be introduced by Siemens to address higher bandwidth, connectionless communication, flexibility of radio resource usage and circuit and packet switched transmission topics. These services will leverage the advantages of the solution realized in the step 1 and 2. However they can be introduced without the two previous mobile Internet access steps. HSCSD will achieve data rates of 28.8 kbit/s and GPRS will achieve data rates of 100 kbit/s.

In the future (approximately in the year 2002) the MIA Step 3 flows into the 3rd mobile generation standard Universal mobile telecommunications system (UMTS). Within UMTS the data rates generally will achieve 2 Mbit/s for stationary and 384 kbit/s for moving applications.

2 Network Survey

As shown in the previous Section 1, the D900/D1800 system concept offers the components:

- GSM PLMN (cellular mobile radio system), for "connecting" GSM mobile subscribers
- CSC (combined switching center), for the connection of GSM subscribers (GSM mobile subscribers and GSM-RITL subscribers) and fixed network subscribers (wirelined ISDN/analog subscribers)
- IN/CAMEL network functions in the GSM PLMN and CSC
  (for GSM subscribers and for fixed network subscribers in the GSM PLMN or in the CSC)
- Mobile Internet access (MIA) functions

Sections 2.1 through 2.3 deal exclusively with the GSM PLMN, whereas Section 2.4 explains the CSC and Section 2.5 explains the IN/CAMEL functionality and Section 2.6 explains the MIA functionality.

2.1 GSM PLMN Service Areas

D900/D1800 is a cellular radio system. The whole public land mobile network (PLMN) area is covered by a great number of radio cells, as is usual with mobile radio systems (Fig. 2.1).

A **cell** (radio cell) is the smallest service area where particular radio channel equipment is used for a connection and the telecommunication services are supplied by a base transceiver station (BTS). Within the radio cell service area a defined quality of reception is provided.

One or more radio cells form a **location area**. A location area is a service area in which a GSM mobile subscriber may move freely without updating a location (or visitor) register. The size of a location area is determined by the operator to meet the demands imposed by traffic density and flow, population density and GSM mobile subscriber mobility.

One or more location areas form a service area of a mobile services switching center/visitor location register (MSC/VLR area). The **MSC/VLR service area** is that part of the PLMN supported by the MSC/VLR and can embrace any area from an urban district to an entire country.

One or more MSC/VLR service areas form the **PLMN area**. This is the geographical area inside which an operator provides telecommunications services. Several areas may geographically overlap.

A **PLMN country** may consist of one or more PLMN areas. A **GSM system area** comprises one or more PLMN countries.

A 'service area' is defined as an area in which a GSM mobile subscriber can be reached by another subscriber without the subscriber's knowledge of the actual location of the GSM mobile subscriber within the area. The location registration system associated with each service area must thus contain a list of all GSM mobile subscribers located within that service area.

D900/D1800 is a system that serves ”mobile” user stations. A mobile station can be carried practically anywhere by the mobile user, for example in the car or as a pocket portable. The D900/D1800 detects when a mobile station crosses the border between two radio cells during a call and ensures handover of the call from one radio cell to the next.

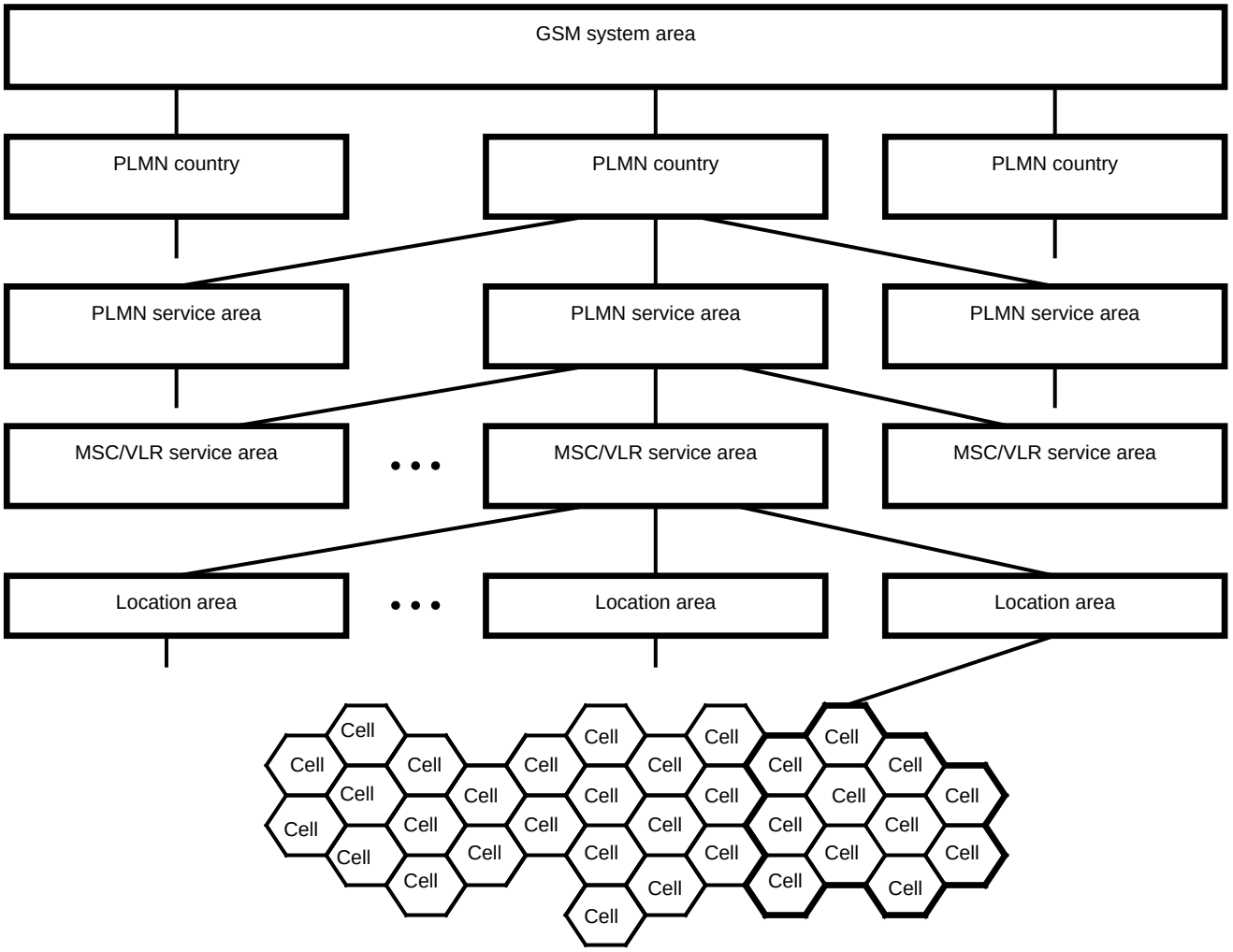


Fig. 2.1 Subdivision of the D900/D1800 PLMN service areas

2.2 D900/D1800 PLMN Subsystems

By realizing the switching subsystem (SSS) network elements on the basis of the Digital Electronic Switching System EWSD with its very powerful multiprocessor CP113C/CR, and by integration of the base-station controller (BSC) and the base transceiver station (BTS) into this system, Siemens offers with D900/D1800 an outstanding mobile communication system which is characterized by high traffic power and great simplicity in the configuration of its components.

The mobile communication system D900/D1800 realizes a GSM PLMN and consists of three subsystems (Fig. 2.2):

- the **switching subsystem (SSS)**
  which offers all switching functions, also fixed-network-specific switching functions, that are necessary either for independent operation of the D900/D1800 network or for combined operation of the D900/D1800 network and a fixed network (e.g. PSTN/ISDN) or another mobile radio network
- the **radio subsystem (RSS)** divided into:
  - the **base-station system (BSS**)
    which offers all functions necessary to provide both the radio coverage of the service area and an extensive distributed intelligence
  - the **mobile station (MS)**, which is not part of the D900/D1800;
    offers all GSM mobile subscribers operating functions
- the **operation and maintenance subsystem (OMS)**
  which offers all functions necessary for operation of the D900/D1800 network and for the acquisition of information about the performance of the D900/D1800 system.

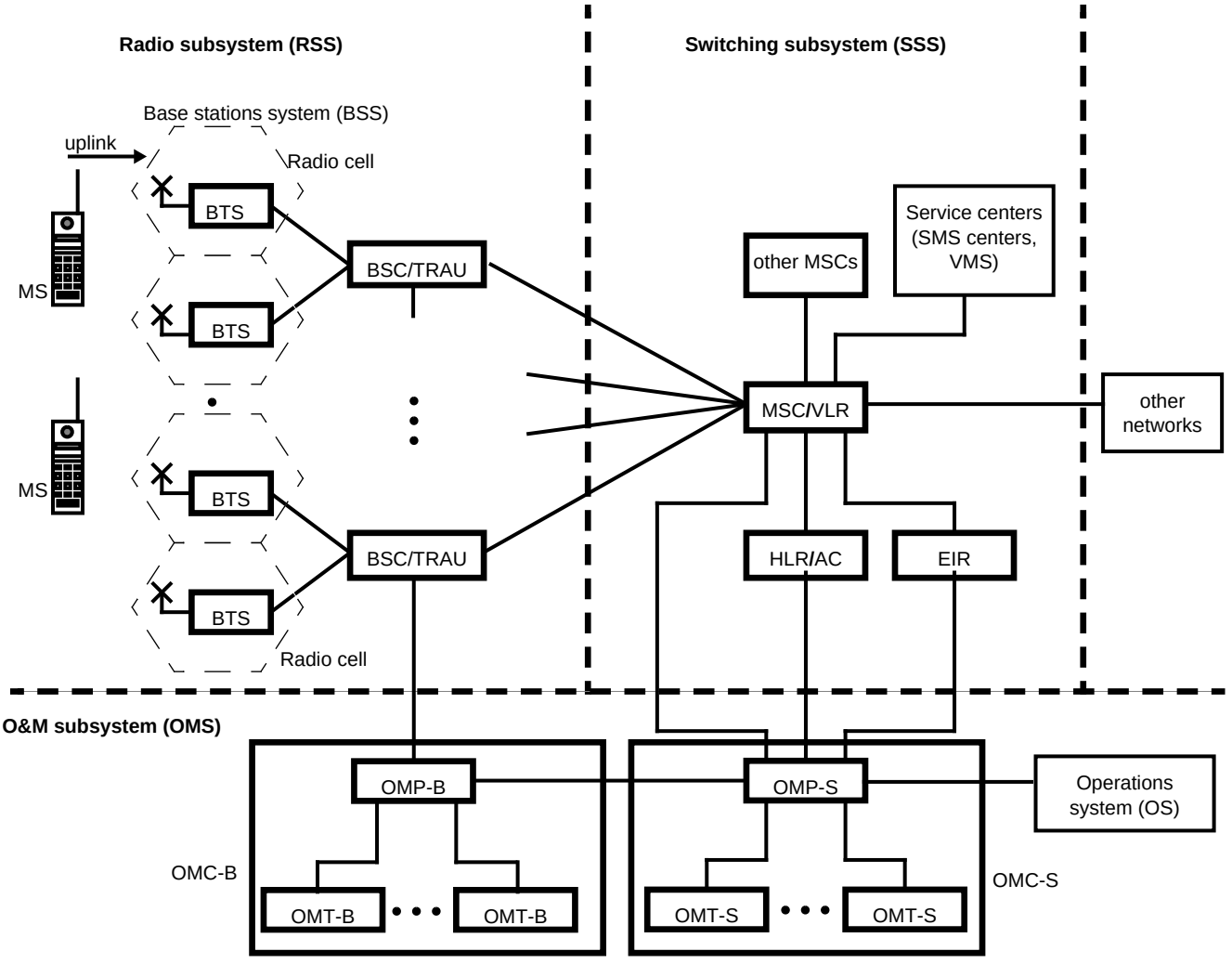


Fig. 2.2 Structure of the D900/D1800 PLMN

2.2.1 Switching Subsystem (SSS)

The switching subsystem (SSS) consists of the following network elements:
- mobile-services switching center (MSCs)
- visitor location register (VLR)
- authentication center (AC)
- home location register (HLR)
- equipment identification register (EIR).

The SSS supports the full-rate/enhanced full-rate channel operation for speech and data services and the half-rate channel operation for speech services.

2.2.1.1 Mobile-Services Switching Center (MSC)

The MSC establishes mobile calls
- between the D900/D1800 mobile radio network and a fixed network (e.g. PSTN/ISDN, PSDN or Internet)
- between the D900/D1800 mobile radio network and another mobile radio network
- within the D900/D1800 mobile radio network between GSM mobile subscribers

In the case of mobile to mobile calls within the D900/D1800 network a connection from one MSC to another MSC or within one MSC is established.

Interworking functions in the MSC make the D900/D1800 compatible with other networks. The MSC can be physically located either in an exchange site of the fixed network or in any other convenient place within or even outside the service area.

2.2.1.2 Visitor Location Register (VLR)

The VLR is a database containing information about all GSM mobile subscribers currently active in its area of responsibility. In D900/D1800 the VLR is collocated with the MSC at a physical network node, for which the abbreviation MSC/VLR is used. When a subscriber checks in with the VLR, this information is forwarded to the home location register (HLR).

In response the VLR receives from the HLR the corresponding GSM mobile subscriber data. For incoming calls for the GSM mobile subscriber the VLR delivers the mobile station roaming number (MSRN) at the request of the HLR. This number serves to establish the traffic channel connection to the visited MSC.

2.2.1.3 Home Location Register (HLR)

The HLR is the main database for GSM mobile subscriber data. It contains the relevant data of its registered GSM mobile subscribers. Included in the relevant data is information about the VLR service area in which the GSM mobile subscriber is temporarily roaming. This information is needed for directing calls to the GSM mobile subscriber. In D900/D1800 the HLR is collocated with the AC in a physical network node, for which the abbreviation HLR/AC is used.

2.2.1.4 Authentication Center (AC)

The AC contains several security boxes with keys and algorithms required for the production of authentication parameters. In the AC several sets of authentication parameters, called 'triples', are generated for each GSM mobile subscriber generally before the GSM mobile subscriber's access to the mobile radio network. The triples are used by the VLR for authentication checks, i.e. to prove whether a GSM mobile subscriber is authorized to enter the network and set up a call. After the check the used triple is abolished and after reaching a certain threshold in the VLR, the VLR will request a set of new triples from the AC via the HLR.

2.2.1.5 Equipment Identification Register (EIR)

The EIR is another database containing information about the device types and identity numbers of all mobile stations (MS) admitted in its area of responsibility. The EIR can be organized in relation to network areas, e.g. with reference to one or more MSCs. In addition there may be a supra-regional master EIR outside of the PLMN. If requested by the MSC, the EIR checks the admission of a mobile equipment. In the event of a suspected defect or misuse of the mobile equipment the EIR decides that the mobile equipment must be observed. The EIR can bar defective or illegal mobile equipments.

2.2.1.6 Service Centers

Service centers, e.g. for the short message service (SMS center) or voice mail system (VMS) for the called GSM mobile subscriber can be connected directly to the MSC or via the fixed networks. Service centers are commercial computer centers and are not a part of the D900/D1800 system.

2.2.2 Base Station System (BSS)

The base station system (BSS) is the D900 part of the radio subsystem (RSS). The BSS consists of the following network elements:

– base station controller (BSC)
– base transceiver station (BTS)
– transcoding and rate adaption unit (TRAU)

The BSS network elements are GSM Phase 2/2+ compatibel.

The product name for the BSS is D900/D1800 SBS. The Siemens base station system (SBS) product includes the BSS network elements and the corresponding operation and maintenance subsystem for BSS (OMS-B).

The BSS supports the full-rate/enhanced full-rate channel or half-rate channel operation or the dual-rate/triple-mode operation (with parallel full-rate/enhanced full-rate channel and half-rate channel operation) for speech and data services.

2.2.2.1 Base Station Controller (BSC)

The BSC forms the intelligent part of the base station system. They control the radio connections, local safeguarding functions, and local operation and maintenance functions. One or more BSCs are connected with one MSC. They also perform the radio processing functions, such as administration of the radio resources, radio channel administration, decentralized call processing and safeguarding functions. One BSC administers several base transceiver stations (BTSs).

The BSC supports various BSC-BTS configurations (e.g. star, multidrop and loop) and has a separate transcoding and rate adaption unit (TRAU).

Between BCS and BTS (Abis interface) a multiplexing of traffic channels from 4x16 kbit/s to 1x64 kbit/s channel at full-rate/enhanced full-rate channels and 8x8 kbit/s to 1x64 kbit/s at half-rate channels is done.

2.2.2.2 Base Transceiver Station (BTS)

The BTSs are radio stations which provide all functions necessary at the antenna site. They support the GSM radio interface, i.e. the radio link between the D900/D1800 network and the mobile stations (MS). They are working for D900 in the GSM900 primary and extended frequency bands and for D1800 in an own GSM1800 frequency band. The BTS are integrated in BTS equipments (BTSE). There are either the “standard” type BTS equipments (with two or six BTS) or the micro BTS equipments (cabinets with two BTS, which are suitable for the introduction of microcells). With D900/D1800 one BTSE can serve one radio cell (omni directional radio cells) or several radio cells (sectorized radio cells) if necessary. The radio cells are the smallest service areas in the D900/D1800 network. Together they cover the whole service area of a D900/D1800 system. The BTSs supports as well full-rate/enhanced full-rate channels as half-rate channels.

2.2.2.3 Transcoding and Rate Adaption Unit (TRAU)

For each traffic channel the TRAU adapts the different transmission rates for speech and data connections on the radio side (Asub interface) to the standardized 64 kbit/s transmission rate at the SSS network side (A interface) of the system. It also performs the allocation between the different speech coding algorithms used within the SSS network side and on the radio side. Additionally, the TRAU serves as a multiplexer between the 64 kbit/s traffic channels of the SSS network side (A interface) and the 16 kbit/s traffic channels for full-rate/enhanced full-rate and half-rate on the radio side (Asub interface). The TRAU thus fulfils the TRAU functions defined in the GSM standards. Therefore the TRAU is usually located at the MSC site in order to save transmission line costs to the remote BSC locations.

2.2.3 O&M Subsystem (OMS)

The OMS largely corresponds to the structures of a telecommunications management network (TMN). The network components of the OMS are formed by the operation and maintenance center (OMC).

Operation and maintenance center (OMC)

There are one or more OMC-S for SSS network elements and one or more OMC-B for BSS network elements. The OMC-S comprises the O&M processors (OMPs) for SSS and the OMC-B comprises the O&M processors (OMPs) for the BSS and the O&M terminals (OMTs) which are connected to the OMPs via a local area network (LAN). The OMP and OMT represents in this case client and server of a client-server LAN architecture.

- O&M processors (OMP-S for SSS and OMP-B for BSS)
  The OMPs are commercial computers (SUN Sparc/Enterprise). In addition to their O&M functions (central management of the BSS and SSS network elements), they handle communication with the BSS and SSS network elements via the packet

switched data network (PSDN) or via TCP/IP based networks (DCN). In addition an OMP uses what are known as mediation functions (MF) to provide a link between specific network elements of the SSS and the operations system (OS) (e.g. personalization center for SIM (PCS) or data post processing systems (DPPS)). The OMP can be multiplied for redundancy purposes (load sharing).

- O&M terminals (OMT)
  The OMTs are workstations or optionally X terminals (SUN Sparc). They provide the man-machine interface between the operator and the OMP, and thereby with the network elements of the SSS and BSS. This interface is implemented with the functions of a graphical user interface (GUI) and a command line interface (CLI) (alphanumeric man machine language (MML)).

  The following remote OMTs can be operated:
  – OMTR: Remote OMT by dialing in via the PSDN(X.25) or via the ISDN/PSTN, or via the GSM radio interface itself for OMC-S.
  – TSC terminal: Remote OMT via the PSDN(X.25), especially for access by the technical service center (TSC) of the PLMN manufacturer to the PLMN network elements. This allows PLMN manufacturing specialists to participate in the error definition process in emergency situations.
- LAN routers
  LAN routers allow the connection of remotely operated LANs in which other OMT and/or backup computers (OMP) are operated.

Local operation and maintenance (O&M) terminals at the network elements of SSS and BSS

- Local O&M terminals (basic craft terminal, BCT) for SSS
  The BCT can be connected to the SSS network nodes (e.g. MSC/VLR, HLR/AC) on the spot.
- Local maintenance terminals (LMT) for BSS
  Laptop computers can be connected to the BSS network elements (TRAU, BSC, BTS) on the spot as local maintenance terminals (LMT). In particular, a remote LMT session can be opened for a BSC from any BTSE or TRAU. This means that the BSS network can be administered from each BSS network element, while this remote access can be barred again from the OMC-B.

2.3 Connections between PLMN Network Elements

D900/D1800 is a fully digital system. The user information, e.g. the voice transmission signal, is transmitted on the radio interface as a digital signal. One of the advantages of digital transmission is the ability to encrypt the signals in such a way that even an expert would be unable to monitor them illegally. The radio transmission includes additional (redundant) data for the reconstruction of defective signals, for measures to correct accumulated radio transmission errors, for synchronization and for the signaling information on the TRAU/BSC/BTS/mobile station.

The D900/D1800 PLMN uses three different types of digital connections between network elements:
– traffic connections (speech and data of MS)
– common channel signaling connections (CCS7)
– operation and maintenance connections (X.25)

The D900/D1800 PLMN can be connected to the following fixed networks:
– public switched telephone networks (PSTN)

– integrated services digital networks (ISDN)
– packet-switched data networks (PSDN)
– Internet

2.3.1 Traffic Connections

Traffic connections are used for the transmission of the user information (voice, data), and as control channels for the exchange of messages between transcoding and rate adaption unit (TRAU) and base station controller (BSC) and base transceiver stations (BTS), and between BTS and mobile stations (MS). Fig. 2.3 shows a typical configuration of network elements of the D900/D1800 PLMN along with the traffic connections. On the fixed network side fixed network exchanges (LE, local exchange) are shown.

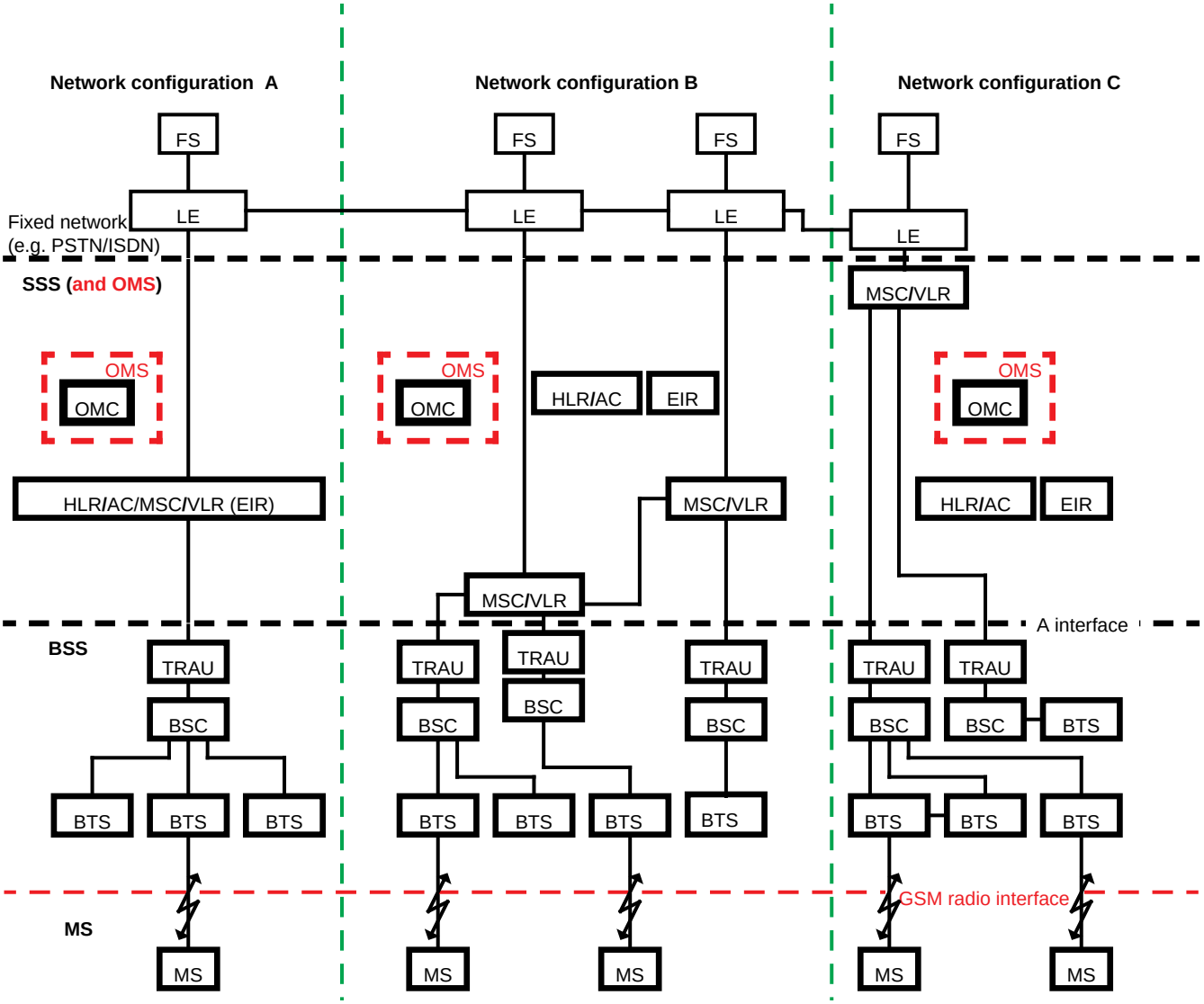


Fig. 2.3 The D900/D1800 PLMN with its digital traffic connections

2.3.2 Common Channel Signaling Connections

Common channel signaling No. 7 (CCS7) links are used for the exchange of messages within fixed networks (e.g. PSTN/ISDN), between fixed network and MSC/VLR, between MSC/VLRs, between MSC/VLR and HLR/AC and EIR, and between MSC/VLR and BSCs. Fig. 2.4 shows a typical configuration of network elements of the D900/D1800 PLMN along with the common channel signaling connections.

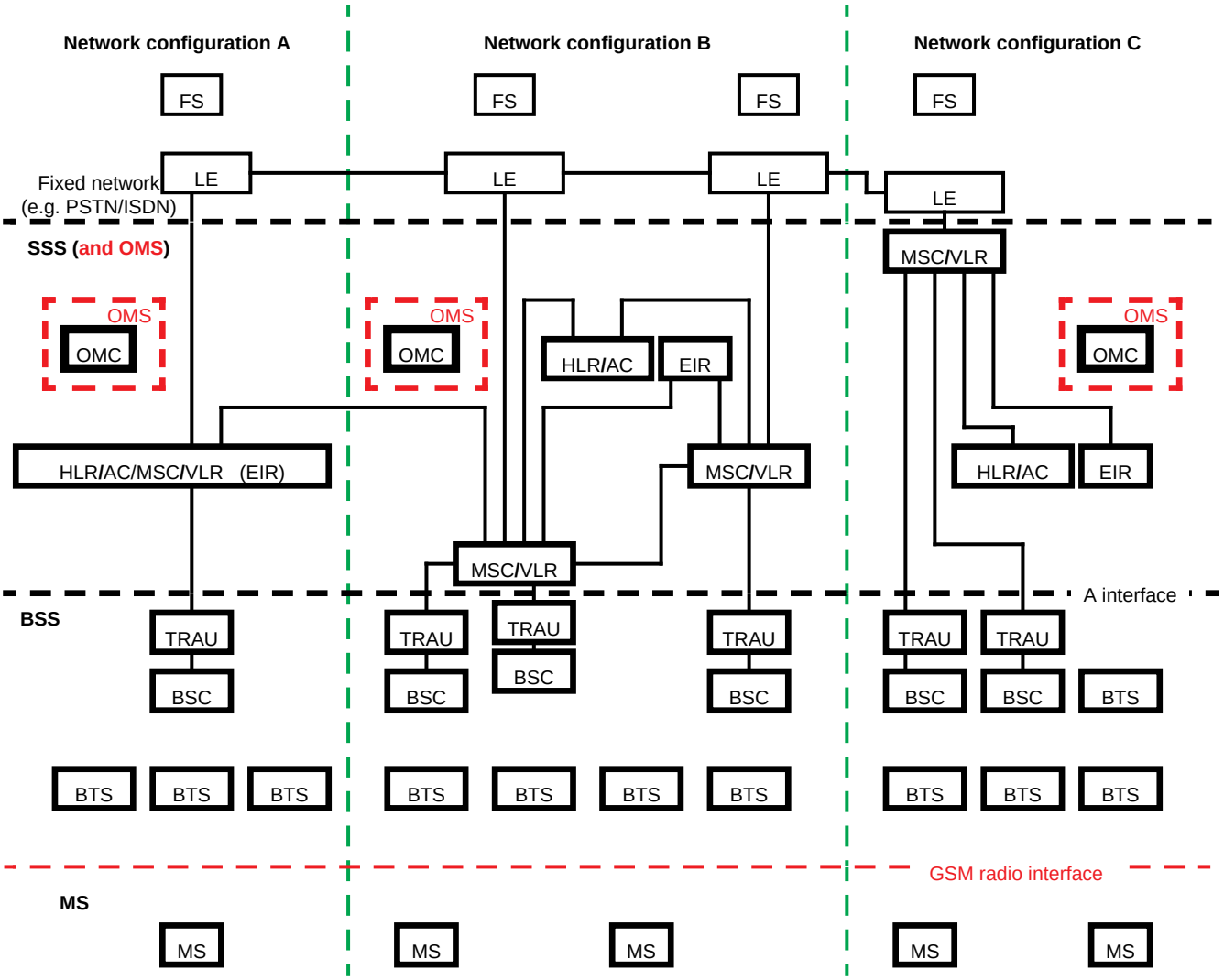
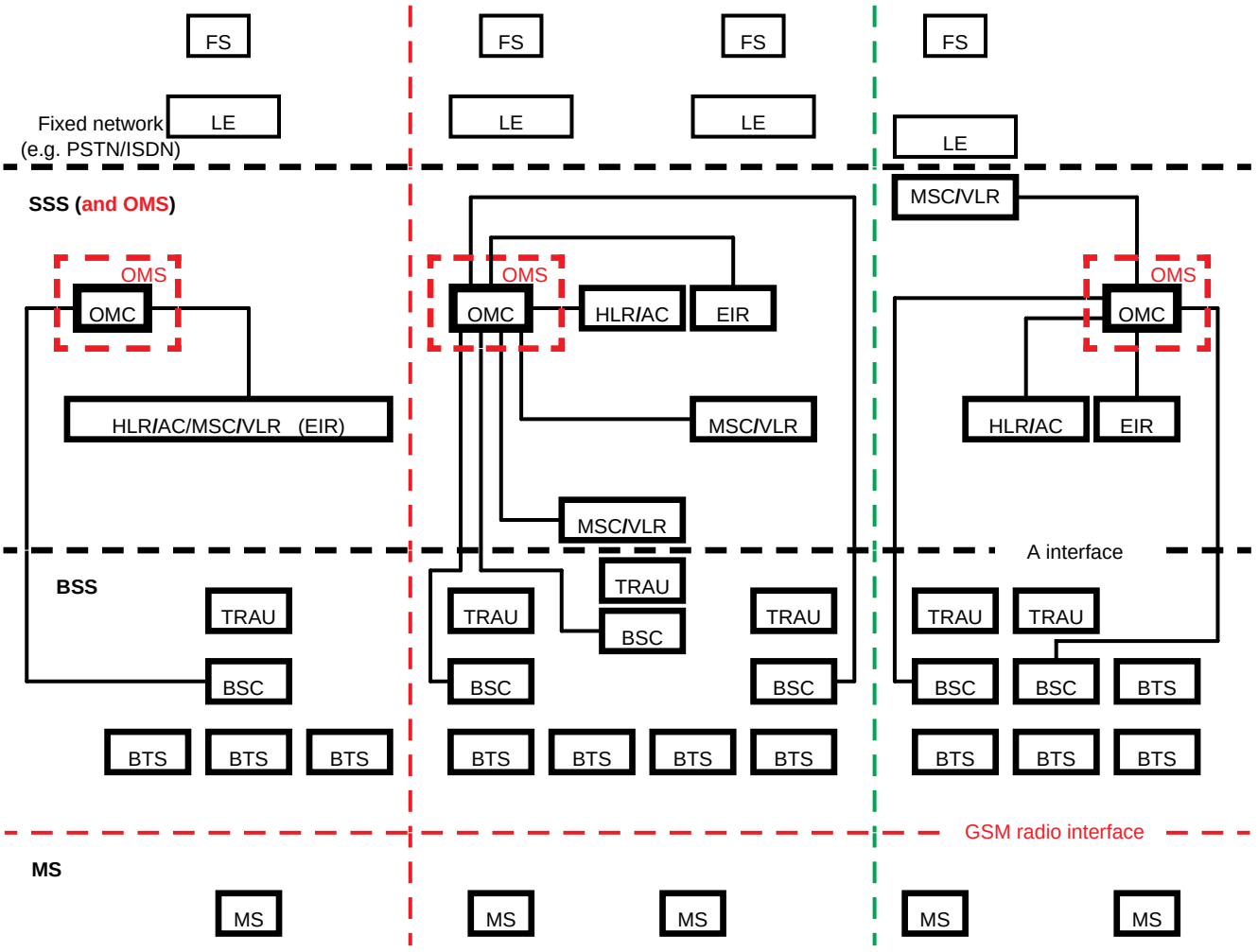


Fig. 2.4 The D900 PLMN with its digital CCS7 connections

2.3.3 O&M Connections

The O&M connections from the OMC (OMC-S and OMC-B) of the OMS are implemented for BSS and SSS by a PSDN with X.25 interfaces. As an option the O&M connections from OMC-B to BSS network elements can be handled by PCM 30 nailed-up connections via MSC. In the SSS the network nodes MSC/VLR, HLR/AC and EIR have such interfaces; in the BSS the BSC and via the BSC the BTS and TRAU. Fig. 2.5 shows a typical configuration of network elements of the D900/D1800 along with the O&M connections.



Note:
1) OMC consists of an OMC-S (for SSS network elements) and an OMC-B (for BSS network elements)
2) O&M connection from OMC (OMC-S/OMC-B) to SSS and BSS network elements shown above are only drawn with type PSDN (X.25) in this figure. Relative to optional O&M connections see Fig 5.1
3) There are also O&M connections between BTSs and BSCs realized by a timeslot in a PCM 30 connection

Fig. 2.5 The D900/D1800 PLMN with its digital O&M connections

2.4 Combined Switching Center (CSC)

The combined switching center (CSC) integrates the functions
– of PLMN-network elements (MSC, VLR etc.)
– of a fixed network local exchange (LE, an EWSD exchange for example)

In a CSC network element, in addition to GSM mobile subscribers, GSM-RITL subscribers and fixed network subscribers (wired ISDN and analog) can be administered or connected.

Tab. 2.1 shows an overview of all kinds of subscribers at the CSC.

Kind of subscriber	Subscriber interface	Standard of interface	Classes of telecommunication services	Allocation of directory number
GSM subscriber	Radio interface	GSM	GSM services	MSISDN with national destinaltion code (NDC)
GSM-RITL subscriber				Directory number of a fixed network, local area code (LAC)
ISDN/analog subscriber	wired	ITU-T	Fixed network services	

Tab. 2.1 Overview of all kinds of subscribers at the CSC (with classifying features)

GSM-RITL subscribers

GSM-RITL subscribers which are supplied by the GSM radio interface are largely administered like normal GSM subscribers, i.e. those without any restriction on their movements. Introducing GSM-RITL subscribers opens up a number of options, depending on the network environment:
– CSC in a PLMN environment: To supplement a local fixed network (PSTN) "pseudo-PSTN subscribers" can be connected via the telecommunications network.
– CSC in a PSTN environment: Within a normal fixed network (PSTN) subscribers can be connected as GSM-RITL subscribers to the telecommunications network.

From the CSC's standpoint, GSM-RITL subscribers are mobile subscribers who are only distinguished from "normal" GSM mobile subscribers by a few typical features. A typical service feature is restriction of roaming to a defined location area. Another feature is the subscriber directory number which corresponds to a directory number from the directory number volume for fixed network subscribers. The CSC network node for these GSM-RITL subscribers can include all typical PLMN network elements (i.e. MSC, HLR, AC, VLR and where necessary, EIR too) and thus represent an isolated "quasi-PLMN" within a PSTN, in which all typical PLMN execution sequences (e.g. interrogation, location update etc.) then take place. It is not however possible to distribute the network elements (e.g. within a PLMN) to different network nodes.

The telecommunications services of a GSM mobile subscriber are also valid for GSM-RITL subscribers (see Section 3.1, GSM Telecommunication Services).

Fig. 2.6 and Fig. 2.7 show examples of how GSM-RITL subscribers are incorporated into typical network environments.

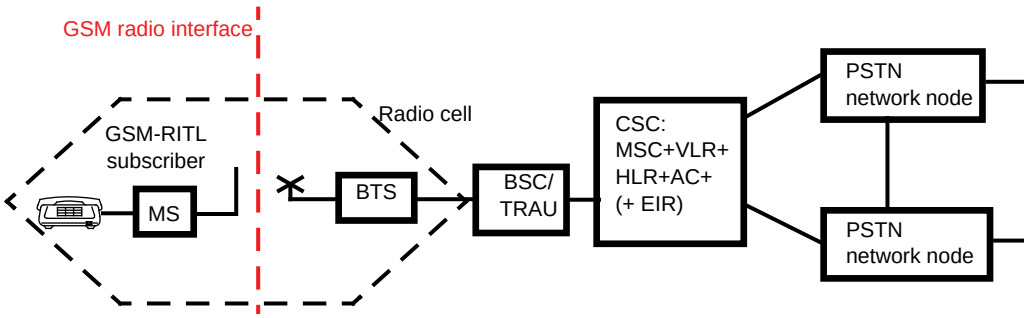


Fig. 2.6 CSC with GSM-RITL subscribers within a PSTN environment

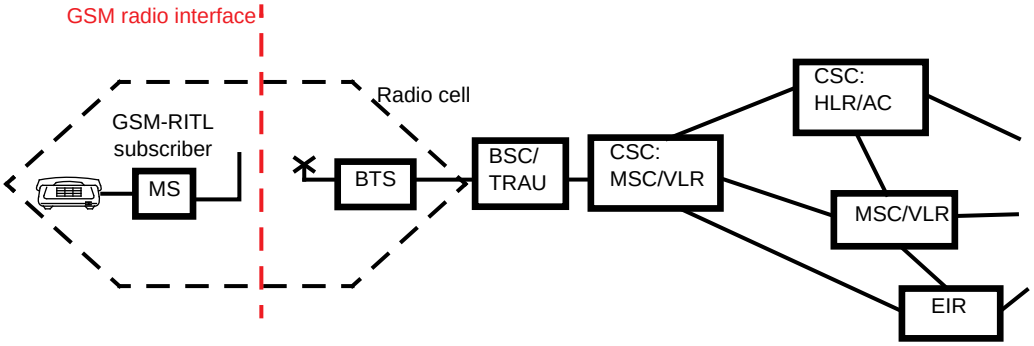


Fig. 2.7 CSC with GSM-RITL subscribers within a PLMN environment

Wired ISDN/analog subscribers

D900/D1800 allows wired ISDN/analog subscribers to connect to a combined switching center (CSC) (Fig. 2.8).

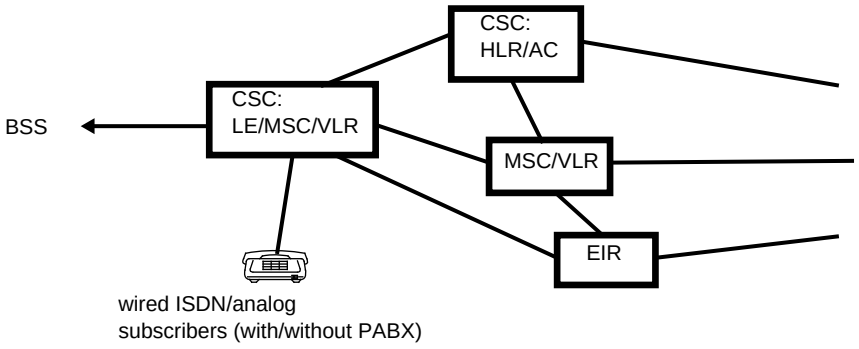


Fig. 2.8 CSC with wired ISDN/analog subscribers within a PLMN environment

ISDN subscribers:

ISDN subscribers can be connected in one of two ways:
- basic access (BA) for ISDN individual connections including little ISDN-PABX
- primary rate access (PA) for medium or great ISDN-PABX

Like the GSM telecommunications services for the GSM mobile subscribers (Section 3.1), telecommunications services can be assigned to wired ISDN subscribers in the PLMN. This assignment is undertaken in the relevant CSC. Section 3.2 gives a list of all available telecommunications services.

Analog subscribers:

As well being assigned to wired ISDN subscribers, the telecommunications services can also be assigned to wired analog subscribers in the CSC of a PLMN (known as analog features). Section 3.2 lists all the available features.

2.5 IN or CAMEL Functions in the PLMN and CSC

IN (Intelligent Network)

The term intelligent network (IN) stands for the concept of a network architecture that is valid for all telecommunication networks. The basic idea is to introduce a control layer which contains the services logic or the services data in a central location, and thus regulates effectively how existing and new services are managed.

CAMEL (Customized Application for Mobile network Enhanced Logic)

The term CAMEL stands for a standard, which has been defined in order to migrate proprietary IN- and operator specific services (OSS) solutions towards standardized GSM network solutions. Using CAMEL support of international roaming for IN services is enabled and IN interworking in a multivendor environment is eased, all of this based on ETSI standards.

In this software release the CAMEL Phase 1 is introduced. CAMEL Phase 1 is a first step to integrate IN into GSM mobile network environment. This first phase of CAMEL provides the mechanism to support value added services consistently, independently of the serving network. The CAMEL features shall facilitate service control of operator specific services external to the home PLMN (HPLMN). CAMEL offers a platform to introduce CAMEL/IN based home services. The content and logic of a CAMEL/IN based home service is on the discretion of the PLMN operator.

IN/CAMEL network architecture

The following components are available for handling IN/CAMEL services:
- service switching point (SSP)
- service control point (SCP)/CAMEL service environment (CSE)
- service management point (SMP)
- service creation environment (SCE)
- intelligent peripheral (IP)

CAMEL provides a standardized SSP-SCP/CSE interface for PLMN interworking.

Fig. 2.9 shows a typical basic IN/CAMEL network architecture.

i The only integral parts of D900/D1800 are the IN/CAMEL components SSP and the IP in the form of an internal IP in the SSP. In particular, the IN/CAMEL components SCP/CSE, SMP, SCE and their functions are not integral parts of the D900/D1800, although these are available, however, as a separate Siemens IN/CAMEL product. The IN/CAMEL functions and the following Siemens IN/CAMEL network components mentioned briefly below are dealt with in greater detail in a separate system description.

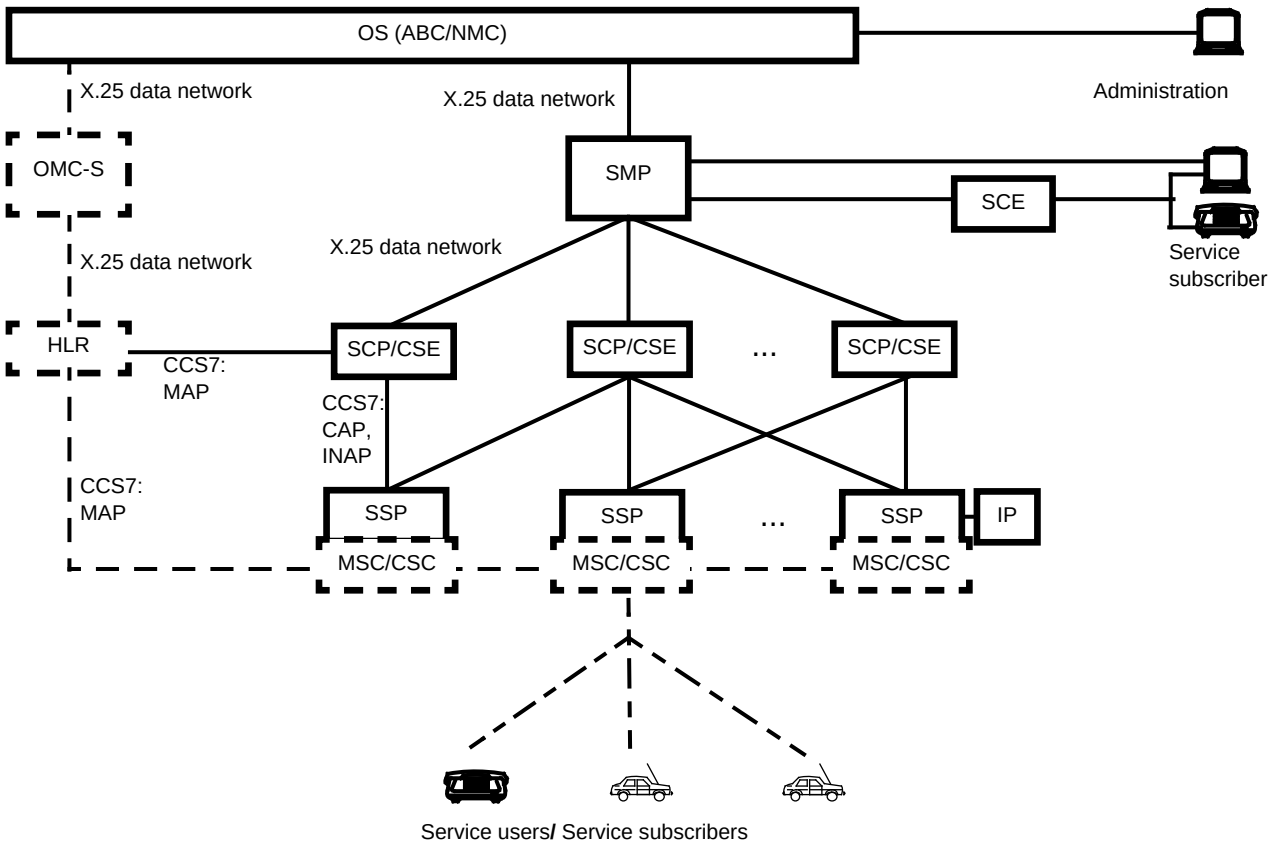


Fig. 2.9 Underlying architecture of IN/CAMEL

There are four typical groups of users in an intelligent network:

– service users,
  are callers who request an IN/CAMEL service e.g. by dialing the defined sequence of digits for this service.
– service subscribers,
  are the called parties in the case of basic IN/CAMEL services; they have subscribed a service which is supported by the service provider in order to offer it to the service user. In the case of subscriber specific IN/CAMEL services, in particular for GSM subscribers, the situation is generally otherwise. Here, e.g. in the case of the IN/CAMEL service prepaid service (PPS), the service user and service subscriber are identical. For the virtual private network (VPN) service the service subscriber is the company which owns the VPN.
– service providers,
  make agreements with the network operators to use the network, offer their services to potential service subscribers and administer these services.
– network provider,
  provide the network and administer the underlying network functions.

The SSP forms the gateway from the basic network to the intelligent network node (SCP) or CAMEL network node (CSE). . The SSP detects whether a service is to be processed by the SCP/CSE and requests the appropriate service-specific information from the SCP/CSE in the relevant case. The SCP/CSE forms the IN/CAMEL node which

exercises central control over the various services. The SCP/CSE database is supplied with input by the “service subscribers” or by the administration via the SMP. The individual service subscribers thus have the opportunity to control an IN service or CAMEL service in accordance with specific criteria. For example a subscriber can limit traffic or direct it to different destinations at different times. SCE network nodes allow service providers/network operators to design their own IN services or CAMEL services with suitable, easy-to-use IN service or CAMEL service creation tools. An intelligent peripheral (IP) provides resources (e.g. IN announcements, mailbox server). Currently two IP solutions are available: a so-called internal IP with an M-SSP network node is used in D900/D1800 and this can provide tones, standard announcements or what are known as user-defined announcements. The second way of an IP is the central IP which is supported with a special assist procedure.

SSP and SCP/CSE in the PLMN

Access to the IN service or CAMEL service for the service user is implemented in an MSC (or CSC in a PLMN environment) with IN/CAMEL-functions dependent on the network environment. The solution for an implementation of this type is provided by the IN network architecture (Fig. 2.10): the SSP function is integrated in every MSC/VLR or CSC of a PLMN. Within the PLMN, a network node of this type, which combines an SSP with an MSC, is then known as an **M-SSP** (mobile SSP). The SCP/CSE is part of the PLMN.

A CSC in a PSTN environment can logical be regarded just like an MSC in the PLMN: The SSP function can be integrated into the own CSC or reached via an SSP within or outside the own network.

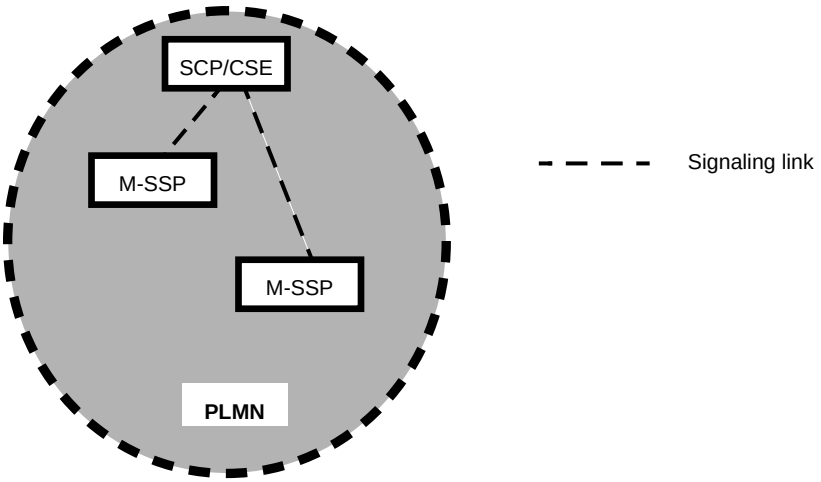


Fig. 2.10 Access to IN/CAMEL function in the PLMN with an integrated IN/CAMEL network architecture

IN or CAMEL triggering

Access from the IN/CAMEL is via a trigger function as part of digit translation and zoning. The mechanism with which the SSP recognizes an IN service or CAEML service is referred to as IN or CAMEL triggering. For each IN service a trigger profile is created in the M-SSP which contains data for addressing the SCP/CSE, i.e. for IN service or CAMEL service administration. The trigger profile data can be used for assigning the specific IN service or CAMEL service to the SCP/CSE for which a signaling connection

has to be set up with SCCP/INAP or SCCP/CAP in order to initiate the service-specific database interrogation.

2.6 Mobile Internet Access (MIA) Functions

The PLMN operator can become an Internet service provider (ISP) by using a Siemens Internet protocol (IP) based value added service (VAS) platform. In this software version the MIA Step 1 is realized, which is named the stand alone solution (see Section 1.4)

i The VAS platform based on third party (OEM) products is connected to the Siemens SSS equipment according to the Siemens mobile Internet access strategy.

With this stand alone solution, access to the internet is achieved via an external remote access server (RAS). With this solution the PLMN operator connects directly to the internet eliminating the PSTN/ISDN as a transfer network. At the same time the call setup time is reduced from approximately 50 sec. to 5 sec. due to the usage of digital connections, eliminating the modem connections.

The different components of the MIA Step 1 are as follows (see Fig. 2.11):

Remote Access Server (RAS)

The RAS is connected to the MSC via a primary rate access (PA) using EDSS.1 signaling system, on the other side it connects to a local area network (LAN) or wide area network (WAN). The RAS terminates the circuit switched call, calls the user and assigns the user a temporary IP address. The RAS supplier is chosen in accordance with the Siemens Internet strategy.

Firewall

The firewall protects the LAN from malicious attacks from external networks. Virtual private network and encryption tunneling capabilities are available for mobile users too. Anti-virus screening for both GSM subscribers and the public Internet are available.

Router

The router connects the LAN to the public Internet (and vice versa) over a WAN connection.

Messaging server

Depending on the voicemail center available on the PLMN site the operator can choose between:

Unified messaging (option 1)

If the PLMN has the required voicemail center (VMC) the following features are available:

– ubiquitous notification (uses short message service center (SMSC) and interactive voice response (IVR))
– media conversion

E-mail messaging (option 2)

If the PLMN operator does not have the required VMC on its site the following features are available:

– same as option 1 without voice capabilities and the unified mailbox

Accounting and security server

The accounting and security server is RADIUS based and contains a database for mobile Internet service provider (ISP) users and their rights (works together with the fire-wall).

Application server

Other server can be implemented, this could be web-servers, yellow pages, wireless application protocol (WAP) server etc., these additional services have to be defined with the customer.

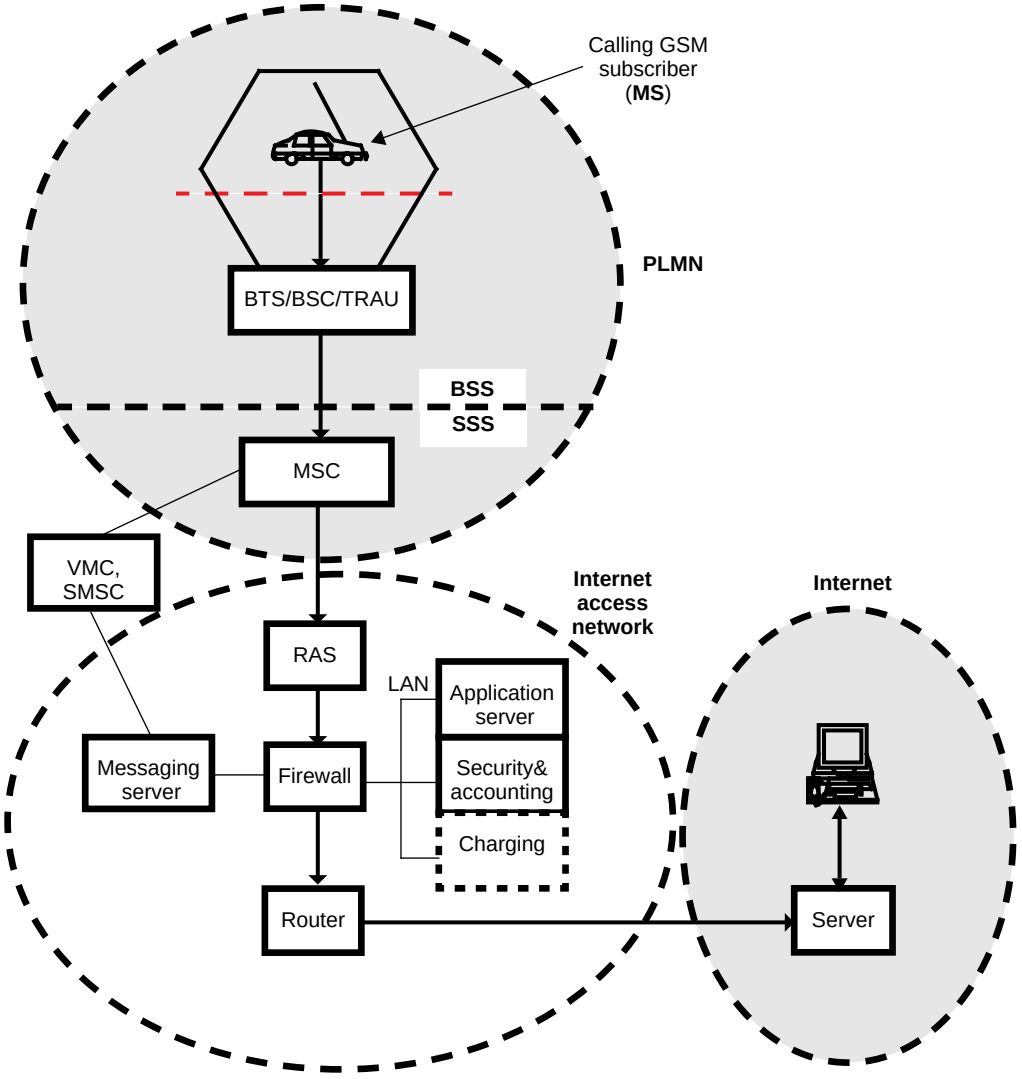


Fig. 2.11 MIA Step 1 architecture for PLMN Internet access

With MIA Step 1 the PLMN operator can offer a value added services platform for:

- Internet service provisioning
  The PLMN operator can provide specific mobile IP based services (e.g. mobile banking or content adaptation through a wireless application protocol (WAP) server).

- Internet content provisioning
  The PLMN operator can provide specific mobile IP based content accessible from both the PLMN and the Internet.

Another key feature of this solution is the integration of an unified messaging server which incorporates:

- an unified mailbox
  The voice mail center holds voice mail, e-mail and fax
- media conversions
  The unified messaging server converts the different media (SMS to fax, e-mail to voice, e-mail to SMS etc.
- ubiquitous notification via short message service (SMS)
  The GSM subscriber is always reachable for all messages (voice mail, e-mail and fax), increasing the call completion and SMS usage.

The PLMN operator has with MIA Step 1 a strong security concept for public and corporate applications in order to be protect attacks from the Internet and create encryption and virtual private networks (VPN) products.

3 Telecommunication Services

3.1 GSM Telecommunication Services

With D900/D1800 the GSM telecommunication services offered to the GSM subscriber (GSM mobile subscriber and CSC GSM-RITL subscriber) are subdivided as follows:

– bearer services (for data only)
– teleservices (for voice and data)
– supplementary services

Bearer services and teleservices are also called basic telecommunication services. The use of GSM telecommunication services is subject to subscription. A basic subscription permits participation in those GSM telecommunication services that are generally available. Additional specific subscription(s) is (are) needed for those GSM telecommunication services that are not generally available. The application in the subscription is handled by the PLMN operator, or its agents, of the country where the subscriber is resident (home PLMN). The regional entitlement is handled within the switching subsystem. If a GSM subscriber roams out of the entitled area there is no possibility of establishing communication (roaming not allowed), except the use of the teleservice emergency call.

3.1.1 Bearer Services

The bearer services are pure transport services for data and thus only the lowest three layers of the OSI reference model (concerning the ISDN reference points in the terminal equipment) are defined. Some of the transmission modes and rates already used in modern data networks are implemented; others are planned.

The following, already implemented, bearer services provide unrestricted information transfer between the reference points in the mobile stations.

Data CDA (circuit duplex asynchronous) + basic PAD (packet assembler disassembler) access

These circuit mode bearer services may be used to support various user applications with data transmission rates of 300 bit/s to 9600 bit/s. In particular an asymmetric type (in the direction of the GSM subscriber at 1200 bit/s and in the direction of the network side at 75 bit/s) support for an access so video centers for example. These services perform a rate adoption of sub-rate information streams. The GSM bearer services mentioned thus support the formats and procedures, like they are usual in PSTN analog modems in accordance with ITU-T Recommendations V.21, V.22, V.22bis, V.23, V.32, V.32bis and V.34.

Data CDS (circuit duplex synchronous)

These bearer services guarantee a synchronous data transfer (i.e. bit-oriented) with data transmission rates of between 1200 and 9600 bit/s. These bearer services are used for circuit switched connections to PSDN subscribers (basic packet switched access), particularly for calls to X.32 PSDN ports or to a packet handler (PH). Access to the packet handler is supported by an X.31 case-A or case-B signaling protocol. These services perform a rate adaptation of sub-rate information streams.

PAD CDA (dedicated PAD access)

These bearer services enable a circuit-switched access to a PSDN via a PAD (packet assembler/disassembler) and may be used to support various user applications with data transmission rates of 300 bit/s to 9600 bit/s. These services perform:

– a rate adaptation of sub-rate information streams
– routing (and hence access) to a packet assembler/disassembler function in front of the PSDN

Alternate speech/data CDA (circuit duplex asynchronous)

This circuit mode bearer service may be used to support various user applications. This service provides:

– the unrestricted digital capability to use sub-rate information streams which are rate-adapted
– the capability to alternate between speech and data during a call. This means an alternate usage of the speech and data capabilities.

Speech followed by data CDA (circuit duplex asynchronous)

This circuit mode bearer service may be used to support various user applications. This service provides:

– the unrestricted digital capability to use sub-rate information streams which are rate-adapted.
– the user with a data capability after the speech call has been established (at any time while the call is in progress)

Data compression on the GSM radio interface as per ITU-T V.42bis

The transmission rate for bearer services is restricted to 9600 bit/s in line with the GSM standard. By compressing data on the GSM radio interface as per ITU-T V.42bis, it is possible to attain a transmission rate which is up to four times faster. This is possible for explained bearer services above with the exception of data CDS bearer services. This allows better adjustment to the higher transmission rates possible in the PSTN/ISDN. Data compression is performed by the interworking function (IWF) and by the mobile station.

3.1.2 Teleservices

Teleservices use both low layer and high layer functions for the control of communication from terminal to terminal. The protocols are related to layers 4 to 7 of the OSI reference model. The following teleservices have already been realized:

Telephony

The telephony teleservice is used to transmit voice information and audible tones in the PLMN and between a GSM subscriber in the PLMN and another subscriber in a fixed telephone network (PSTN/ ISDN). Transparency for telephone signaling tones is ensured. The transmission of dual-tone multifrequency signals (DTMF) is possible for a mobile originating call (MOC).

Emergency call

The emergency call teleservice is used to establish a voice connection from a mobile station to an emergency center allocated to the location where the call originated.
It can be defined on a project-specific basis whether the emergency call is to be possible

with or without inserting a chip card. The barred state of a mobile station is overridden by the emergency procedure. Emergency calls also supersede all restrictions caused by supplementary services or mobile station features used by other teleservices or bearer services. Emergency calls are routed to the emergency center in agreement with the national regulations.

Short message service (SMS)

(Mobile terminated, point-to-point) (Mobile originated, point-to-point)

The teleservices short message service are data telecommunication services. The mobile terminated type permits a PLMN subscriber to receive a short alphanumeric message (text) from a fixed-network or GSM subscriber, if the mobile station is equipped to handle this telecommunication service. The mobile originated type allows a PLMN to send short messages to other GSM subscribers or fixed-network subscribers (ISDN/PSDTN, PSDN). For this teleservice a short-message service center must be connected to the D900/D1800, which receives and redistributes the short messages.

Short message cell broadcast

This service allows short messages to be broadcast within a defined service area to all the MSs located in this area. Depending on the particular requirements, this service area can be either a radio cell, a group of radio cells or the entire PLMN. A cell broadcast center (CBC) transmits the short messages directly to the BSS (i.e. BSC).

Automatic facsimile (group 3)

The facsimile (group 3) teleservice provides a reproduction of all forms of graphical, handwritten or printed material at a distant location, within the limits and characteristics specified by the ITU-T. It belongs to the data teleservices. The so-called transparent mode is supported, not the non-transparent mode.

Alternative speech and facsimile (group 3)

This teleservice permits alternation during a call between voice transmission and facsimile (group 3). The so-called transparent mode is supported, not the non-transparent mode.

3.1.3 Supplementary Services

Supplementary services are services which extend beyond the normal bearer services and teleservices (basic telecommunication services) and can be subscribed to separately.

In the following a supplementary service is called simply service, in contrast to basic telecommunication service.

A distinction must be made between ”pure” GSM supplementary services and non-GSM supplementary services. The supplementary services described in Sections 3.1.3.1 to 3.1.3.8 follow the recommendations of the GSM standard.

3.1.3.1 Number Identification Services

Calling line identification presentation (CLIP)

Allows a called GSM subscriber to indicate the number of the calling subscriber with possible additional address information (e.g. subaddress in a PBX), which must be

provided by the calling subscriber exchange; the indicated number must identify unambiguously the calling subscriber and is provided to the called GSM subscriber before answering. If the calling subscriber has “CLIR” activated, the called GSM subscriber receives an indication “presentation restricted”.

Calling line identification restriction (CLIR)

Allows a calling GSM subscriber to restrict the presentation of the calling GSM subscriber number to the called subscriber. It can optionally be activated for a call by the operator or by the GSM subscriber.

Connected line identification presentation (COLP)

Connected line identification presentation allows a calling GSM subscriber to display the number of the called subscriber, which is to be provided by the called subscriber's exchange; the number displayed must uniquely identify the called subscriber and is presented to the calling subscriber before the call is accepted. If the called subscriber has activated connected line identification restriction (COLR) the calling subscriber receives the message “presentation restricted”

Connected line identification restriction (COLR)

Connected line identification restriction allows a called GSM subscriber to block the presentation of his or her number at the calling mobile station. COLR is available as an option only for the operator.

3.1.3.2 Call Offering Services

The call forwarding services can be applied to a specific basic telecommunication service (i.e. a telephony teleservice call can be forwarded to a first directory number and another facsimile teleservice call to a second directory number) or to all basic telecommunication services in general. They may be offered separately or in combination of two or more services (packages).

The number to which a call is forwarded may be entered by the PLMN operator or by the GSM subscriber with a control procedure.

Call forwarding unconditional (CFU)

Allows a GSM subscriber to redirect all incoming calls (or those from to a specific telecommunication service) to another directory number; the incoming calls are immediately forwarded when the service is activated.

Call forwarding on mobile subscriber busy (CFB)

Allows incoming calls to be redirected if the GSM subscriber is busy, e.g. if he is just using a traffic channel on the GSM radio interface.

Call forwarding on no reply (CFNRy)

Allows incoming calls to be redirected after the GSM subscriber does not answer the call within a certain ringing time.

Call forwarding on mobile subscriber not reachable (CFNRc)

Allows a GSM subscriber to redirect the incoming calls if he is not reachable for mobile-specific reasons:

– all radio channels of the radio cell in which the GSM subscriber is presently situated are seized (radio congestion)
– the GSM subscriber does not respond to paging messages
– the GSM subscriber is de-registered (i.e. has withdrawn the SIM chip-card and is in the ”not activated” condition (IMSI detach).

Call forwarding by default (CFD)

The feature call forwarding by default (CFD) enables the PLMN operator to assign one additional call forwarding number to a GSM subscriber for the conditions “busy”, “no reply” and “not reachable”. This number is used to forward an incoming call when neither the appropriate GSM conditional call forwarding service nor automatic routing of not completed calls service is invoked.

3.1.3.3 Call Completion Services

Call hold

Allows a GSM subscriber to interrupt and to continue communication on an existing connection. After interruption, the channel is available to originate another outgoing call or to accept a waiting call.

Call waiting (CW)

Provides the possibility for a GSM subscriber to be informed of an incoming call while he is busy; in that case the GSM subscriber is able either to answer, to reject or to ignore the incoming call. If the waiting call is answered, the existing call can be put on hold.

3.1.3.4 Multi-Party Service

This multi-channel supplementary service (MPTY) lets the GSM subscriber set up a voice conference in which, including himself, six subscribers can participate. MPTY subscribers may be subscribers of the PLMN and fixed networks (PSTN/ISDN etc.). For multi-channel connection setup with MPTY the GSM subscriber requires authorization for the supplementary service call hold. To initiate a multi-channel connection with MPTY one connection must be put on hold and another connection activated.

3.1.3.5 Charging Services

Advice of charge (AOC)

AOC (advice of charge) lets the GSM subscriber see the billed charge information, which will later also be billed at his home PLMN.

– AOC information level (AOCI)
  For an MOC and MTC the PLMN (MSC) sends to the mobile station AOC parameters (charge advice information, CAI), which allow it to calculate and display the charges accruing during the call.
  In the mobile station the charge information for call is displayed and stored on the SIM chip card. The call charges are shown in the currency of the home country of the GSM subscriber.

– AOC charging level (AOCC)
  The charging level is intended for applications in which not the GSM subscriber (administered by the network operator) himself, but a user temporarily appointed by him sets up a connection. This user subsequently pays the GSM subscriber for the call(s). Examples of such applications are club telephones (payphones) and rented telephones.
  In contrast to AOCI the user of a mobile station with authorization for AOCC cannot set up a mobile connection in a foreign PLMN (without AOCC support).
  (In addition to the GSM standard solution for AOCI/AOCC the D900/D1800 has a specific IN-AOCI/AOCC solution with improved charge, beyond the GSM standard.)

3.1.3.6 Call Restriction Services

Allow a GSM subscriber to bar certain categories of calls originated from or terminated at his mobile station. The calls may be associated with all or with a specific basic telecommunication service.

The GSM subscriber may optionally have a password to override this barring or to deactivate the service and define a period in which the service is active. If he has the associated option he may change his password himself.

Barring of all outgoing calls (BAOC)

The GSM subscriber may not set up any outgoing call, except emergency calls.

Barring of all outgoing international calls (BOIC)

The GSM subscriber may set up outgoing calls only to a subscriber of his present PLMN and the associated fixed network (e.g. PSTN/ISDN) and activate no call forwarding. The present PLMN is his home or a visited PLMN.

Barring of all outgoing international calls except to home PLMN country (BOIC-exHC)

The GSM subscriber may set up outgoing calls only to subscribers of his present PLMN and additionally to subscribers of his home PLMN country and the associated fixed network (e.g. PSTN/ISDN). When the GSM subscriber is present in his home PLMN country he may set up calls only to subscribers of his home PLMN country.

Barring of all incoming calls (BAIC)

With BAIC (barring of all incoming calls) the GSM subscriber can receive no incoming calls.

Barring of all incoming calls when roaming outside home PLMN country (BIC-Roam)

In case of roaming outside home PLMN country the GSM subscriber may not receive incoming calls of all PLMNs and the associated fixed networks (e.g. PSTN/ISDN) of any country. When the GSM subscriber is present in his home PLMN country, barring is inactive.

3.1.3.7 Closed User Group (CUG)

The supplementary service CUG (closed user group) allows a GSM subscriber, as member of a PLMN, to form a closed user group with other GSM subscribers or subscribers of fixed networks (e.g. PSTN/ISDN). The GSM subscriber may participate in a maximum of 10 different CUGs. By the basic definition of a CUG the CUG members may only use connections within their CUG.

3.1.3.8 User-To-User Signaling Service 1 (UUS1)

User-to-user signaling service 1 (UUS1) allows a GSM subscriber to exchange short messages (max. 32 bytes) with an ISDN subscriber during the set-up or clear-down phase of a MOC or MTC. The messages are exchanged via the signaling connection which is set up during this call phase and assigned to the traffic channel.

3.1.3.9 Non-GSM Supplementary Services

Hot billing

Hot billing allows a network operating company to create short-term call charge records for every call, regardless of the normal accounting interval for other GSM subscribers.

The flow of call charge information goes from the charge-computing MSC to a DPPS (data post-processing system) in the operations system (OS) and thence to the GSM subscriber or e.g. to the lessor of a mobile station.

Following non-GSM supplementary services may be added on a project-specific basis:

Automatic routing of not completed calls (call diversion service)

Automatic routing of not completed calls allows a GSM subscriber who is temporarily not available (e.g. busy) to divert incoming calls to a personal voice mailbox. The personal voice mailbox is a computer box in the PLMN (voice mail system, VMS) and acts as a kind of call answering machine in the PLMN. The GSM subscriber can retrieve the recorded messages from the external computer box using an access code. These supplementary services are implemented with USSD (see Section 3.1.4).

Call transfer (CT)

Call transfer (CT) allows a GSM subscriber to transfer an established incoming or outgoing call to a third party (not the same as call forwarding). The established call is put into the hold state, the call to the third party is set up; the call can then be transferred. These supplementary services are implemented with USSD (see Section 3.1.4).

Completion of calls to busy subscribers (CCBS)

Allows a calling GSM subscriber to be informed when a called busy subscriber becomes free. If the calling GSM subscriber desires, the call to the subscriber specified previously is set up once again.

The calling GSM subscriber may be waiting for several subscribers to become free and may cancel one or all invocations. The canceling of one must include information which correlates with the initial invocation, e.g. transaction identity or destination. The number of invocations is limited.

At the time of this implementation, the CCBS supplementary service has not yet been finally standardized for GSM by ETSI. This solution is therefore only of a proprietary nature. These supplementary services are implemented with USSD (see Section 3.1.4).

Follow me

Generally the supplementary service follow me allows a GSM mobile subscriber to redirect calls to his own mobile station which originally have been destined to another GSM mobile subscriber's mobile station. Follow me enables an A-GSM mobile subscriber to manipulate the unconditional call forwarding events of a B-GSM mobile subscriber in order to control whether the incoming calls which were originally directed to the B-GSM mobile subscriber should be forwarded to the A-GSM mobile subscriber or not.

As the supplementary service follow me can be requested without any access control, this feature is specifically suited for usage in private mobile networks, such as GSM-R. In these kind of networks the follow me feature can be used for functional addressing across international networks. In future releases it is planed to extend this feature by an access control mechanism which allows to restrict the follow me service to authorized subscribers only (password protection). This will allow applications in public land mobile networks (PLMN).
These supplementary services are implemented with USSD (see Section 3.1.4).

3.1.4 Subscriber Control of Supplementary Services

- Subscriber controlled inputs (SCIs) for GSM supplementary services
  Subscriber controlled inputs (SCIs) for GSM supplementary services represent the control procedures with functional signaling, defined in the GSM standards, between the mobile station and the HLR. SCIs let a GSM subscriber control the supplementary services and if necessary modify the respective subscriber database in the HLR.
- SCI with container messages
  Unlike controlling GSM-defined supplementary services with functional signaling, controlling non-GSM-standard defined (PLMN-specific) supplementary services by GSM subscribers is supported by means of unstructured supplementary service operations on the basis of "unstructured supplementary service data" (USSD) as per GSM Phase 1. The USSD are also defined by GSM and allow PLMN-specific supplementary services to be incorporated. A USSD handler in the mobile station recognizes the USSD-MMI format structure, which can be similar to that of the SCI for GSM supplementary service. This USSD-MMI format structure has a different predefined character set. The USSD-MMI procedures are transported transparently by means of a container system from the mobile station to the location in the PLMN at which there is an application for the non-GSM service (MSC, VLR or HLR)

3.2 Fixed Network Telecommunications Services at the CSC

ISDN subscribers at the CSC:

Like GSM subscriber telecommunications services (Section 3.1), wired ISDN subscribers in the PLMN can be assigned CSC telecommunications services. This assignment is undertaken in the CSC concerned. Tab. 3.1 lists all the available telecommunications services.

ISDN bearer services, ISDN teleservices	ISDN supplementary services, ISDN features
ISDN bearer services	**ISDN supplementary services**
Circuit mode speech	CLIP/CLIR
Circuit mode 64 kbit/s unrestricted digital	COLP/COLR
Circuit mode 3.1 kHz audio	Call forwarding unconditional (CFU)
Packet mode, switched B channel access, case B	Call forwarding busy (CFB)
Packet mode, B channel access, case A	Call forwarding on no reply (CFNR)
ISDN teleservices	Call waiting (CW)
Telephony 3.1 kHz	Call hold (HOLD)
Telephony 7 kHz	Closed user group (CUG)
Videotelephony	Terminal portability (TP)
Telefax, group 3	Multiple subscriber number (MSN)
Telefax, group 4	Subaddressing (SUB)
Videotex ∗)	Direct dialing in (DDI)
Teletex ∗)	User-to-user signaling 1 (UUS1)
	ISDN features
	Call completion to busy subscribers (CCBS)
	Three-party service
	Call barring
	Catastrophe handling
	Emergency call
	Priority dialing
	Local dialing
	Line hunting services (Type=MLHG)
	Hot line delayed
	Hot line immediately
	Do not disturb
	PBX number economy
	More virtual PABX groups per PA
	Call deflection
	Partial rerouting

Tab. 3.1 Basic telecommunications services for wired ISDN subscribers at the CSC

ISDN bearer services, ISDN teleservices	ISDN supplementary services, ISDN features
	Overflow between DDI PBXs

*) Are possible for GSM subscribers with GSM bearer services BS2.x

Tab. 3.1 Basic telecommunications services for wired ISDN subscribers at the CSC

Analog subscribers at the CSC:

In addition to the wired ISDN subscribers the wired analog subscribers in the CSC of a PLMN can also be assigned telecommunications services (known as analog features). Tab. 3.2 below lists all the available features.

Analog features
3.1 kHz audio/speech
Call diversion immediate to any subscriber number
Call diversion to any subscriber number on no reply
Call diversion to any subscriber number on busy
Call waiting
Three-party service, hold for enquiry with 3-way conversation
Call completion to busy subscribers (CCBS)
Closed user group (CUG)
Abbreviated dialing
Direct dialing in
Series completion
Emergency call
Priority subscriber
Local dialing
Call barring
Line hunting services (Type=MLHG)
Hot line delayed
Hot line immediately
Overflow between DDI PABXs
PABX number economy
Do not disturb

Tab. 3.2 Telecommunications services for wired analog subscribers at the CSC

3.3 IN or CAMEL Telecommunications Services in the M-SSP

3.3.1 Categories of IN Services or CAMEL Services

In the M-SSP a distinction must be made between basic IN services and subscriber-specific services (see Tab. 3.3). Only the basic IN services are also available to wired ISDN/analog subscribers within a CSC with M-SSP functionality.

Category of IN/CAMEL service	Applicability to the kind of subscriber		Initiation of IN/CAMEL services
Basic IN services	All kinds of subscribers (Fixed network subscribers at CSC and GSM subscribers)		By dialing a special basic IN directory number
Subscriber-specific IN services (for fixed network subscribers at CSC)	Fixed network subscribers at CSC (wired ISDN/analog subscriber) as well as GSM subscribers with signed subscription of the corresponding IN service		By dialing a special IN directory number
	Fixed network subscribers at CSC (wired ISDN subscriber) with signed subscription of the corresponding IN service	IN services for originating calls with EDSS.1 signaling	Implicitly (with OLT/TLT)
		IN services for terminating calls with EDSS.1 signaling	
Subscriber-specific IN services (for GSM subscribers)	GSM subscribers for which the authorization of the relevant IN service is entered	IN services for MOC: supported by the MSC serving the calling GSM subscriber	Implicitly (with service class mark (SCM))
		IN services for MTC: supported by the MSC which performs the interrogation	
Subscriber-specific CAMEL services (for GSM mobile subscribers)	GSM mobile subscribers for which the authorization of the relevant CAMEL service is entered	CAMEL services for MOC: supported by the MSC serving the calling GSM mobile subscriber	Implicitly (with CAMEL subscription information (CSI))
		CAMEL services for MTC: supported by the MSC which performs the interrogation	

Tab. 3.3 Categories of IN services or CAMEL services in the CSC-SSP and M-SSP

Basic IN services, as well as subscriber-specific IN services for fixed network subscribers at CSC (wired ISDN/analog subscriber) as well as GSM subscribers are generally accessible by dialing a special (basic) IN directory number prefix.

Subscriber-specific IN services for ISDN fixed network subscribers at CSC with EDSS.1 signaling are accessible implicitly without being initiated by a specific directory number. The IN dialog is set up by the originating line trigger (OLT)/terminating line trigger (TLT) similiar to GSM subscribers with SCM or CSI concept.

Subscriber-specific IN services for GSM subscribers are accessible without being initiated by a specific directory number. For this IN marks (known as service class marks

(SCM)) which describe authorization to such IN services, are set in the GSM subscriber database.

Subscriber-specific CAMEL services for GSM mobile subscriber are initiated implicitly without a specific directory number. CAMEL service marks (known as CAMEL subscription information (CSI)) are set in the GSM mobile subscriber database in the HLR in order to describe authorization to such CAMEL services.

In the Siemens IN/CAMEL system for D900/D1800, the following **Basic IN services** are available for example in the current version:

- **Freephone service (FPH)**
  Service which allows no-charge calls to be made, i.e. calls at the expense of the service provider.
- **Teleinfo service (TIS)**
  Teleinfo service allows value added services with flexible charging to be used between service user and service subscriber.
- **Universal number (UN)**
  Service which allows getting of a subscriber on the terminal under a universal directory number in a network or in a country
- **Mass calling service (MCS) or Televoting (TV)**
  Service with which opinions can be offered for surveys with each call paying.

All basic IN services are reached exclusively via trigger and signaling procedures.

Subscriber-specific CAMEL services for GSM mobile subscribers must be defined in the HLR and assigned to the GSM mobile subscribers in correlation to the CAMEL subscription information (CSI). During call setup, similar basic procedures (triggering, signalling) are then used as are used for basic IN services.

Possible applications of subscriber-specific IN services or CAMEL services for GSM mobile subscriber are:

- International **Virtual private network (VPN)**
  A truly international VPN service with full on-net access and availability of private numbering plan features while roaming abroad.
- International **Control of use (COU)**
  Service, which allows control of the reachability status when GSM mobile subscriber is roaming abroad (e.g. checking of access to a mobile station, a screening function for mobile radio connections and the use of hot-key numbers).
- International **Prepaid service center (PPSC) subscriber/Debit subscriber**
  (GSM subscriber with prepayment and individual charging; see Section 3.3.2).
  International PPS is only possible with the CAMEL SCP/CSE supported rerouting concept (see a few pages above).

The mentioned services are also applicable for fixed network subscribers at the CSC.

3.3.2 GSM subscribers with Prepayment

D900/D1800 allows administration of GSM subscribers with prepayment (prepaid service (PPS) subscriber/debit subscriber) in the form of an IN solution. The basic demand of having GSM subscribers with prepayment is to access new target groups, to inhibit fraud and to minimize the administrative operating costs by direct booking of the call charges from a prepaid GSM subscriber account. Charges are booked out for GSM subscribers with prepayment by using the “prepaid service center (PPSC)” service in the SCP/CSE. The GSM subscriber does not generally receive a bill for these charges.

In the SCP/CSE, normally a specific amount of money is stored for the prepaid service GSM subscriber from which charges are deducted for all chargeable calls made by this subscriber e.g. MOC - who meets an activated supplementary service call forwarding (CFU, CFNRc). For each call setup, the SCP/CSE is initially interrogated by this IN service or CAMEL service. If the account balance of the prepaid service GSM subscriber allows, the desired call can be set up.

While a call is active the SCP/CSE makes regular checks on the account balance and disconnects the call if necessary (after warning the prepaid service GSM subscriber beforehand), when the account balance reaches a given threshold during the call (e.g. “zero”). The prepaid service GSM subscriber can enter a control procedure (USSD or DTMF) at the mobile station to request his remaining SCP/CSE charge account.

3.3.3 Charge Recording with the M-SSP

For the charge recording for the service user with M-SSP there is the function complex “influencing the charge recording with SCP”. Within this function complex the IN solution of the GSM supplementary services AOC information level (AOCI) and charging level (AOCC) achieves a special part function for an MOC. This function lets the SCP directly influence the AOC charging parameter and therefore transmit the current charge information to the mobile subscriber. The SCP receives the necessary modified interfaces in the M-SSP for accepting this charging information from the INAP signaling (SendChargingInformation). Disadvantages of the GSM standard solution for AOC can be improved with this IN-AOC solution, e.g. the subscriber authorization data of the service user or the relevant service provider or the tariff model can be used here.

4 Switching Subsystem (SSS)

4.1 System Architecture

PLMN SSS

The switching subsystem (SSS) is responsible for call processing and the administration of GSM subscriber and mobile equipment data. The SSS contains the following network elements (see Fig. 4.1):

- the mobile-services switching center (MSC)
- the visitor location register (VLR)
- the home location register (HLR)
- the authentication center (AC)
- the equipment identification register (EIR)

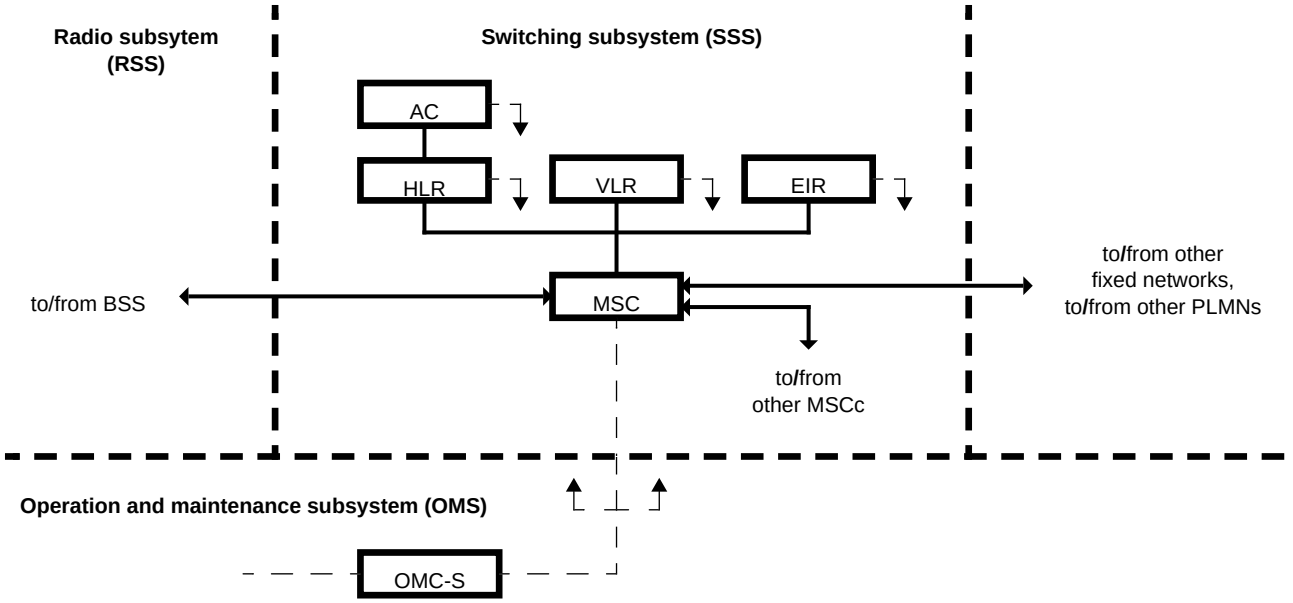


Fig. 4.1 Network structure of the SSS

Network nodes house the network elements of the switching subsystem. One or more network elements may be located in one network node. The composition of network elements in a network node depends on the operational and geographical network requirements of the PLMN operating company. The dynamic load, interworking and reliability aspects also have to be taken into account. All these requirements and factors determine whether an integrated or a stand-alone arrangement provides the best solution. The most common solution is provided by combining all network elements (MSC, VLR, HLR, AC, EIR) in one network node. The advantage here is that the dynamic load, caused for example by interworking via CCS7 signaling links, is kept to a minimum. Another approach is to combine the network elements in accordance with the requirements of the PLMN operating company. Combinations MSC/VLR and HLR/AC (where an EIR is combined with the combination MSC/VLR or HLR/AC, or can be self-contained if necessary) are a suitable solution mainly concerned with the most flexible way of structuring the D900/D1800 PLMN.

The network nodes in the switching subsystem are realized with the proven Siemens Digital Electronic Switching System (EWSD). The advantages of EWSD include:

– fully digital design
– compliance with ITU-T and ETSI
– completely modular
  hardware, autonomous subsystems with their own controls
  software, functionally divided into software shells, subsystems and modules
– mechanical construction, flexible in combining modules, frames and racks
– clear-cut function organization
– standardized internal and external interfaces
– mature CHILL technology
– extensive safeguarding measures to ensure trouble-free operation

Combined switching center (CSC)

The system architecture of a combined switching center (CSC) is determined by how it is used within the network environment concerned (i.e. as regards use of GSM-RITL-subscribers in a PLMN or PSTN environment) by the following network elements (Fig. 4.2):

– fixed network local exchange (LE)
– mobile switching center (MSC)
– home location register (HLR)
– visitor location register (VLR)
– authentication center (AC)
– equipment identification register (EIR)

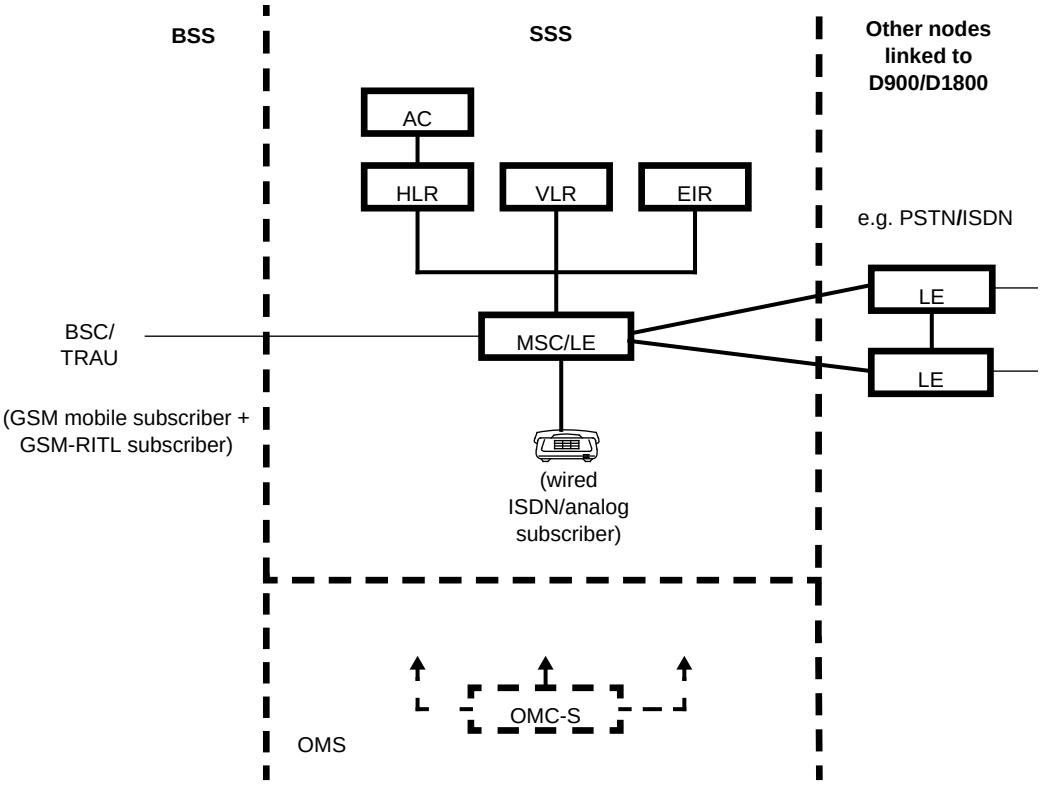


Fig. 4.2 Network elements of a PLMN-SSS with CSC

These network elements are produced by the subsystem configuration described in Section 4 (hardware and software).

IN/CAMEL subsystem functions M-SSP and service control point (SCP)/CAMEL service environment (CSE) in the GSM PLMN

The system architecture of an IN/CAMEL in the GSM PLMN and thus access to IN services or CAMEL services for service users is determined in an MSC (or CSC in a PLMN environment) with IN/CAMEL functions dependent on the network environment (see Fig. 4.3) .

D900/D1800 implements the integrated IN/CAMEL function: The SSP function is integrated into each MSC/VLR or CSC of a PLMN. This type of network node is referred to as an M-SSP. The SCP/CSE is architecturally part of the PLMN.

A CSC in a PSTN environment can logically be considered to be just like an MSC in the PLMN: The SSP function can be implemented into the own CSC or be reached via an SSP inside or outside the own network.

Network element M-SSP (SSP combined with an MSC/VLR network node or CSC) is produced by the subsystem configuration (hardware and software) described in Section 4.2 and 4.3. The IN/CAMEL network elements SCP/CSE or service management point (SMP) are not implemented by the D900/D1800 network components or network node subsystems described here but by other designs of computer network node.

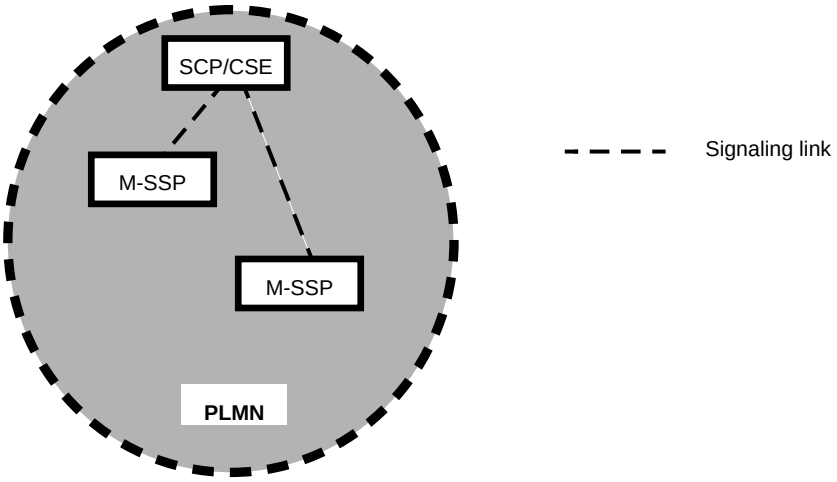


Fig. 4.3 Access to IN/CAMEL functions via M-SSP in the PLMN

4.1.1 Network Elements

Mobile-services switching center (MSC)

The MSC is a stored-program controlled digital switching center. The MSC is the switching center in the PLMN, which

- performs call processing
- acts as a gateway to other networks,
- is linked to other MSCs in the PLMN,
- connects the network elements of the SSS with the network elements of the BSS in the service area of the PLMN.

The MSC has functions that are familiar from the switching centers of the fixed networks as well as special functions that are not necessary in the switching centers of the fixed networks. The mobile communication-specific functions are provided because of the mobility of the GSM subscribers.

The basic functions of the MSC are, for example:
- choice of routes
  (e.g. with the function ”trunk reservation” it is possible to reserve transmission channels for the routing of emergency calls to emergency call centers)
- setting up traffic and signaling connections
- supervision of connections
- call charge registration
- traffic measurement
- overload handling
- support of telecommunication services
- juridical interception
- charge accounting

Enhanced functions of call routing, charging and user information are, for instance:
- flexible routing of calls in the SSS (A-number dependent)
- IMSI/MSISDN dependent routing
- GSM subscriber data specific routing
- GSM subscriber data charging generation
- multilingual announcements

The mobile-specific call processing functions in the MSC are:
- expansion of basic functions within the PLMN
  (e.g. cell-oriented routing of service numbers; GSM-subscriber-related routing of service numbers)
- mobility administration:
  interrogation,
  paging,
  handover,
  location update
- resource management (e.g. supporting half-rate channel operation)
- access to PLMN databases (VLR, HLR, EIR)
- control of queue operation with priority stages for the BSS
- special security functions (e.g. checking the IMEI)
- interworking function (IWF) for GSM data services
- fraud prevention functions
- capacity increasing function

Other network elements of the SSS can also be implemented in the MSC network node (e.g. the VLR).

Combined switching center (CSC)

Within a PLMN SSS one of the CSC’s functions is to perform all the tasks of a MSC/VLR network node for GSM mobile subscribers, another is to perform the functions of a local exchange for GSM-RITL subscribers and wired ISDN/analog subscribers. When included in a GSM PLMN the CSC links the other network elements of the PLMN SSS with the BSS for GSM mobile subscribers and GSM-RITL subscribers. The CSC also forms the access network node for fixed network subscribers at CSC (wired ISDN/analog subscribers).

Examples of underlying functions, i.e. those that extend beyond the MSC functions of the CSC are:
– routing for wired ISDN/analog subscribers
– supporting telecommunications services for wired ISDN/analog subscribers
– ISDN/analog subscriber database in network element LE in the CSC
– charge recording for wired ISDN/analog subscribers

Additional mobile-radio-specific functions of the CSC which extend beyond the MSC functions are as follows:
– mobility administration (particularly location registration specifically for GSM-RITL subscribers, i.e. roaming only within a defined location area
– identification and addressing (fixed network directory number specifically for GSM-RITL subscribers)
– access to GSM-RITL subscriber databases (VLR, HLR, AC)

Mobile service switching point (M-SSP)

Within a PLMN SSS one of the M-SSP's (SSP combined with an MSC/VLR-network node or CSC) functions is to perform all the tasks of an MSC/VLR-network node or CSC. When included in a GSM PLMN the M-SSP (mobile SSP) links the other network elements of the PLMN SSS with the BSS. The M-SSP also forms the interface to the other network elements of the IN/CAMEL, that is to the service control points (SCP)/CAMEL service environment (CSE) and from there to the service management points (SMP). In an M-SSP there is what is known as an internal IP (intelligent peripheral) which provides such features as user-defined IN announcements.

Typical examples of additional MSC functions which extend beyond IN/CAMEL-specific functions of the M-SSP are:
– call setup and cleardown (transaction setup and cleardown to the SCP/CSE)
– routing (IN or CAMEL triggering)
– identification and addressing (IN/CAMEL directory number for basic IN service and subscriber-specific IN service for fixed-network subscribers, OLT/TLT for subscriber specific IN services for fixed-network subscribers, service class mark (SCM) for subscriber-specific IN service for GSM subscribers, CAMEL subscription information (CSI) for subscriber-specific CAMEL service for GSM mobile subscribers)
– user information (e.g. IN tones, IN announcements via the internal intelligent peripheral (IP))

Visitor location register (VLR)

The VLR is essentially a database that holds all information on those GSM subscribers currently roaming in the VLR area it controls.

On connection setup, the VLR can recognize a GSM subscriber by the following identifiers:
– the international mobile subscriber identification (IMSI)
– the local mobile subscriber identification (LMSI)
– mobile station roaming number (MSRN) or
– the temporary mobile station identity (TMSI) together with the local area identity (LAI).

When a GSM subscriber checks into a VLR service area, this information is forwarded to his home location register (HLR). An authentication check may have gone before. The HLR then sends to the VLR information about the authorization status of this GSM subscriber.

For the duration of call setup the VLR allocates a mobile station roaming number (MSRN); as soon as this is requested in a mobile terminating call (MTC) by the network-access MSC (GMSC) via the HLR. The connection is set up via this number.

The VLR service area covers one or more location areas. As long as an MS only moves within one location area, it is not necessary to update the visitor location register VLR.

The VLR database is split into a semipermanent and a transient part. The semipermanent part is imaged on double disks.

The signaling-routing database resides in the semipermanent part of the VLR database. It contains the IMSI and the LAI digit translator, which supply the HLR address and the address of the previous VLR.

The national roaming database stores in its semipermanent part the data for the areas in which GSM subscribers are allowed to set up a connection in accordance with national agreements.

The GSM subscriber database resides in the transient part of the VLR database. It contains the call processing data of the GSM subscribers currently roaming in this area. Its memory is allocated dynamically and separately for each GSM subscriber. The data are distributed in several pools, e.g.:

– in the common data pool with IMSI, ISDN; TMSI, LAI and the registered services
– in the basic telecommunications data pool with the registered and activated supplementary services (e.g. call forwarding data)
– CUG data pool (e.g. CUG index)

Another transient database contains the temporary mobile subscriber identities (TMSI). With these an individual GSM subscriber is addressed and identified.

The VLR database contains the current ciphering key (Kc) and the ciphering key sequence number sent to the MS during authentication.

The VLR is realized in the MSC network node in the D900/D1800 SSS standard configuration.

Home location register (HLR)

The HLR contains the main database of the GSM subscribers. The database entries may be generated, deleted and read by the PLMN operator, remotely by the OMS-S or by a PCS (personalization center for SIM) via the OMS-S or on the local O&M terminal (BCT). By subscriber controlled input (SCI) the GSM subscriber can also remotely input specific subscriber data (for supplementary services).

At call setup, the HLR can identify a GSM subscriber with the aid of the following identifiers:

– international mobile subscriber identifier (IMSI)
– international mobile subscriber identifier (MSISDN)

The HLR participates in setting up a mobile terminating call (MTC). On setup of an MTC the HLR is requested by the network access MSC (GMSC), to retrieve the mobile subscriber roaming number (MSRN) of the GSM subscriber from the current VLR. The HLR does this and sends the MSRN to the GMSC.

During a location update the HLR supports the current VLR of the GSM subscriber by supplying the necessary data, and the VLR in turn supplies its VLR address.

The HLR database contains both semipermanent and transient data.

The semipermanent data include:

– HLR GSM subscriber data

– signaling data (network data of the HLR)

The transient data include:
– HLR GSM subscriber data
– traffic measurement data

The semipermanent HLR GSM subscriber data are split into the following data modules and tables:
– common data module
– basic telecommunication service data module
– supplementary services data module
– MSISDN bearer capability data module
– CUG data module
– GSM bearer capability information element (BCIE) table
– roaming restriction table
– SIM chip card exchange table (IMSI exchange)
– HLR services table (for GSM subscribers with access authorization to specific service centers, e.g. for routing dependent on the directory number of the calling GSM subscriber)

The transient HLR GSM subscriber data are split into the following data modules:
– mobility data module
  (e.g. MSRN, relationship to the VLR address and local mobile subscriber identification (LMSI))
– short message waiting data module

Authentication center (AC)

The AC is equipped with several security boxes, in which the authentication keys and algorithms required for generation of the authentication parameters of a GSM subscriber are stored. In the AC for each GSM subscriber a number of authentication parameters RAND (random number), authentication response (SRES, signed response) and Kc (cipher key) are generated, before the GSM subscriber obtains access to the network. The authentication parameters are used by the VLR for authentication tests, i.e. to determine whether a GSM subscriber is authorized for access to the network and call setup.

On request from the HLR the AC supports the required number of triplets and removes them from the AC database. New triples are then calculated, in order to bring the set of triples up to strength again.

The AC administers all together the following safety-related functions
– administration of the secret individual authentication keys (Ki) of the GSM subscribers
– generation of n triples (RAND, SRES, Kc) for each GSM subscriber
– storing the PLMN operator-specific algorithms A3/A8 (and A2, A4, A7) in the security box

The AC database is divided into a semipermanent and a transient part. The semipermanent part is imaged on duplicated disk devices and is updated by each data change.

The semipermanent part of the database consists of the sections:
– AC GSM subscriber database
  contains the individual authentication key (Ki) in A2 encrypted form, the version number of the algorithms A3/A8, and the A2 identification for calling up the A2 algorithm.

– triple table
  contains a triple set for each GSM subscriber.
– key database
  contains key organization data (for K2, K4, K7) and encrypted and marked keys for data protection purposes.

The transient part of the database consists of the sections:
– triple database
  contains 5 sets of triples (RAND, SRES, Kc) at each instant for each IMSI.
– triple status table
  states for each GSM subscriber whether valid triples are present.
– key reference table
  for storing K4 keys for the duration of a communication connection.

The AC is collocated with the HLR in a network node in the D900/D1800-SSS standard configuration.

Equipment identity (EIR)

The EIR stores the equipment identity of the mobile stations. Using this information, the MSC can check whether the equipment of a GSM subscriber is approved, whether it is to be observed or whether it is even to be barred from service.

In the EIR the mobile stations are arranged in three lists:
– the white list for approved mobile stations
– the grey list for mobile stations to be observed
– the black list for barred mobile stations

The EIR test is requested by the MSC. When the EIR receives a request from the MSC it looks for the international mobile equipment identity (IMEI) concerned in the database (white, grey, black list) and sends back an acknowledgment to the MSC indicating whether the IMEI is unknown, or whether it is in the white, grey or black list. Subsequent actions taken by the MSC are dependent on this result.

The EIR (IMEI) database contains semipermanent data. The database is imaged on double hard disks, which are continuously updated and kept consistent.

The white list contains the type approval code (TAC) and the final assembly code (FAC), both of which are known as ”number series” (and a serial number range). The gray and the black list are realized in a further section of the database. Access to these is obtained via the 15-digit IMEI number. The IMEI is considered to be unknown, if it does not appear in any list.

In the D900/D1800-SSS the EIR can be implemented in a network node together with HLR/AC or MSC/VLR or where necessary in a self-contained network node.

4.1.2 Combination of Network Elements

The modularity of the D900/D1800 network elements allows different configurations of the SSS. Each configuration consists of the SSS network elements mentioned above.

The following points must be taken into account when selecting a configuration:
- performance capacity
- storage capacity of the coordination processors involved
- transmission capacity of the links between the separate network nodes

Estimates of the transmission capacity of the CCS7 show that the VLR should not be physically separated from the MSC. The same applies to AC and HLR. When considering the combination of EIR network elements network-organization criteria are of primary interest.

This produces either the combination HLR/AC/EIR or also MSC/VLR/EIR or an EIR on its own. When a CSC network node is used this results in the combination LE/MSC/VLR, and when an M-SSP network node is used in the combination SSP/MSC/VLR or SSP/LE/MSC/VLR.

Fig. 4.4 shows a block diagram with a combination of HLR/AC or HLR/AC/EIR or with an EIR on its own. Fig. 4.5 shows a block diagram with a combination of MSC/VLR.

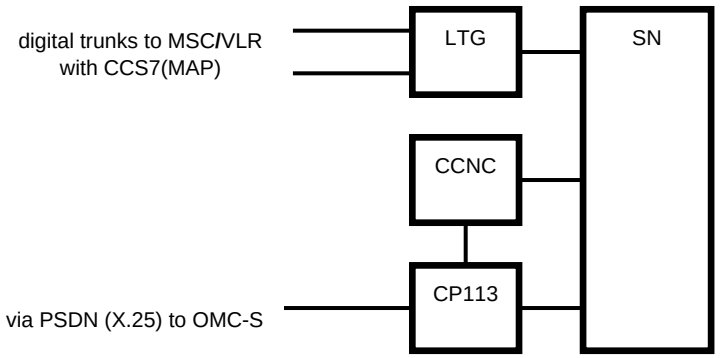


Fig. 4.4 Block diagram with a combined HLR/AC or HLR/AC/EIR or with a stand-alone EIR network node

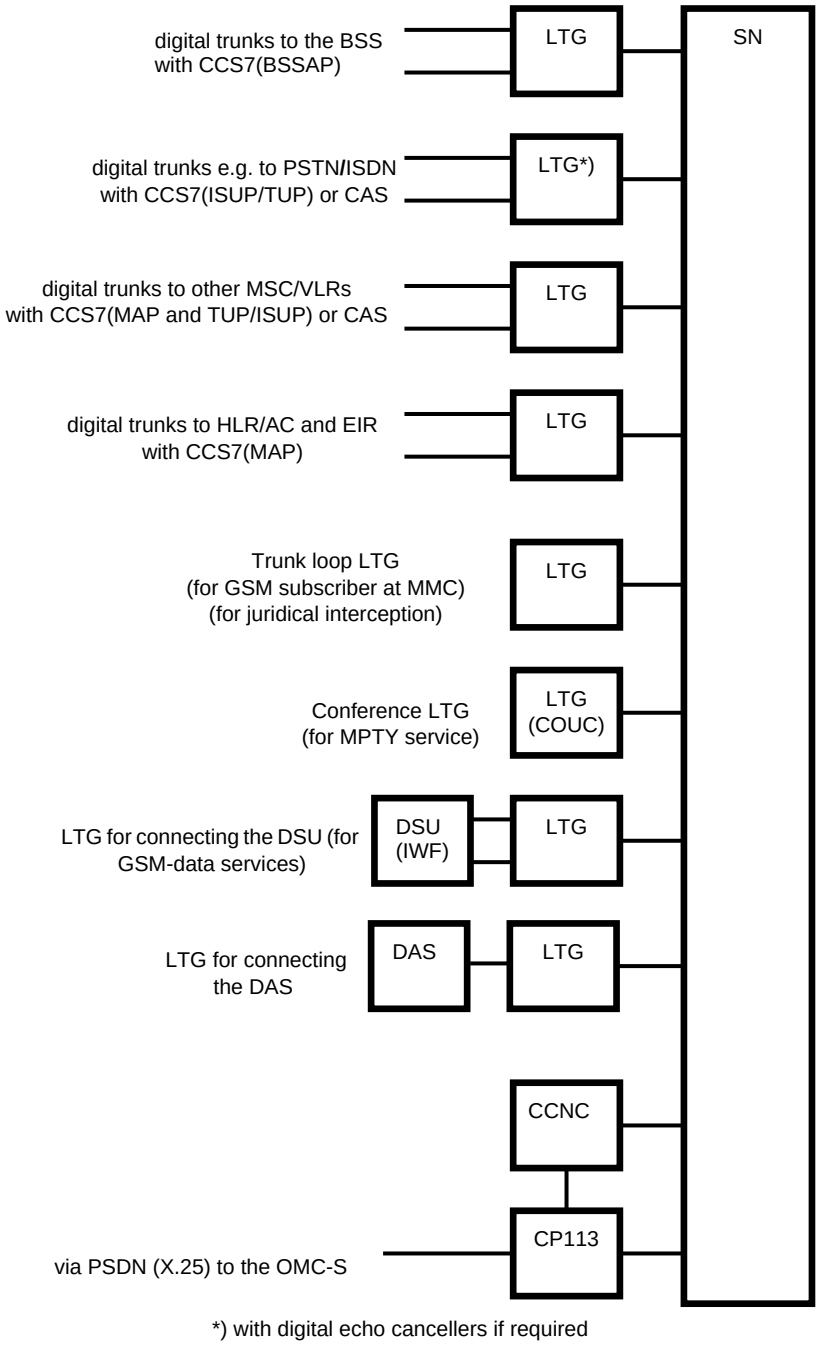


Fig. 4.5 Block diagram with a combined MSC/VLR (including MiniSwitch) or MSC/VLR/HLR/AC node

4.1.3 Interfaces

Interface PLMN – Public-switched telephone network (PSTN)

This interface is used to connect the GSM PLMN to the fixed PSTN network. The provision of signaling systems (e.g. CCS7(TUP), CAS(IKZ50, MFC:R2)) and services is the responsibility of the country concerned. The number of traffic and signaling channels used is dependent on the MSC/CSC/M-SSP traffic load.

Interface structure:
– traffic channel, PCM30 (A law) with 64 kbit/s unrestricted or 3.1 kHz audio restricted (national decision)
– CCS7 signaling (e.g. TUP) or CAS channel associated signaling (e.g. IKZ50, MFC:R2; national decision)

Interface PLMN – Integrated services digital network (ISDN)

This interface is used to connect the GSM PLMN to the fixed ISDN network. CCS7 is used for those services offered by GSM PLMN. The number of traffic and signaling channels used is dependent on the MSC traffic load.

Interface structure:
– traffic channel, PCM30 (A law) with 64 kbit/s unrestricted
– CCS7 signaling (ISUP)

Interface PLMN – Packet-switched data network (PSDN) *)

This interface is necessary for packet-switched data services which are not supported by the connected ISDN or PSTN. Interworking functions (IWF) are necessary in order to adapt the GSM bearer services and low layer compatibilities as defined by GSM standards.

Interface structure:

The interface definitions are the responsibility of the country concerned.

*) The interface can be implemented with a PAD access or a packet handler (PH) access. The PAD access is "circuit switched", i.e. with CCS7 signaling. Access from the PAD to the PSDN is controlled from the PAD. With basic PAD access the PAD access is generally via PSTN/ISDN. The PLMN operator is not the PAD operator. With dedicated PAD access PAD access can be direct. The PLMN operator can be the PAD operator (by purchasing or leasing).
PH access can be “circuit switched” (X.31 case A) or "packet switched" (X.31 case B). Access to the PSDN is controlled by the PH.

Interface PLMN – Circuit-switched data network (CSDN) **)

This interface is required for circuit-switched data services that are not supported by the connected ISDN or PSTN. Interworking functions (IWF) are only required for matching the GSM bearer services and the low-layer compatibilities as defined in the GSM standards.

Structure of the interface:

Interface definitions are laid down in accordance with the national regulations.

**) This interface is not supported by D900/D1800. A CSDN access is possible via ISDN, however.

Interface PLMN to other PLMNs via PSTN/ISDN

The interface of the PLMN to another PLMN via one or several PSTN/ISDNs is specified in the GSM standard as an interconnection interface.

The configuration of one PLMN does not affect another PLMN, if both comply with the GSM standards.

The interfaces depend on the national implementations, e.g. the PSTN type.

Interface MSC – VLR (B-Interface)

This interface is used for access by the MSC to the VLR database of the GSM subscriber, if these data are required in the MSC.

Since the MSC is combined with a VLR, an external CCS7 interface is not necessary. The signaling communication is handled inside the SSS network node.

From GSM Phase 2 onward, this interface is no longer defined in the GSM standards.

Interface MSC – HLR (C-Interface)

This interface is chiefly required when the MSC performs the function of a network access MSC (GMSC). In an MTC it supports the interrogation of the HLR database with respect to the signaling routing information.

Structure of the interface: CCS7 signaling (MAP)If the MSC besides other network elements is combined with the HLR in the configuration MSC/VLR/HLR/AC/EIR, no external CCS7 interface is necessary. The signaling communication is handled inside the SSS network node.

Interface VLR – HLR (D-interface)

This interface is used for the transfer of GSM subscriber data between the VLR and HLR databases.

Structure of the interface: CCS7 signaling (MAP)

If the VLR besides other network elements is combined with the HLR in the configuration MSC/VLR/HLR/AC/EIR, no external CCS7 interface is necessary. The signaling communication is handled inside the SSS network node.

Interface MSC – MSC (E-interface)

Via this interface a connection is setup between one MSC service area and another. It is used for setting up mobile terminating calls (MTC) and mobile originating calls (MOC) and connection setup at handover. The interface covers traffic channel connections and CCS7 signaling connections.

Structure of the interface:
– traffic channel, PCM30 (A-law)
– CCS7 signaling (ISUP, MAP) or in special cases national PSTN signaling (e.g. TUP or MFC:R2)

Interface MSC – EIR (F-interface)

This interface is used for interrogation of the equipment status of a mobile station with the aid of the international mobile equipment identifier (IMEI) of the GSM subscriber.

Structure of the interface: CCS7 signaling (MAP)

If the VLR besides other network elements is combined with the HLR in the configuration MSC/VLR/HLR/AC/EIR, no external CCS7 interface is necessary. The signaling communication is handled inside the SSS network node.

Interface VLR – VLR (G-interface)

This interface is used for the transmission of GSM subscriber data between VLR during location registration.

Structure of the interface: CCS7 signaling (MAP)

Interface HLR – AC (H-Interface)

This interface is used to interrogate the AC database for authentication parameters of the various GSM subscribers in the case of a decentralized AC.

Structure of the interface: CCS7 signaling (MAP)

If the VLR besides other network elements is combined with the HLR in the configuration MSC/VLR/HLR/AC/EIR, no external CCS7 interface is necessary. The signaling communication is handled inside the SSS network node.

Interface MSC – BSS (A-interface)

The A-interface is the interface from the TRAU to the MSC. It is used as follows:
– voice/data traffic
– BSS management (e.g. channel assignment)
– connection control (e.g. setup of MTC/MOC)
– mobility management (e.g. location update)
– supplementary services
– short message service
– dual-tone multi-frequency signaling (DTMF)

The interface embraces traffic channels and CCS7 signaling connections.

Structure of the interface:
– traffic channel, PCM30 (A-law) with GSM bearer services
– CCS7 signaling (BSSAP; DTAP and BSSMAP)

Interface PLMN – satellite network

An MSC can be used as gateway-MSC (GSC) for interworking from a PLMN (or also PSTN/ISDN) to a satellite network. This GSC then provides an interface to a “BSC” in the direction of the satellite on the one side and an interface (E-interface) between a GSC and a gateway MSC (GMSC) of the PLMN, for example, on the other side. It is also possible to support the latter interface via satellite. Both interfaces are compliant with ITU-T G.703 and employ preventative cyclic retransmission (PCR) to safeguard data transmission.

Interface M-SSP – SCP/CSE and HLR – SCP/CSE

The *interface M-SSP - SCP/CSE* is used for communication between IN/CAMEL network elements M-SSP and SCP/CSE.

Structure of interface: CCS7 signaling (INAP or CAP)

The interface only includes CCS7 signaling links.

The *interface HLR - SCP/CSE* is used for communication between GSM network network elements HLR and SCP/CSE.

Structure of interface: CCS7 signaling (MAP v3)

Interface PLMN – Internet

The interface between the PLMN and the Internet is not specified by the GSM standard as an external interface. This interface is necessary for access to the Internet.

The interface structure corresponds to the Siemens mobile Internet access (MIA) solution, Step 1. This interface is realized with an ISDN primary rate access (PA) between the MSC and remote access server (RAS).

Structure of interface: EDSS.1 signaling

Interface CSC – wired ISDN/analog subscribers at CSC

This interface is used to connect wired ISDN/analog subscribers to the CSC.

Structure of interface: EDSS.1 signaling for ISDN subscribers, and
pulse/multifrequency dialing for analog subscribers.

The interface includes user channels and EDSS.1 or pulse/multifrequency signaling links.

Interface SSS – OMS-S or OS

This interface is used for central operation and maintenance of the switching subsystem (SSS). The network elements of the SSS are connected via X.25 interface links of a packet-switched data network (PSDN) with the OMC-S of the OMS. The network components of the operations system (OS) can be linked to the OMC-S either with X.25 interface connections of a packet switched data network (PSDN) or with TCP/IP interfaces connections (via LAN). The SSS network elements also can be connected with the OS network components directly.

The O&M interfaces via the PSDN are components of a TMN (telecommunication management network) with a Q3 interface structure.

The OSI layer structure of the O&M interface is as follows:
– Layers 1 to 3 as per ITU-T X.25 Recommendations
– Layers 4 to 7: OSI protocol stack functions, where layer 7 has user-specific services (e.g. CMISE, FTAM and TMN/SAS server)

4.2 Hardware

The hardware represents the physical components of a system. In a modern switching system such as D900/D1800 SSS the hardware is modular, reliable, flexible and of high quality. It also permits adaptation to new technologies and economic manufacturing (also in the country of use). This is achieved by:

– clear and easy-to-understand, future-oriented hardware architecture
– modular mechanical design (Section 4.2.2)
– use of modern hardware technologies
– painstaking hardware quality assurance (Section 9)

4.2.1 Hardware Architecture

The hardware architecture of D900/D1800 SSS permits many flexible combinations of switching subsystem elements and has clearly-defined interfaces. This forms the basis for cost-effective use of D900/D1800 in all areas of the broad spectrum of applications. Functions determined by the network environment are handled by the line trunk groups (LTGs). The common channel signaling network control (CCNC) handles the message transfer part (MTP) of signaling system CCS7. The function of the switching network (SN(B)) is to interconnect the trunks in accordance with the call requirements of the subscriber and the network administration. The controls of the subsystems involved carry out practically all the tasks arising in their area independently (e.g. the line/trunk groups handle digit reception, charge registration, supervision and other functions). Only for system-wide and coordination functions, such as routing and zoning for example, do they require the assistance of the coordination processor (CP113C/CR). The MSC/VLR network node can be realized as a **MiniSwitch**, that is a very compact SSS node with switching functions. In this case the coordination processor CP113CR (rural version) is used. Fig. 4.6 shows how the most important controls are distributed throughout a SSS network node (without CSC or M-SSP function). This principle of distributed control reduces the amount of coordination involved and the necessity for communication between the processors, and contributes to D900/D1800's very high dynamic performance standard. The flexibility inherent in distributed control also makes it easy to introduce and modify features and to assign features to specific subscribers.

For interprocessor communication, the switching network sets up 64-kbit/s connections in the same way as connections between subscribers. However, the connections between the processors remain established and are therefore referred to as semipermanent connections. This avoids the need for a separate interprocessor control network.

The structure of an SSS network node comprises the following main hardware components:

– line trunk groups (LTG)
– data service unit (DSU)
– digital line unit (DLU) in the case of a CSC
– switching network (SN)
– common channel signaling network control (CCNC)
– coordination area with coordination processor (CP113)

Fig. 4.6 shows an example of an SSS network node (i.e. without DLUs of a CSC or LTGs of a M-SSP network node).

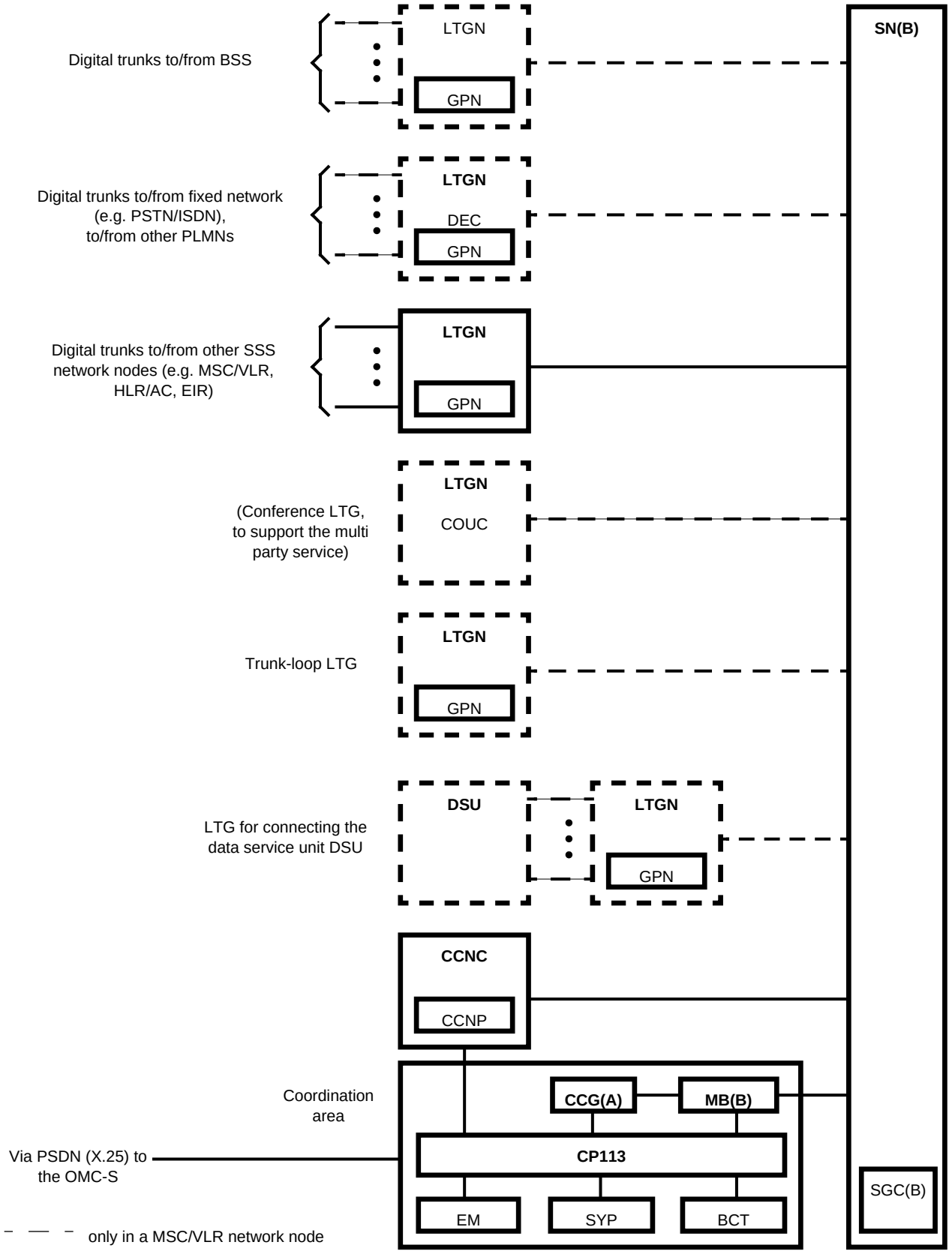


Fig. 4.6 Structure of a D900/D1800 network node in the SSS

With the current software version the hardware components described in the next sections are used for new equipping of the SSS network node. These components are:

- line/trunk groups (LTG) of type N for trunk use including DEC use and trunk-loop use and for supplementary service multiparty, Type G for internal IN intelligent peripheral
- data service unit (DSU) for the interworking function (IWF)
- digital line unit B (DLUB) for access of wired ISDN/analog subscribers
- switching network (SN(B))
- common channel signaling network control (CCNC)
- coordination area, with coordination processor (CP113C/CR)

4.2.1.1 Line Trunk Groups (LTG)

The different LTGs control and supervise the incoming and outgoing trunk traffic (MTC and MOC) to and from:

- the base station system (BSS)
- other public networks
  (e.g. other PLMNs or fixed networks (PSTN/ISDN etc.))
- other D900/D1800-SSS network nodes
- short message service centers (SMSC)
- service center for GSM-subscriber-related routing of service numbers
- voice mail system centers (VMSC)
- IN/CAMEL network node (SCP/CSE)

Furthermore the LTGs control the connection to the fixed network subscribers at the CSC:

- wired ISDN/analog subscribers served by the CSC (direct to the LTG via primary access (PA) for ISDN subscribers or via a DLUB for all other cases)

In addition, the LTG controls the connection traffic to special functions, such as :

- interworking function (IWF) in the DSU (for GSM data services)
- trunk loop function (for connections with ISDN/analog subscribers on the CSC and mobile to mobile calls (MMC))
- trunk loop function (for connections with juridical interception)
- conference function (when using the supplementary service multi-party)
- user-interaction (UI) function (with IN; implementation of an internal IP)
- digital announcement systems (DAS) in the MSC/CSC

The LTGs support all normal signaling systems (e.g. CCS7, MFC:R2). Digital echo cancellers (DEC) are used on the connections to/from subscribers of the PSTN and for mobile to mobile calls (MMC).

Although the signaling methods on the lines may differ, the line/trunk groups (LTG) have an internal signaling-independent interface to the switching network. This simplifies:

- flexible introduction of additional or modified signaling procedures
- a signaling-independent software system in the CP113C/CR for all applications

The bit rate on the multiplex lines linking the line/ trunk group (LTG) and the switching network is 8192 kbit/s (8 Mbit/s). Each 8-Mbit/s highway contains 128 channels at 64 kbit/s each. Each LTG is connected to both planes of the duplicated switching network (SN).

Depending on the use of the LTG the following two different LTGs may be used:
– LTGN (for all kinds of trunks and connection lines and for a conference LTG for multi-party)
– LTGG (for the implementation of a user interaction LTG for internal IN-IP)

Each **LTGN** has the following functional units (Fig. 4.7):
– group processor N (GPN)
– supplementary LTU position (LTU:S) (with digital echo cancellers (DEC120) and conference unit C (COUC))

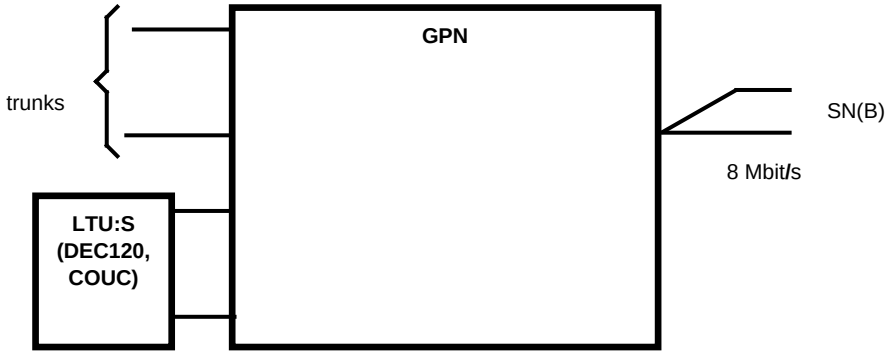


Fig. 4.7 Line/trunk group N (LTGN)

Each **LTGG** has the following functional units (Fig. 4.8):
– group processor (GP)
– group switch and interface unit (GSL)
– signaling unit (SU)
– line trunk unit (LTU0 ... 4)
(in the case of a LTG used for internal IP in a M-SSP IN network node: with max. 1 OCANEQ speech processor control and memory (OCE:SPM), and 3 code receiver modules (CRP8))

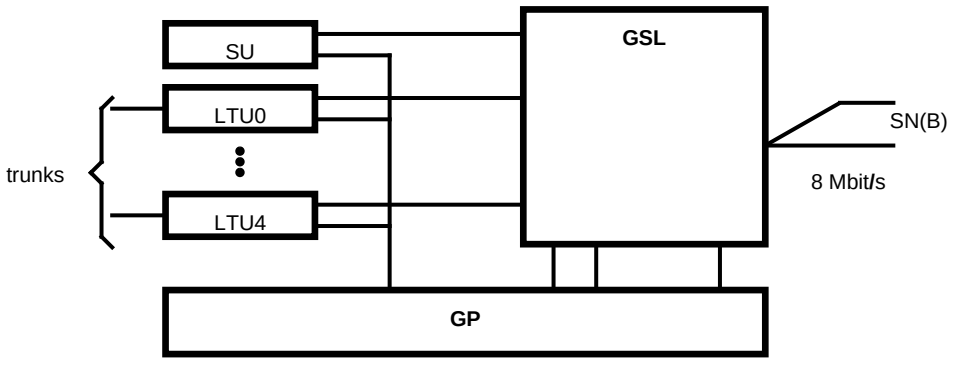


Fig. 4.8 Line/trunk group G (LTGG)

4.2.1.2 Data Service Unit (DSU)

The data service unit (DSU) serves to support the bearer services (pure data services).

The data service unit DSU consists of the central functional units (Fig. 4.9):

– DLU systems (0 and 1)
  (in each case with modules: digital interface unit for digital line unit (DIUx), digital line unit control (DLUC) and bus distributor BD.. with clock generator ..CG (BDCG))
– signal distribution networks

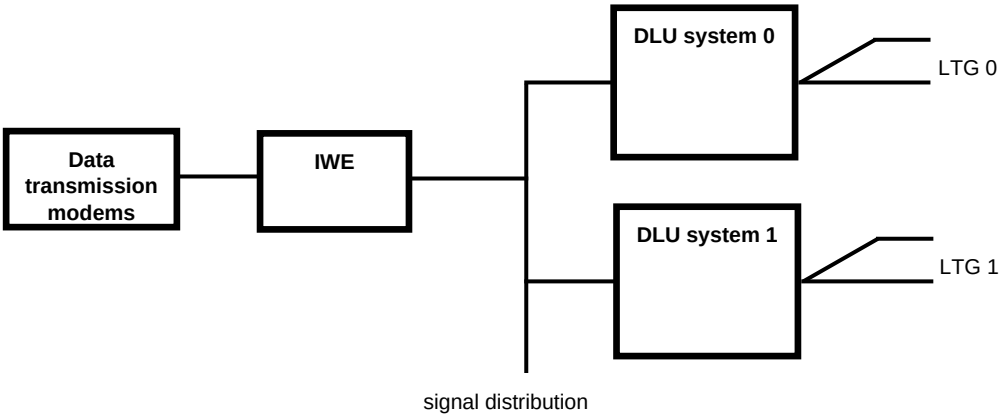


Fig. 4.9 Data service unit (DSU)

The central functional units are joined by the ”peripheral” units:

– interworking equipment (IWE)
– data transmission modems (multi modems according to V.21, V.22, V.22bis, V.23, V.32, V.32bis, V.34 and V.42/V.42bis)

For data transmission and the associated bearer services it may be necessary to match the radio side to the fixed-network side (e.g. PSTN/ISDN). For this reason in the MSC interworking functions (IWF) are provided. The IWF are introduced into the connection via line/trunk groups.

They perform the following functions:

– mapping the GSM signaling to the ISDN signaling and vice-versa
– synchronization of the traffic channel
– matching the bitrate to the radio side and to the fixed-network side (in areas where digital connections are used throughout)
– modem and codec functions, in case digital connections cannot be guaranteed on the whole route

4.2.1.3 Digital Line Unit B (DLUB)

Digital line unit B (DLUB) is used to connect wired ISDN/analog subscriber lines (incl. analog access lines for analog PABXs) at the CSC.

Digital line unit B (DLUB) consists of the following central functional units (Fig. 4.10):

– DLU systems (0 and 1)
  (each with modules “digital interface unit for digital line unit (DIUx)”, “digital line unit control (DLUC)”, central clock generator for DLUB (GCG:DLUB) and bus distributor BD)
– signal distribution networks

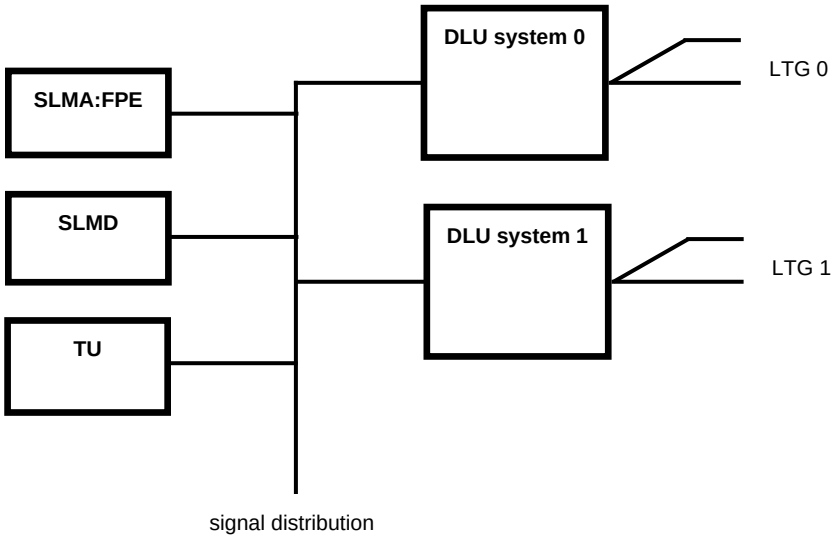


Fig. 4.10 Digital line unit B (DLUB)

As well as the central functional units there are “peripheral" units:

– subscriber line module, analog (SLMA:FPE) for connecting analog subscribers
– subscriber line module, digital (SLMD) for connecting ISDN subscribers
– test unit (TU) for running tests and taking measurements on the subscriber lines

4.2.1.4 Switching Network (SN(B))

The switching network B (SN(B)) is an especially compact version compared with switching network (SN).

The SN(B) consists of time stages and space stages. In time stages, octets to be switched change time slot and highway according to their destination. In space stages they change highway without changing time slots.

The parameters of the time and space stages (4I4, 16I16, 8I15, 15I8, Fig. 4.11) always represent the number of 8-Mbit/s highways, which have 128 channels each. Connection paths through the time and space stages are switched by the switch group controls (SGCB) in accordance with the switching information from the coordination processor (CP113C/CR). The SGCBs respond to commands from the CP113C/CR. The SGCBs also independently generate the setting data and set the message channels (e.g. between CP113C/CR and the LTG) for data exchange between the distributed controls.

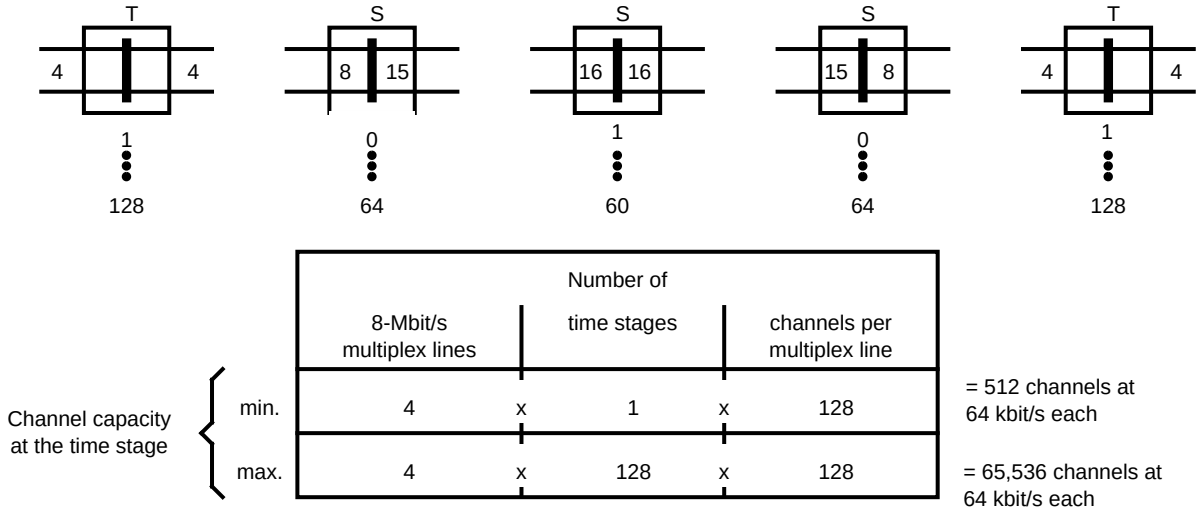


Fig. 4.11 Division of switching network (SN(B)) into time (T) and space (S) stages (showing only one plane of the duplicated SN) and range of connection capacity

In its maximum configuration, the SN(B) contains only 5 different types of modules. The SN can be expanded in small stages by adding plug-in modules and cables and if necessary by assigning extra racks. Optimized switching network B configurations are available in a range of sizes.

The SN is always duplicated (planes 0 and 1). Each connection is switched simultaneously through both planes, so that a standby connection is always immediately available in the event of a failure.

In digital switching networks, the octets being sent in the two directions between the calling and called subscribers are transmitted separately. This corresponds to a 4-wire connection in analog systems. Fig. 4.12 shows the basic principles of a connection switched through the switching network (with time slots x,y,z).

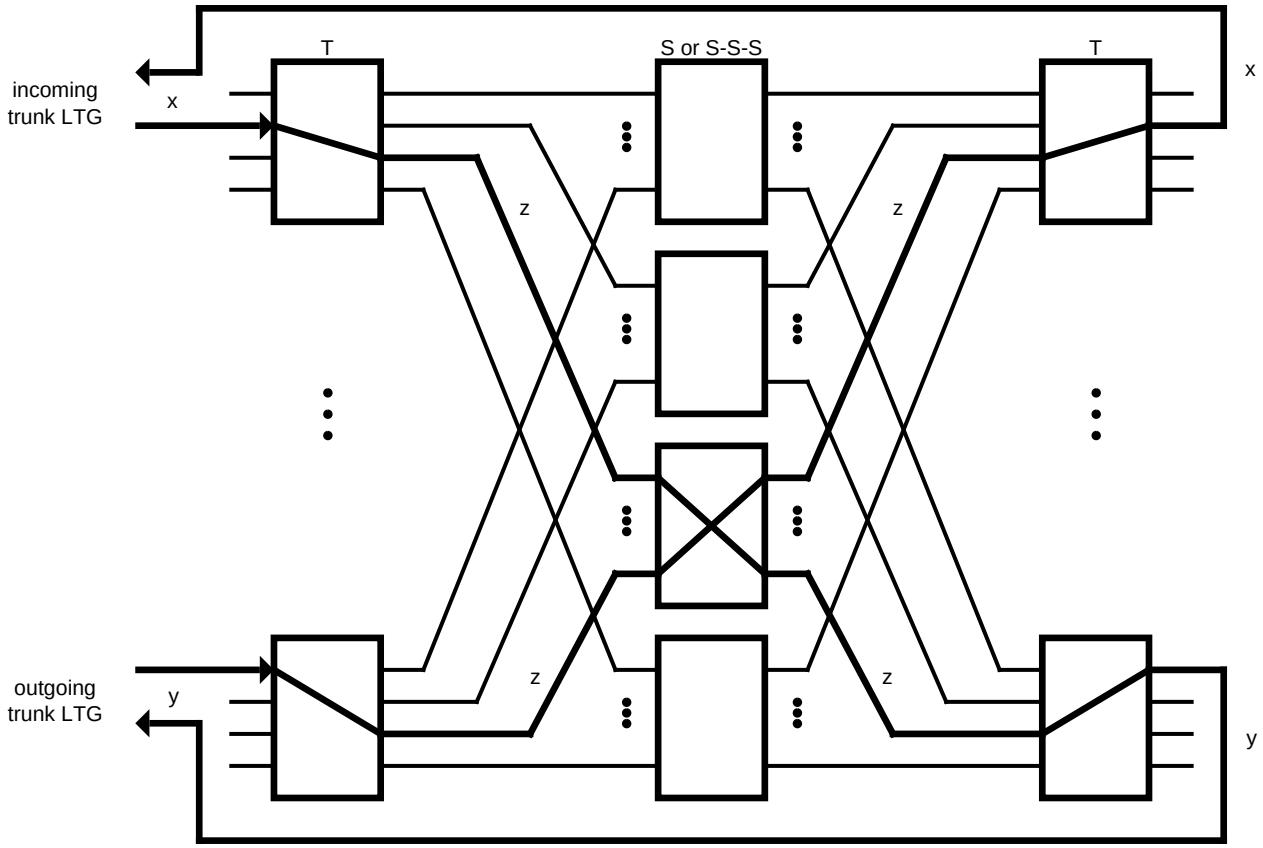


Fig. 4.12 Connection through the SN(B) (simplified)

4.2.1.5 Common Channel Network Control (CCNC)

For the exchange of signaling between network nodes in D900/D1800 the ITU-T standardized signaling method No.7 (CCS7) is used (e.g. MSC/VLR PSTN/ISDN; MSC/VLR/ MSC/VLR; MSC/VLR HLR/AC; MSC/VLR EIR; MSC/VLR BSS). By distinguishing between a message transfer part (MTP) and several user parts (UP) / application parts (AP) great flexibility is achieved using this signaling system. The UP/AP are dependent on the specific applications (e.g. ISUP = ISDN user part, TUP = telephony user part, MAP = mobile application part, BSSAP = BSS application part). The common MTP functions in a D900/D1800 SSS network are performed by the common channel network control (CCNC). The UP/AP is contained in the software of the corresponding LTG.

A maximum of 112 common signaling channels can be connected via digital data links to the CCNC . The digital data links run from the LTG over both levels of the duplicated switching network and multiplexers to the CCNC. The CCNC is connected by up to two 8 Mbit/s lines to the switching network. Between the CCNC and the two switching network levels 112 channels are available for each of the two transmission directions (112 channel pairs).

These channels carry the signaling information with a bitrate of 64 kbit/s over the two switching network levels from and to the LTG.

For reasons of high availability the CCNC has a duplicated processor (CCNP), which is connected via a likewise duplicated bus system with the CP113C/CR. The CCNC (Fig. 4.13) consists of:

– up to 30 groups with max. 8 terminal units for signaling channel (30 SILT groups, SILTG) and
– a duplicated processor for the network of the common signaling channels (CCNP)

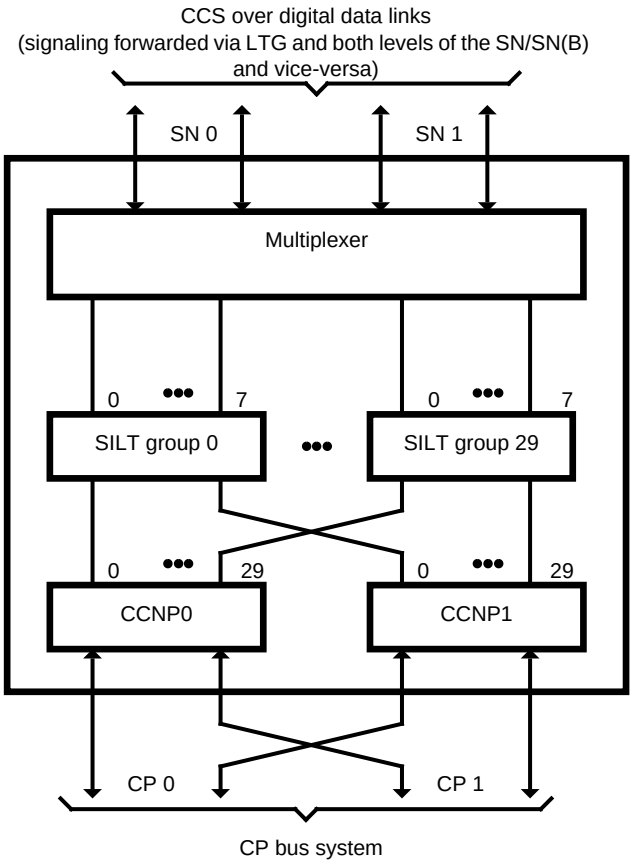


Fig. 4.13 Common channel network control (CCNC)

4.2.1.6 Coordination Processor (CP113C/CR)

The CP113C/CR is responsible for the main database and for configuration and coordination of the distributed microprocessor controls and data transfer between them:

– storage and administration of all programs and data of the MSC, VLR, HLR, AC, EIR or CSC and M-SSP
– storage and administration of all programs, exchange, trunk data
– processing of received information for routing, path selection, zoning, charges
– generation of the security parameter in the security boxes (IOP:AUC in the AC)
– communication with operation and maintenance center
– supervision of all subsystems, receipt of error messages, analysis of supervisory result messages and error messages, alarm treatment, error detection, error location and error neutralization and configuration functions
– handling of the man-machine interface

The CP113C/CR is used in the network nodes of the D900/D1800 SSS. The CP113C/CR is a multiprocessor and can be expanded in stages.

In the CP113C/CR (Fig. 4.14) two or more identical processors operate in parallel with load sharing. The rated load of n processors is distributed among n+1 processors. This means that if one processor fails, operation can continue without restriction (redundancy mode with n+1 processors). The main functional units of the multiprocessor are as follows:

– base processor (BAP) for CP113C basic configuration and CP113CR (which is only used for **MiniSwitch**); for operation and maintenance and call processing
– call processor (CAP) for maximum configuration of the CP113C; for call processing only
– common memory (CMY)
– input/output controller (IOC)
– input/output processors (IOP)

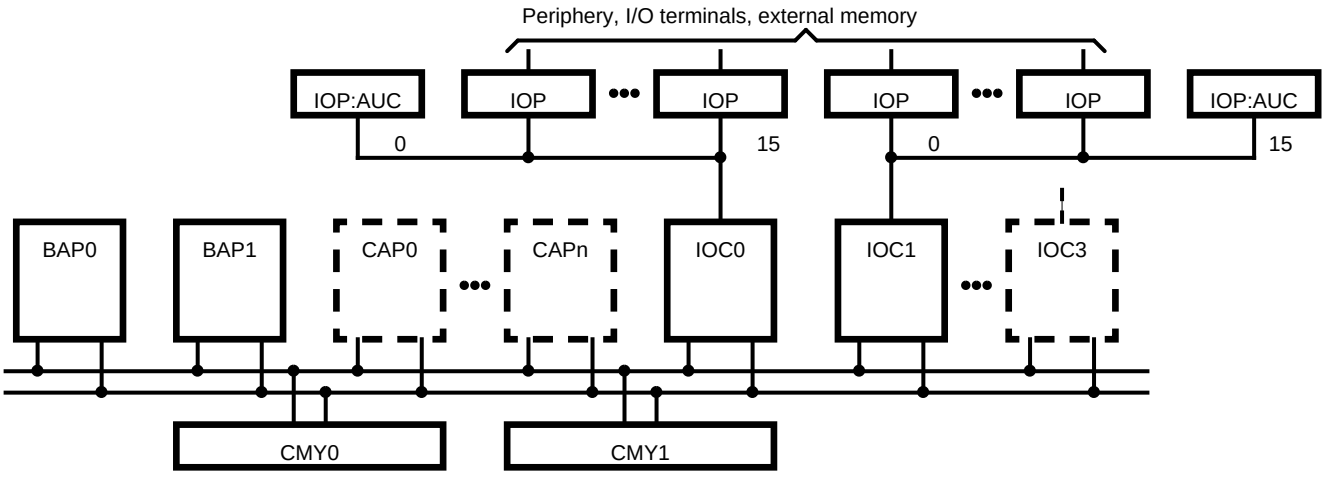


Fig. 4.14 Coordination processor (CP113C/CR)

Other units assigned to the CP113C/CR (Fig. 4.6) are:

Message buffer (MB (B)) for coordination of internal message traffic between the CP113C/CR, the SN(B), the LTGs and the CCNC in an SSS node.

Central clock generator (CCG (A)) for the synchronization of the SSS node and, where necessary, the network. The CCG(A) is extremely accurate (10^{-9}). It can, however, be synchronized even more accurately by an external master clock (10^{-11}).

System panel (SYP) to display system-internal alarms, advisories and the CP113C/CR load. It thus provides a continuous overview of the state of the system. The SYP also displays external alarms such as fire and air-conditioning system failure for example.

Local O&M terminals (BCT) for operation and maintenance. There are two versions of BCT. A BCT-boot version is used for APS installation, recovery and O&M. It is connected via a V.24 interface and is operated in BMML command level. A BCT-common version is used for common operation, administration and maintenance with a graphical user interface. It is connected via a X.25 interface.

External memory (EM), e.g. for

– programs and data that do not always have to be resident in the CP113C/CR
– a mirror image of all resident programs and data for automatic recovery
– call charge and traffic measurement data

To ensure that these programs and data are safeguarded under all circumstances, the EM is duplicated. It consists of two magnetic disk devices (MDD). The CP113C/CR also has a magneto-optical disk (MOD) or magnetic tape device (MTD) for input and output.

4.2.2 Mechanical Design

4.2.2.1 Rack Layout

D900/D1800 SSS uses the modular SIVAPAC packaging system for the mechanical design. Its basic units are:

– modules
– module frames
– racks
– rack rows
– cables

All modules and cables are of the plug-in type. SIVAPAC reduces the risk of error in the installation of D900/D1800-SSS and permits short installation times. Installation test manuals and acceptance test manuals are provided to aid the operating company in carrying out commissioning and acceptance testing for the D900/D1800-SSS node.

- Modules have a standard format and are mounted vertically in the module rack. A faceplate on the front edge can have front facing connectors and display and control elements; the rear edge is fitted with spring contact strips, which make contact with the blade connectors in the module rack. The printed circuit boards are constructed as multilayer boards. Plated through holes connect the individual layers with each other and the components to the layer. Surface mounted devices (SMD) are used where high packing density, mounting of components on both sides of the circuit board and optimum heat dissipation are required simultaneously.
- Module racks combine the modules to form a constructional and wiring unit. A module rack basically consists of a backplane, assembly rails, side sections and guide bars for the modules. The backplane forms the rear section of the module rack. It consists of a multilayer board with blade contact strips pressed in to make the electrical contact. Its contact pins are arranged to project beyond the rear edge of the backplane so that cable connectors can be plugged in and additional wire wrapped connections made.
- Racks accommodate module racks and auxiliary devices (e.g. current converters). Wide opening doors allow unrestricted access to the built in system components. Simple clamping elements are used to connect the racks together to form a rack row and also provide electrical connections.
  The racks can either stand directly on the floor of the system room or on a raised floor. The raised floor allows underfloor cabling as well as a direct supply of cooling air to the bottom of the racks. If the racks are arranged without a raised floor a planar cable shelf above the racks is required.
- The cables are of plug-in design: they are manufactured and tested in the required lengths and delivered to the site fitted with connectors. During installation the cable connectors only need to be plugged into the module rack backplane. From the connector the cables are routed either up to a planar cable shelf or down under a raised floor.
  D900/D1800 SSS installations obtain their supply voltages (48 V or 60 Vdc) from central power supply units. Standard flexible cables and distribution buses carry the operating voltage to current converters, inverters and tone/frequency generators.

Current converters produce the dc voltages for the electronic circuits, the inverters supply power to ac operated peripheral equipments (such as printers) and the tone/frequency generators supply the ringing tones.

Natural convection removes dissipated heat from the vertically mounted modules in the module racks. Dissipated heat can be discharged very easily if the racks are set up on a raised floor. In some cases slide in ventilator units in the rack and/or air conditioning help to dissipate the heat.

The interface between internal and external lines is the main distribution rack. The Siemens compact mini distributor for 2 Mbit/s signals meets the requirements of most operating companies for space saving technology. It is suitable for all sizes of D900/D1800 SSS nodes. Its solderless connection technique, mature technical standard and proven cost effectiveness make it an ideal accessory for D900/D1800 SSS.

Examples of rack layout

An SSS node consists of the following racks (R:...), for:

- Coordination processor (CP113C/CR)
  R:CP113C/CR
  R:DEVB
- Switching network (SN(B)) message buffer (MB(B)),
  central clock generator (A) (CCG(A)) and with line/trunk group N (LTGN)
  R:SNB/MB/LTGN
- Service equipment: analog modems for remote BCT connection,
  digital announcement system (DAS) and system panel control (SYPC)
  R:SE
- Line/trunk group N (LTGN), as well as partially equiped with LTGN and LTGG
  R:LTGN
- Common channel network control (CCNC)
  R:CCNP/SILTD
  R:SILTD
- Data service unit (DSU)
  R:DLU
- Digital line unit B (DLUB)
  R:DLUB

The following figures show example of rack layout complements.

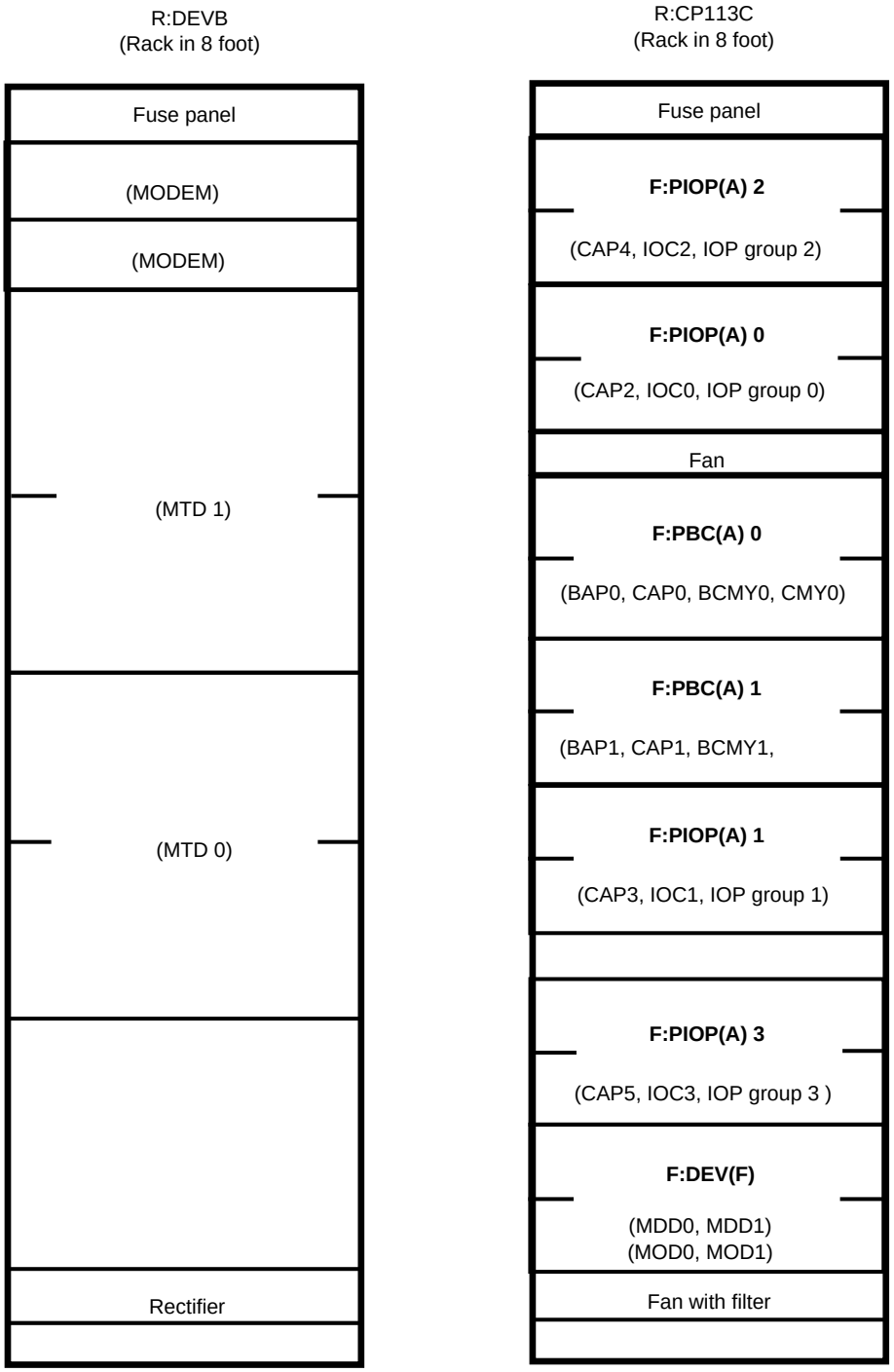


Fig. 4.15 Standard racks of the coordination processor (CP113C) (Maximum capacity stage)

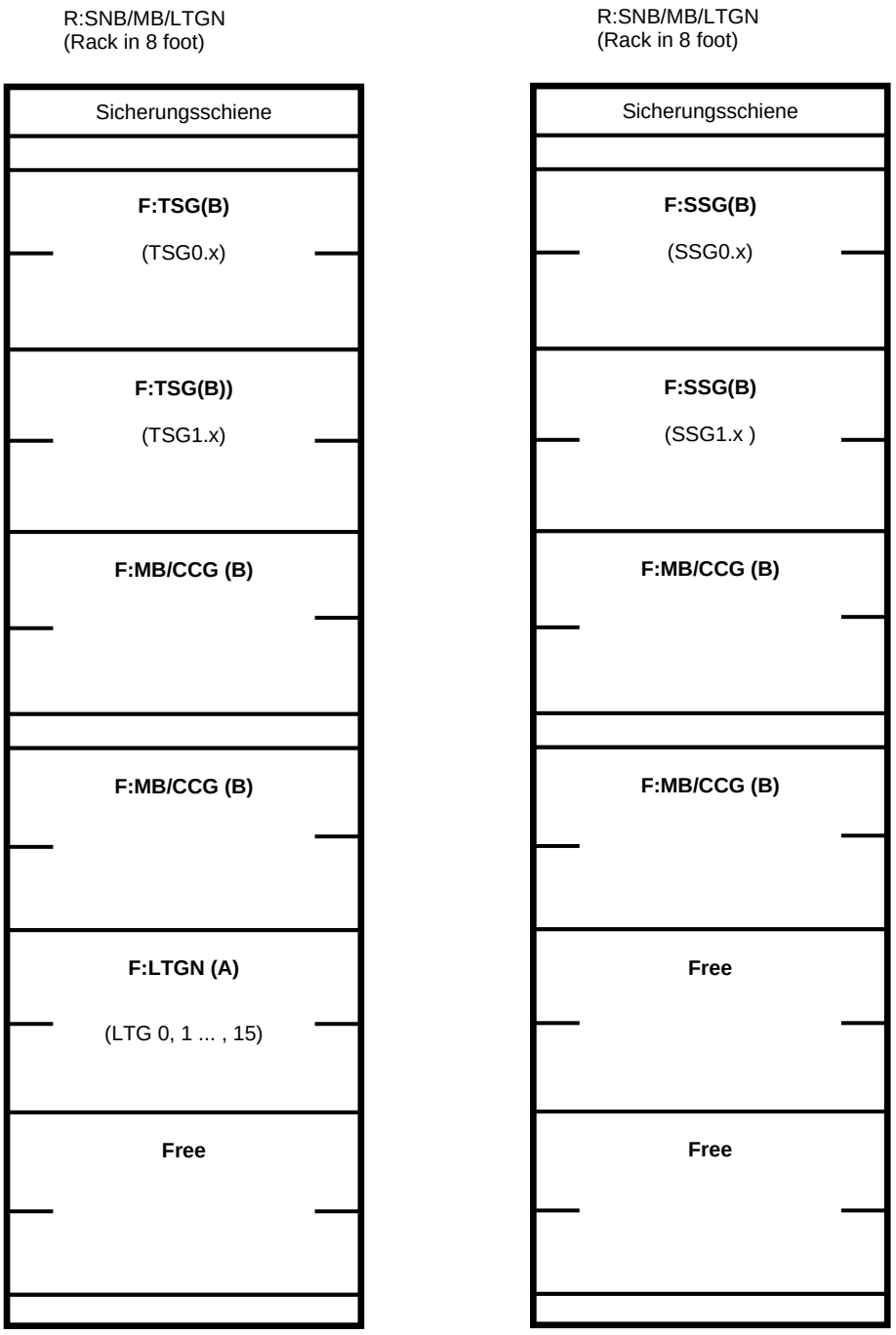


Fig. 4.16 Racks for switching network B, message buffer B, central clock generator A and line/trunk group N(R:SNB/MB/LTGN)

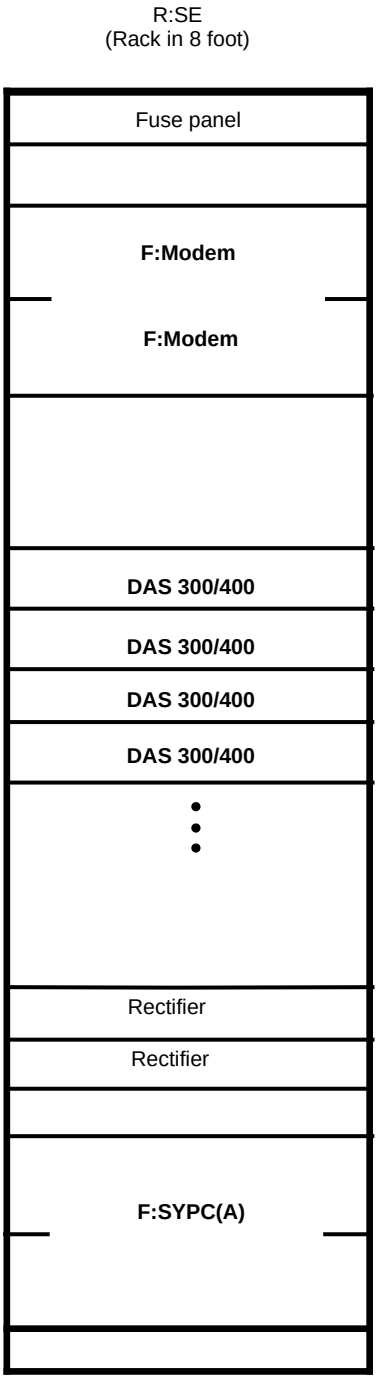


Fig. 4.17 Rack for service equipment: analog modems for remote BCT connection, digital announcement system (DAS) and system panel control (SYPC)

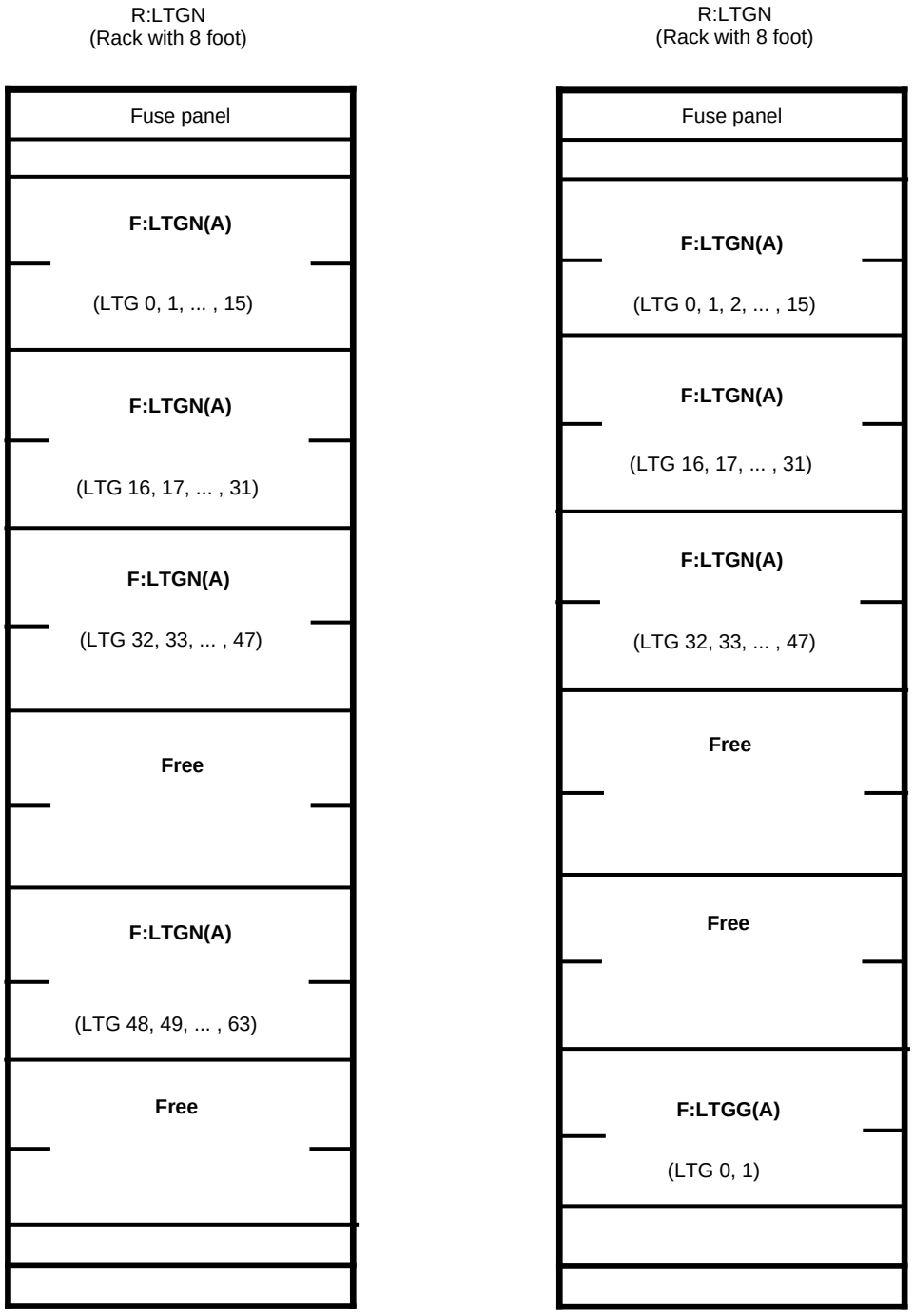


Fig. 4.18 Racks for line/trunk group N (LTGN), as well as partially equiped with LTGN and LTGG

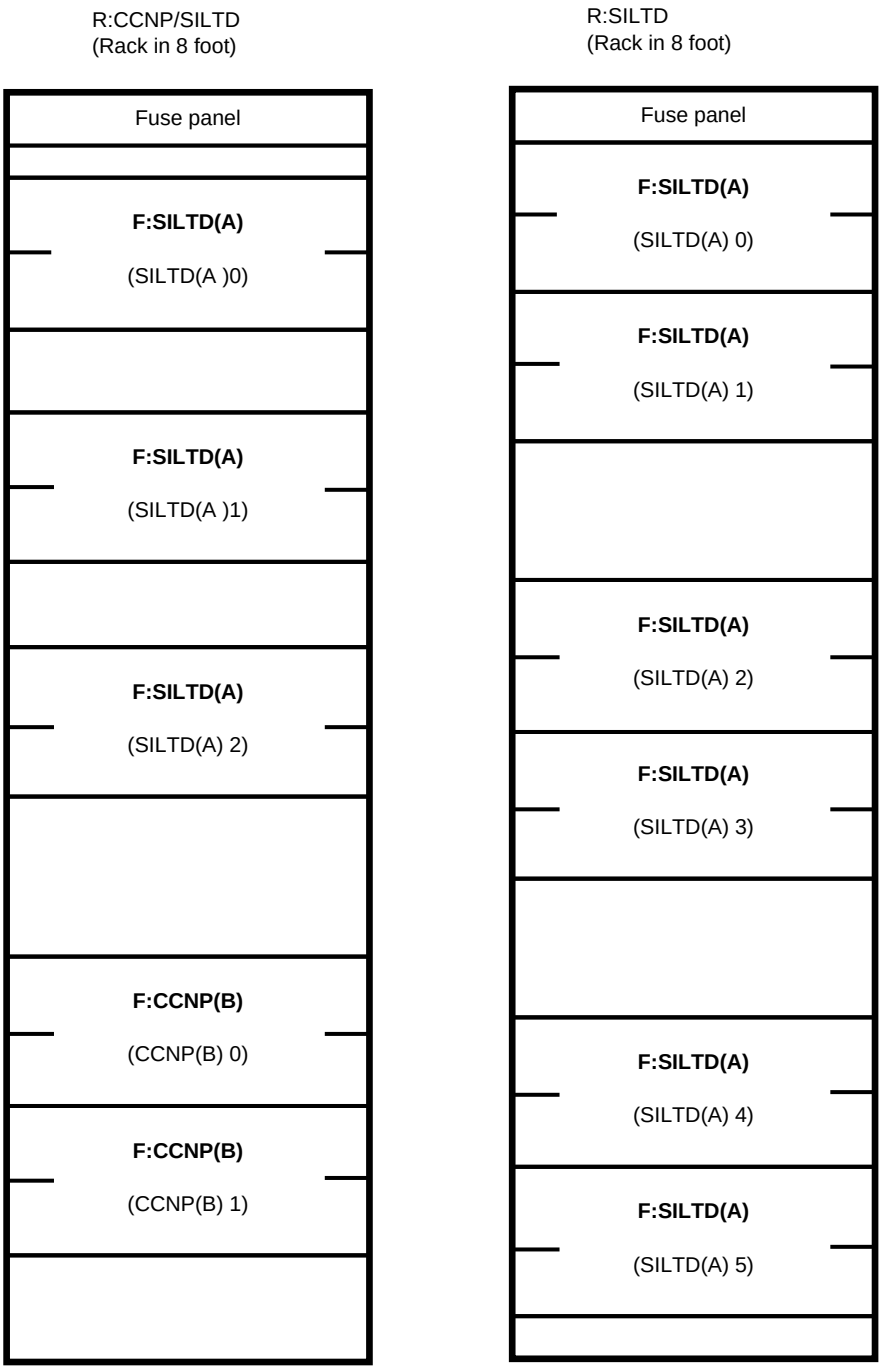


Fig. 4.19 Racks for common channel network control (CCNC)

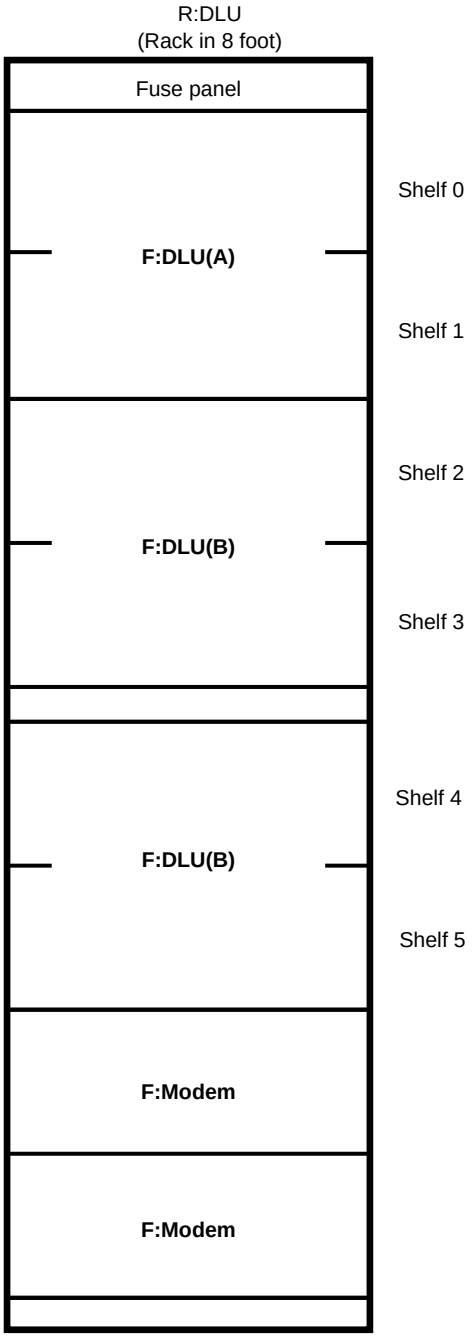


Fig. 4.20 Rack for DSU

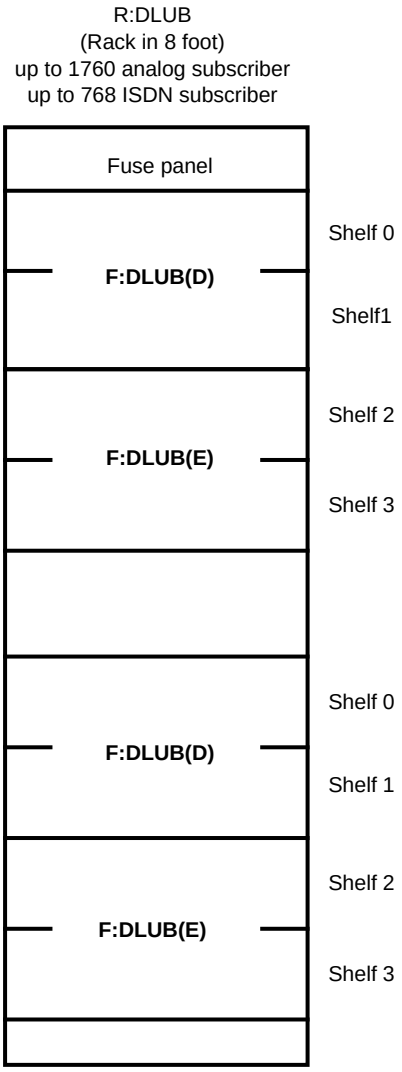
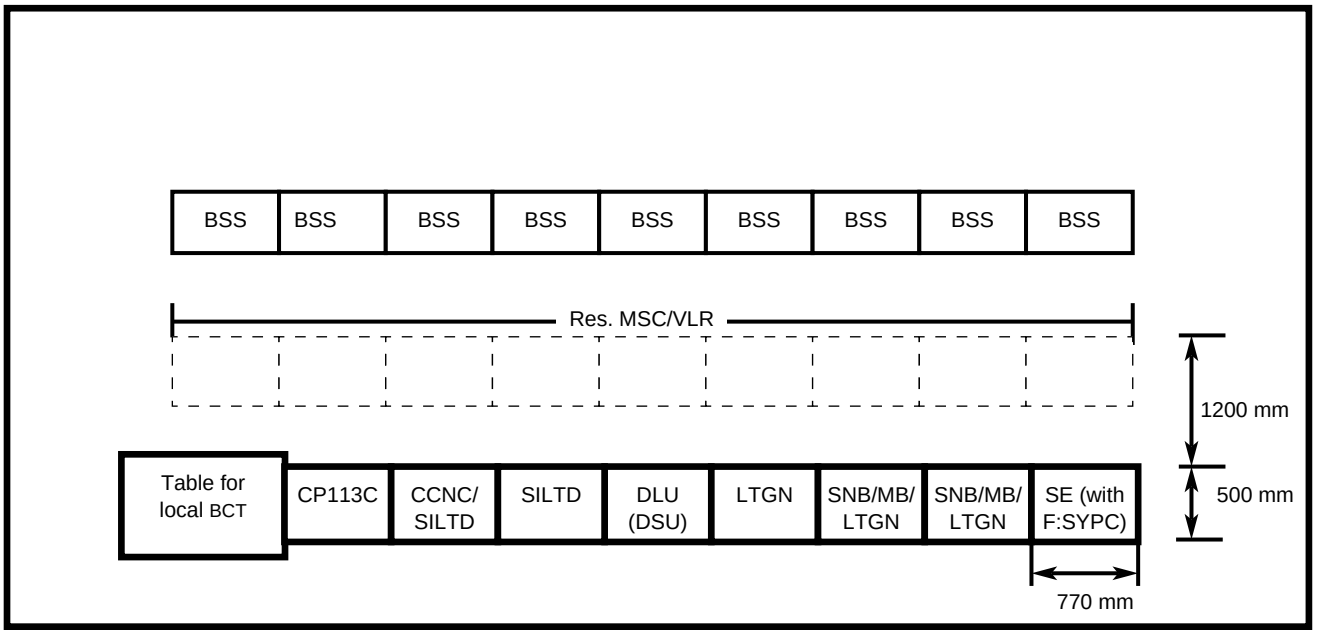


Fig. 4.21 Rack for DLUB (R:DLUB)

4.2.2.2 Layout Plan

The compact, modular design of the D900/D1800 SSS allows operating companies to install nodes with remarkably little space requirements (Fig. 4.22). With this advantage of the D900/D1800 SSS the operating company can in many cases use existing buildings for powerful network nodes or plan and construct new buildings that are significantly smaller and hence less expensive than those for conventional electromechanical switching systems.



LTG = Line/trunk groups (LTGN, or LTGN mixed equipped with LTGG)
DLU = Data service unit (DSU)
SE = Service equipment (digital announcement (DAS), system panel control (SYP) and so on
SNB/MB/LTGN = Switching network (SN(B)), message buffer (MB(B)), central clock generator (CCG(A)) and line/trunk groups (LTGN)
DEVB = CP drives (magnetic tape device);
BSS components: TRAU = Transcoding equipment, BSC = Base station controller (optional)

Fig. 4.22 Example layout draft for an MSC/VLR network node

4.2.2.3 MiniSwitch (Very Compact MSC/VLR Network Nodes, including Containers)

For use in rural switching centers with the need of low space a very compact MSC/VLR network node (**MiniSwitch**) is available. Generally the **MiniSwitch** consists of four special combined 7 foot racks for installation in a building (Fig. 4.23).

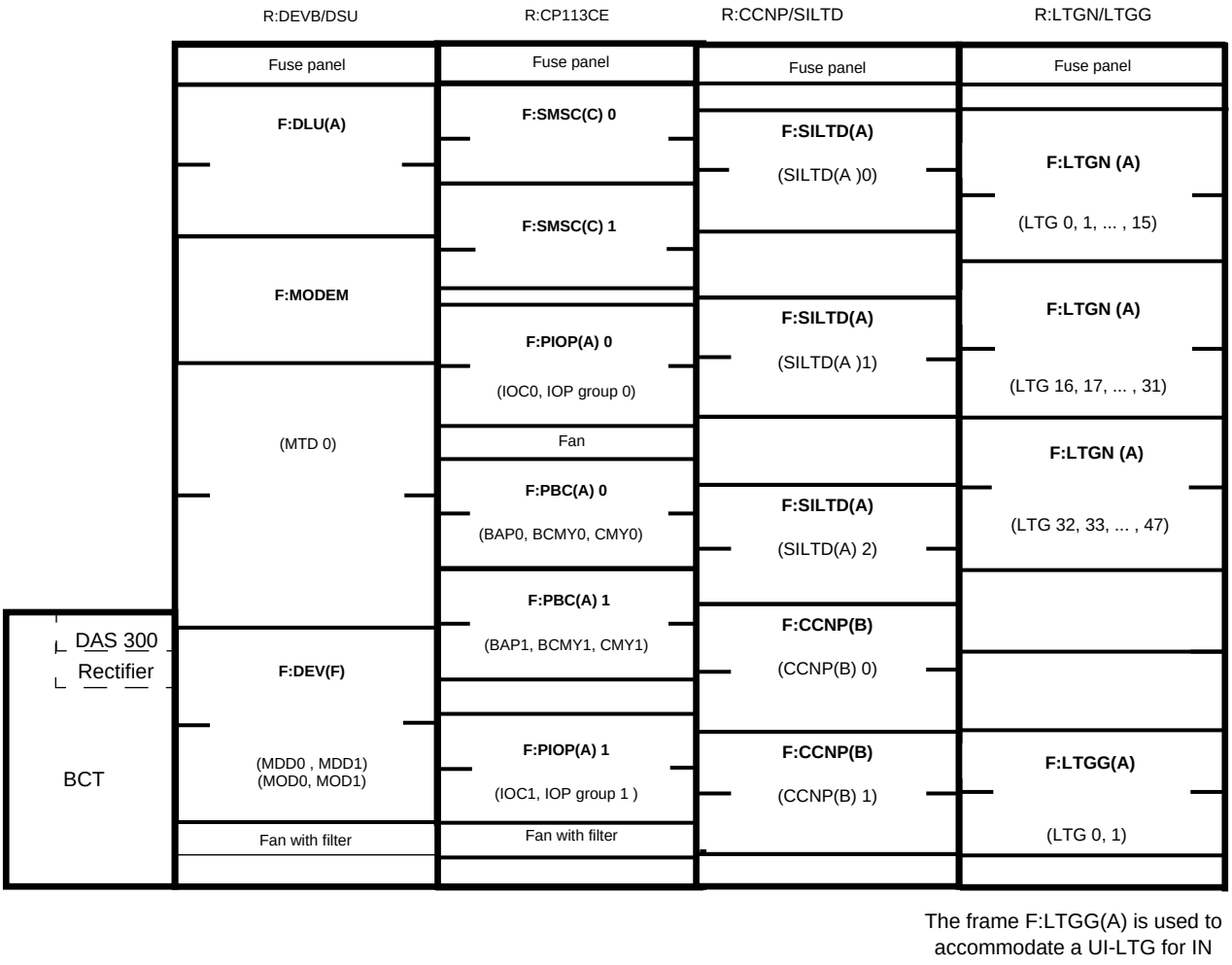


Fig. 4.23 Rack layout for a MiniSwitch (example)

The advantageous low space requirements mentioned above also permit installation of the **MiniSwitch** in containers. For protection in transit against mechanical shock, all racks in containers are mounted on vibration absorbers. The 6058 mm (20 foot) container accommodates all facilities and peripheral equipment required for operation of the D900/D1800 SSS.

4.3 Software

D900/D1800 SSS software is characterized by high quality and reliability, extensive dynamic capabilities (real-time requirements) and flexibility for implementations of additional functions. These characteristics have been achieved in a cost-effective manner by:

– flexible, modular software architecture (Section 4.3.1)
– efficient CHILL-based software technology (Section 4.3.2)
– consistent software quality assurance (Section 9.2)

4.3.1 Software Architecture

The great flexibility of D900/D1800 SSS stems from the extensive use of reloadable software. Only a few processors, namely those with a narrow range of functions and not dependent on the application, such as the switching network and message buffer controls, contain programs which are stored in read-only memories.

The reloadable software for a D900/D1800 SSS node including the node-specific data forms the application program system (APS). For reasons of security a current image of the APS is held in the duplicated external memory in each D900/D1800 SSS node.

Hardware is subject to rapid technological change. To enable D900/D1800 to profit from this evolution, the D900/D1800 SSS software is designed so that only a minimum of it is hardware-dependent.

In accordance with the distributed control within D900/D1800 SSS each processor in the system requires its own software. This software is divided into an application-independent and an application-specific part (Fig. 4.24).

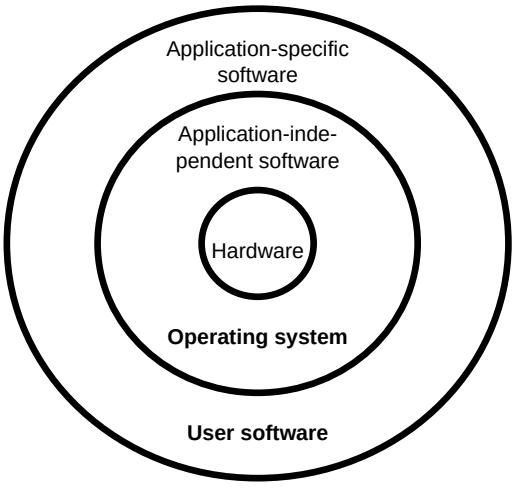


Fig. 4.24 Software shells for a processor

The application-independent part always contains the operating system which is tailored to the functions of a particular hardware subsystem. The application-specific software – also called the user software – implements the functions for the various applications. The operating system provides all the programs in the user software with a uniform convenient interface via which they can make use of operating system functions and thus the resources of the processor.

The software of the individual processors normally contains a wide variety of functions. It is accordingly divided into subsystems. Each subsystem generally contains several modules. These represent the smallest units for compilation.

The various types of data are an essential component of the D900/D1800 SSS software. The data can be classified according to type, scope, lifetime and storage location. Node-specific data are held in the database of the CP113C/CR. Its size and contents depend on the equipment and the network environment of the node involved. The database is part of the user software.

The call processing programs control the establishment of connections in accordance with subscriber requirements. Apart from the appropriate hardware resources, these programs require information on the network termination characteristics and the network environment (e.g. for routing). This information has to be provided by the operating company. Man-machine language (MML) commands can be used to incorporate such information into the system and to administer it there. Commands of this type are evaluated by the administration programs. The call processing programs also provide charge data and traffic data; the administration programs edit these data, save them and output them on demand.

Safeguarding and maintenance programs guarantee unimpaired system operation. The safeguarding programs are part of the operating system and are executed automatically. In contrast, the maintenance programs – like the call processing and administration programs – are user programs. Some of them only run after the appropriate MML commands have been entered. They make use of safeguarding program functions.

4.3.1.1 Operating Systems

Each processor in D900/D1800 SSS has its own operating system with capabilities dependent on the tasks to be performed by the processor and the resources which it manages. All operating systems have to perform their functions under real-time conditions. They are therefore interrupt-driven and work according to priorities. The coordination processor (CP113C/CR) operating system consists of executive and safeguarding programs.

Executive programs

The integral parts of the executive programs are:

– scheduler
– timer administration
– memory management
– input and output

- The scheduler determines the sequence in which the CP113C/CR performs its tasks. After the start phase this is generally the sequence of events such as inputs or operating system requests. Individual functions or subfunctions are mainly arranged as processes in the CP113C/CR and are administered by the scheduler via process queues. The processes are assigned different priorities.
  When an event occurs it generates an interrupt of the process currently executing and activates the scheduler, which then analyses the event sufficiently to determine the process or program which is to perform further processing. The scheduler then transfers control to the process with the highest priority which is ready to run. If two or more processes with the same priority are ready to run, the process which has been waiting the longest is given preference. The interrupt facility, the defining of processes to match the functions performed and the correct assignment of priorities

guarantee that the real-time conditions are fulfilled and that the CP113C/CR can respond to an event within an appropriate time.

- Timer administration allows user programs to set and reset timers. They can thus supervise the correct timing for execution sequences and initiate further activities after a specific time. In addition, the user programs can interrogate timer administration to obtain the current date and time of delay.
- The time-critical part of the CP113C/CR software is always loaded into the memory unit of the CP113C/CR (resident). The remaining memory (unassigned memory) is available for the reloadable software where required. It is allocated and released again by memory management.
- The input and output part of the executive programs controls and supervises the exchange of messages with the call processing periphery (LTG), the common channel signaling network control (CCNC) and the operation and maintenance periphery, and preprocesses MML commands.

Safeguarding programs

The functions of the safeguarding programs are:

– determination of a functional system configuration on start-up and establishing this configuration
– recording and processing safeguarding messages from the periphery and from CP113C/CR processes
– controlling the execution of periodic checks
– evaluating alarms from supervision circuits in the CP113C/CR
– collecting error symptoms and saving them
– analysing and locating errors
– reestablishing an operable system configuration after hardware faults, and
– rectifying, by means of adequate recovery measures, the effects of software errors which cannot be neutralized by the user programs themselves

Recovery measures in D900/D1800 SSS are implemented on several levels. The main levels are restart, new start and initial start.

– Restart only applies to the currently running process and does not affect more than one connection.
– New start resets all processes and affects those connections which are currently being set up.
– Initial start, which involves reloading the entire software, results in the release of all connections.

The choice of recovery level depends on the type and frequency of the detected software error. In the first instance, the level that promises success while involving the least impairment of normal operation is selected. But if the same error then recurs, the next higher recovery level comes into effect (escalation).

4.3.1.2 User Software

The user software implements the call processing, administration and maintenance functions and the associated database required for the specific application. New features, e.g. a specific signaling system for trunks, and whole feature packages can be easily implemented in D900/D1800 SSS by means of appropriate subsystem variants or by adding new subsystems.

Database

The node-specific data stored in the database cover, for instance, the following:

Hardware image
- hardware configuration
- hardware characteristics
- hardware states

Termination characteristics, e.g.
- service features
- signaling features
- grouping of lines (trunk groups)

Data for the establishment of links, e.g. between
- equipment number and termination data

Call setup, e.g.
- digit translation
- routing

Data accumulated during operation, e.g.
- charging
- traffic measurement

The database contains both transient and semipermanent data. The transient data are largely call-related and therefore continually being changed by the call-processing programs during operation. The semipermanent data, on the other hand, describe conditions and characteristics which change relatively seldom during operation, for instance the system configuration or line characteristics. These data are under write protection and their current image is always kept in the external memory. Changes to semipermanent data are made by entering the appropriate MML commands or by means of subscriber input.

A number of modules in the database contain the definitions of the data structures, the data declarations and the access procedures. Users can only access the data via these procedures. Initially, the data fields are only small, their ultimate size depending on the capacity and port assignments of a particular node. A utility program is employed to expand the data fields to meet the planned requirements. The database can be extended while the system is in operation.

In accordance with the distributed control principle employed in D900/D1800 SSS, images of parts of the database are also found in peripheral processors such as the group processors and the common channel signaling network control.

Call processing programs

In the coordination processor the call processing programs, e.g. for the MSC/VLR nodes, only handle those call processing functions which require access to data available only to the CP113C/CR:
- reading and analysis of call and network termination data

– digit translation with the following functions:
  destination routing with possible route processing
  charge zone determination
– path selection in the switching network image and sending of setting commands to the switching network control
– sending of messages to the group processors with the objective of initiating specific actions and transferring to the group processors the information required for further independent call processing

The call processing programs in the group processors (GP/GPN) deal with most of their call processing tasks without involving the CP113C/CR. They are activated by call processing events from the LTG periphery, commands from the CP113C/CR, reports from other GP/GPNs and order from the CCNC. Event and message processing activities of the GP/GPN are as follows:

– timing supervision
– evaluation of call data and network termination data
– modification of call data and transient network termination data
– identification of signals
– sending of messages to the CP113C/CR, reports to other GP/GPNs, or order to the CCNC
– seizure and release of traffic channels
– standardization of signaling before informing the CP113C/CR or another GP/GPN (physically different signals from different signaling procedures with identical meanings are converted into uniform internal messages)
– control of signaling
– pre-analysis of dialed digits
– execution of service-feature specific activities (provided no central coordination is required)
– sending of setting commands to the group switch
– generation of charge statistic and traffic data

Administration programs

The CP113C/CR administration programs process the administrative MML commands. Activities required here are as follows:

– incorporation of data into the database
– modification of data in the database
– reading and editing data in the database for output
– using appropriate messages to pass information to the peripheral processors, (GP/GPN, CCNP) concerning data modification
– control of traffic measurement processes in the CP113C/CR
– activation of measurements (traffic and statistics) in the periphery

In addition the administration programs save charge, statistics and traffic data in the external memory. These are obtained from the call processing programs in the CP113C/CR or supplied by the administration programs of the peripheral processors.

The administration programs of the peripheral processors (GP/GPN and CCNP) process the messages from the administration programs of the CP113C/CR. In response they:

– inform other peripheral processors
– modify their own data (partial image of the database)
– start or end measurements (statistics and traffic)
– transfer data to the CP113C/CR

Maintenance

The CP113C/CR maintenance programs process the MML commands that are essential to the provision of trouble-free service. Among the activities required here are:
- control of configuration and recovery processes with the aid of safeguarding programs
- control of measurement and testing processes for the trunk network
- control of fault analysis and diagnostic processes
- initiation of configuration, recovery, testing, measurement and diagnostic activities in peripheral processors using the appropriate commands

In addition they process messages containing measurement, testing and diagnostic results from the LTGs (GP/GPN). Another function of the maintenance program is to display faults on the system panel and provide audible signals for them where necessary.

The maintenance programs of the GP/GPN process:
- commands from maintenance programs in the CP113C/CR
- results from test equipment for trunks in the LTGs
- messages from supervision equipment and supervision programs in the LTGs (e.g. trunk maintenance)

Possible GP/GPN reactions are as follows:
- sending control messages to test equipment
- starting test and diagnostic procedures
- executing configuration measures
- sending messages to the CP113C/CR

4.3.2 Software Technology

The D900/D1800 SSS software technology is characterized by:
- a software engineering production plan (SEPP)
- powerful standardized description and implementation languages (SDL, CHILL)
- extensive and convenient hardware and software support (support software also based on CHILL)

4.3.2.1 Software Engineering Production Plan

The D900/D1800 SSS software is developed in accordance with a software engineering production plan (SEPP). It ensures a uniform and systematic approach and therefore guarantees cost-effective development, complete documentation and above all high-quality software.

4.3.2.2 Description and Implementation Languages

An important design aid for D900/D1800 SSS software is the specification and description language (SDL) standardized by the ITU-T. It is particularly suitable for providing unambivalent descriptions of processes and execution sequences which are characterized by states, events and by the ensuing actions and state transitions. The D900/D1800 SSS development environment allows the developers to design, modify and administer computer-aided SDL diagrams and their graphic symbols. The SDL diagrams are the basis for coding in CHILL or Assembler. A special software tool allows Assembler code to be generated directly from the SDL logic.

CHILL

The source modules of the D900/D1800-SSS software are largely written in the ITU-T standard high-level language CHILL. CHILL guarantees both structured programming and modular structure. Software written in CHILL is to a large extent self-documenting, easy to read, easy to expand and easy to maintain. CHILL as a modern high-level programming language is the basis for the extensive portability of D900/D1800 SSS software. This means that software written in CHILL can be run on commercial data processing systems as well as on D900/D1800 SSS coordination processors.

In contrast to many other programming languages, CHILL provides specific facilities for declaring data types (modes) and structures. This allows interfaces to be precisely defined and automatically checked. This is extremely important in a project where more than one thousand software modules have to be linked together to an application program system (APS).

4.3.2.3 Support Software

Efficient development and quality of software are greatly influenced by the support available. For D900/D1800 SSS software development, commercial computer systems, personal computers and switching processors are used. Commercially available software is only able to support development activities to a limited extent. An extensive package of D900/D1800 SSS support software is therefore needed to support rapid development, production and updating of application program systems. This software, including the CHILL compiler, is written in CHILL and is thus portable. It supports all phases of D900/D1800 SSS software development from analysis to application.

5 Base Station System (BSS)

5.1 System Architecture

5.1.1 Network Elements

The base station system (BSS) and the corresponding operation and maintenance subsystem (OMC-B) form the Siemens base station system (SBS). The base station system (BSS) consists of base station controllers (BSCs), base transceiver stations (BTSs) integrated in BTS equipments (BTSEs), transcoding and rate adaption units (TRAUs) and local maintenance terminals (LMTs) as shown in Fig. 5.1. The structure with an intelligent centralized controller part and several low cost transceiver stations is well appropriate to both smallest cell networks, as preferably used in urban areas, and large-cell rural networks. The advantage of smallest cell networks is the internal handover offered by the BSCs, the advantage of large-cell networks is the coverage of large areas by low-cost BTSs.

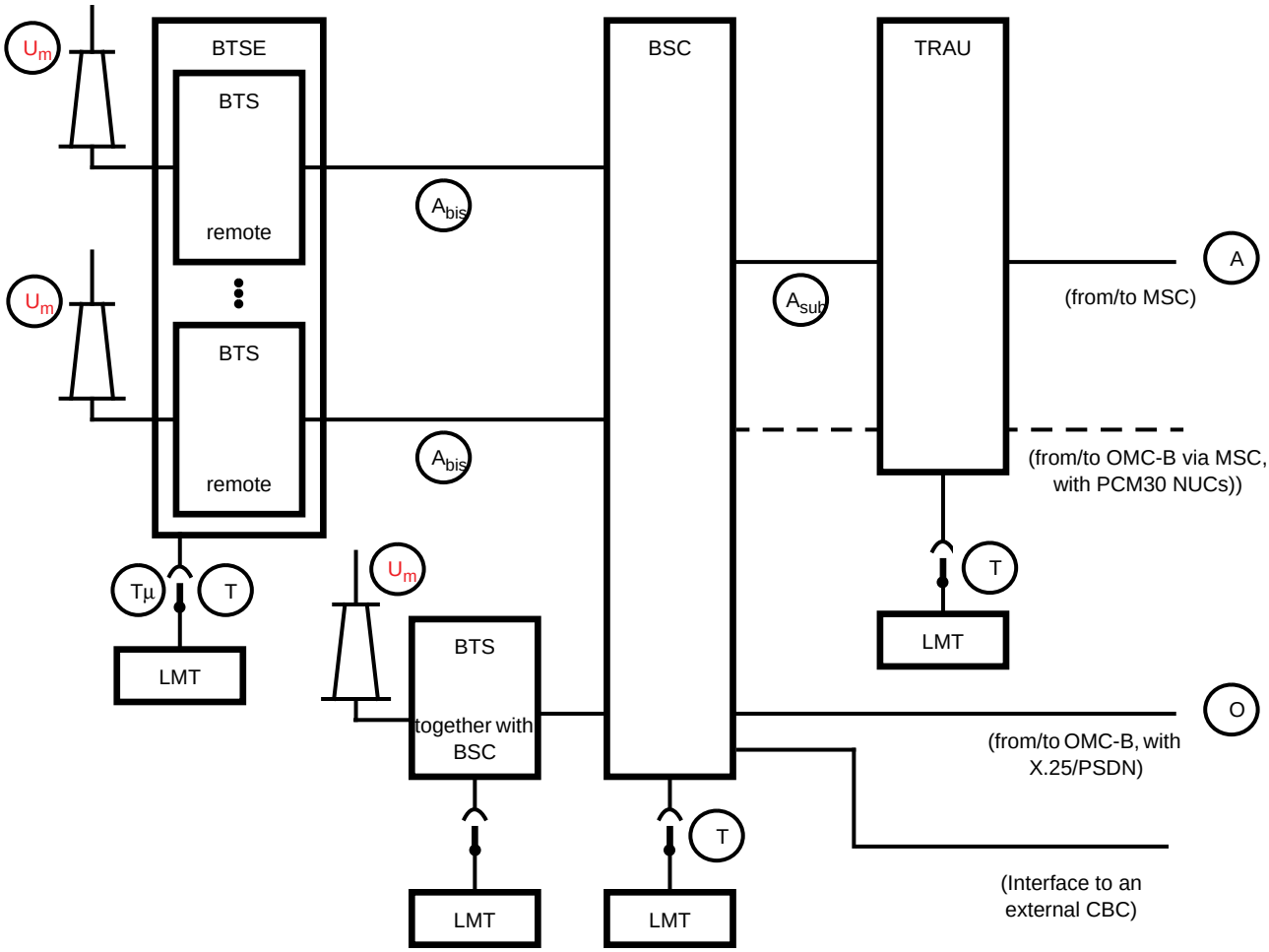


Fig. 5.1 Structure of the D900/D1800 BSS

Base transceiver station equipment (BTSE)

BTSEs are distributed over the whole radio service area. Each BTSE supports generally more BTS but at least one BTS. Each BTS serves a radio cell.

Base station controller (BSC)

One or more BSCs are linked to an MSC. Physically the BSCs can be grouped together at a central point on MSC sites or remotely in a shelter or in a confined space. The BSC can then act as a concentrator for the links between the Abis and Asub interfaces. A BSC serves one or more BTSs.

Transcoding and rate adaption unit (TRAU)

Although the TRAU is logically part of the BSS it is designed to be physically located at the MSC site. This helps to save transmission capacity on the Asub-interface (refer to Section 5.1.2).

5.1.2 Interfaces

The interfaces shown in Fig. 5.1 are defined as follows.

A-Interface

The A-interface is the interface of the TRAU towards the MSC. The interface comprises traffic channels and as signaling link the common channel signaling No.7 (CCS7) system. See also SSS interfaces in Section 4.1.3.

Asub-interface

The Asub-interface is the interface from the TRAU to the BSC. The interface comprises traffic and control channels. Submultiplexing of the traffic channels (4 x 16 kbit/s on a 64 kbit/s channel) is generally applied.

Abis-Interface

The Abis-interface is the interface of the BSC towards the BTSs. Physical transmission is realized with 2048 kbit/s or multiples of 64kbit/s. Submultiplexing is performed with full-rate channels for 8 traffic channels onto 2 x 64-kbit/s and with half-rate channels for 16 traffic channels onto 4 x 64 kbit/s or 2 x 64 kbit/s. Even if the BSC and the BTSs are collocated the Abis-interface is implemented.

O-Interface

The O-interface is the interface of the BSC towards the OMC-B. It is a packet-switched data network (PSDN) interface based on the X.25 interface specification of the ITU-T . Optional the O&M connections from OMC-B to BSS network elements can be handled by PCM30 nailed-up connections (NUCs) via MSC.

Interface from BSS to (an external) CBC

The interface to an external cell broadcast center (CBC) provides the possibility of connecting an external CBC of any vendor. This interface is an X.25 one.

T, Tμ Interface

The T interface is the interface of the BSC, BTS and TRAU towards the LMTs. It is also based on the X.21/V.11 interface specification of the ITU-T. The Tμ interface is the specific interface of the BS-11 BTS. It is based on RS232/V.24 interface specification of the ITU-T.

Um-Interface (GSM radio interface)

The Um-interface is the GSM radio interface between the BTS(-antenna) and the GSM mobile stations. This interface provides a number of logical channels. Mobile user information (voice, data) is transmitted via traffic channels, control signals and short messages are transmitted via control channels. Such control channels are:

– broadcast channels
  for frequency correction, synchronization
– common control channels
  for paging, random access and access grant
– dedicated control channels
  for slow associated control, fast associated control and stand-alone control

• Radio frequency channels and bands of D900
  The D900 provides the GSM900 primary band (890-915 MHz for uplink, 935-960 MHz for downlink) as well as the GSM900 extended band G1 (880-915 MHz for uplink, 925-960 MHz for downlink). The radio channel assignment for the D900 BSS (GSM900 primary band) is shown in Fig. 5.2, and (GSM900 extended band G1) is shown in Fig. 5.3.

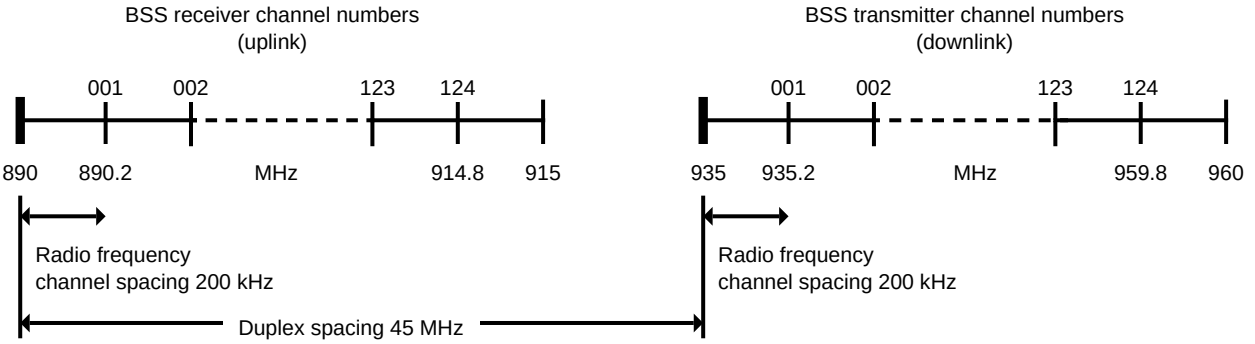


Fig. 5.2 Radio channel assignment for the D900 BSS (GSM900 primary band)

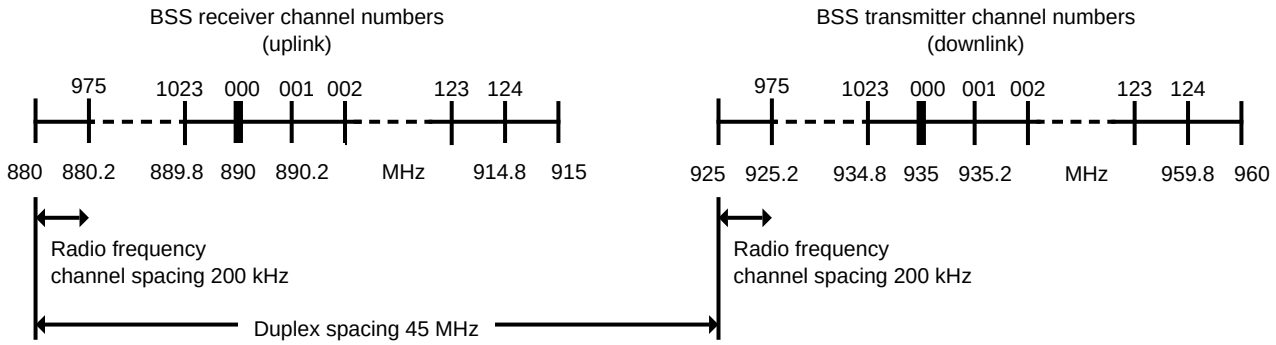


Fig. 5.3 Radio channel assignment for the D900 BSS (GSM900 extended band G1)

BTSs of adjacent cells use non-adjacent radio channels in order to avoid mutual interference. The mobile stations can use any pair of the 124 (174 for extended band G1) radio channels on the uplink or on the downlink. The decision as to which frequency pair is used for a particular connection is taken by the BSC and transmitted to the mobile station as a radio command via a signaling channel.

D900 for European Railways: With the services required by the European Railway Consortium, the SBS (BSS + OMS-B) platform becomes able to provide service to MSs working in the GSM-R frequency band (876-880 MHz for uplink and 921-925 MHz for downlink). This opens to the future introduction of the advanced speech call items (ASCI) services currently being specified by ETSI in their Phase 2+.

- Radio frequency channels and bands of D1800
  The D1800 provides the GSM1800 frequency band (1710-1785 MHz for uplink, 1805-1880 MHz for downlink). The radio channel assignment for the D1800 BSS is shown in Fig. 5.4.

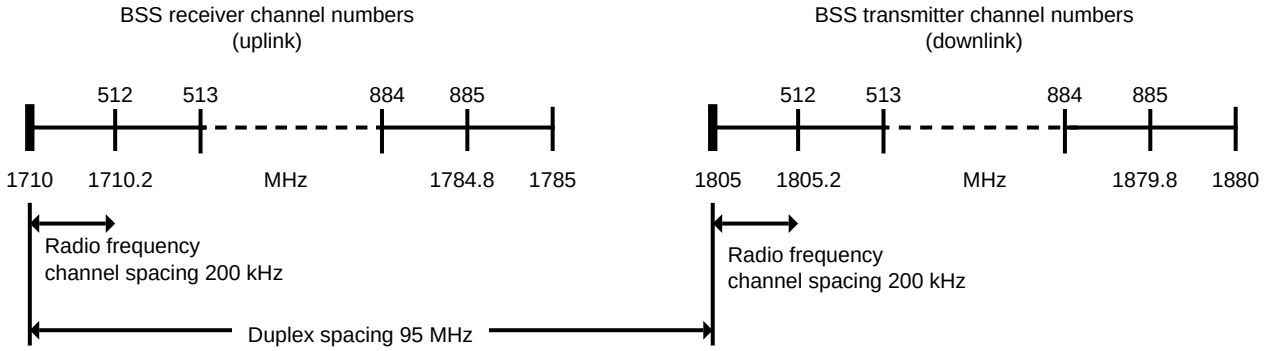


Fig. 5.4 Radio channel assignment for the D1800 BSS

BTSs of adjacent cells use non-adjacent radio channels in order to avoid mutual interference. The mobile stations can use any pair of the 374 (absolute radio frequency channel 512 ... 885) radio channels on the uplink or on the downlink. The decision as to which frequency pair is used for a particular connection is taken by the BSC and transmitted to the mobile station as a radio command via a signaling channel.

- Time division multiplex access (TDMA) frame
  Present-day PLMNs employ a type of frequency division multiple access (FDMA) in which each traffic or control channel is related to one radio channel. Each radio channel pair in this case requires one transmitter and one receiver. The radio channels are separated by analog filters.
  The D900/D1800 system employs a combination of frequency division multiple access (FDMA) and time division multiple access (TDMA) with eight traffic or control channels displaced in time and transmitted via one radio channel. With full-rate channels only one transmitter and one receiver are required for 8 traffic or control channel pairs (with half-rate channels for 16). This results in reduced space and energy requirements in the base transceiver stations (BTSs).
  A TDMA frame is shown in Fig. 5.5 .

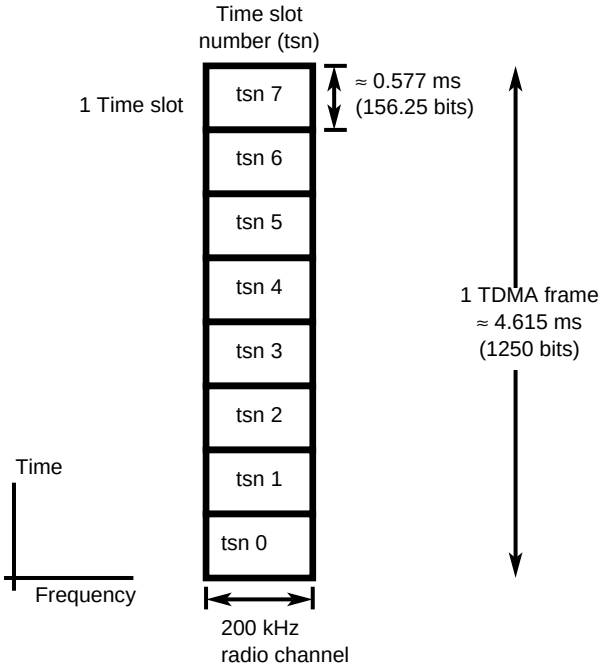


Fig. 5.5 Time division multiplex access (TDMA) frame of the GSM radio interface of the BSS

Each radio channel is time multiplexed. The nature of TDMA communication makes the 200-kHz transmission bandwidth available to 8 full-rate channels or 16 half-rate channels, not all at the same time but at intervals (time slots) repeated in a fixed pattern.

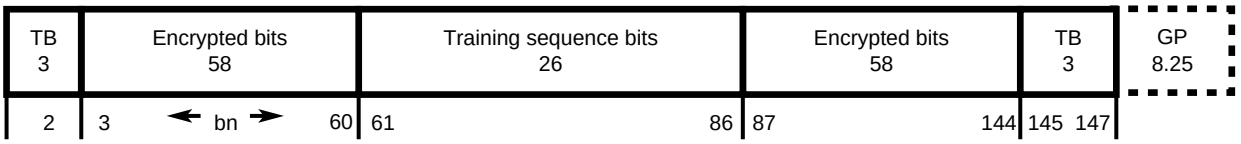
The time slots of a particular time slot number carry the signals of one traffic or control channel. These signals are split into portions, compressed to about one eighth of their duration and then entered into a selected time slot. After the radio transmission the compressed time portions are picked up from the time slots, regenerated by expanding them to their original duration, and finally put together to form the original signal.

In the case of voice transmission the electric analog voice signals produced by the microphone are initially converted for full-rate channels into a 13 kbit/s bit stream (for half-rate channels into a 6.5 kbit/s bit stream) in a voice encoding process developed especially for digital PLMNs. In order to enhance the noise immunity of the information to be transmitted, the process also provides an error control (forward error correction), allowing the transmitted information to be reconstructed to a certain extent at the receiver, even if the transmission path is disturbed. This increases the bit rate for full-rate channels to 22.8 kbit/s (for half-rate channels to 11.4 kbit/s).

In addition, the information bits are interleaved and separated at the transmitter and receiver respectively, to cope with error bursts occurring on the radio path. Additional synchronizing and control information and transmission-free intervals between the time slots further raise the bit rate to a total of 33.9 kbit/s. The transmission rate for the overall TDMA signal is eight times as high, i.e. about 270 kbit/s. The modulation method implemented is called gaussian minimum shift keying (GMSK).

A TDMA frame corresponds to 1250 bits transmitted in 120/26 ≈ 4.615 ms, a time slot corresponds to 156.25 bits transmitted in 15/26 ≈ 0.577 ms.

- Time slot structure
  The time slots may carry different kinds of bursts: frequency correction, synchronization, access, dummy, and normal bursts. A burst is a period of the radio frequency carrier which is modulated by a data stream. The modulation is applied for the useful duration of the burst. In general, the useful duration of the burst is the duration equivalent of 147 bits (from 0.5 to 147.5 bit time equivalent), except the access burst, which has a useful duration equivalent of 87 bits (from 0.5 to 87.5 bit time equivalent). A burst represents the physical content of a time slot. The bit with the lowest bit number (bn) is transmitted first. In order to minimise interference the mobile station is required during the guard periods (GPs) to attenuate its transmission amplitude and to adjust possible time shifts and the amplitudes of the bursts. Frequency correction bursts are used by the mobile station to adjust its receiver and transmitter frequencies. Synchronization bursts are used to establish an initial bit and frame synchronization. The access burst has an extended guard period which helps to control the time lag of the signals due to the initial distance between mobile station and BTS which can be up to 35 km. Once the time lag has been corrected, the delta time lag resulting from the alteration of distance of a moving mobile station is controlled with the aid of the normal guard periods of 8.25 bit durations. The dummy burst is applied if the message queue is empty. The structure of a normal burst is shown in Fig. 5.6.



bn = bit number, GP = guard period (8.5 bit time equivalent), TB= tail bit

Fig. 5.6 Time slot with a normal burst

The training sequence in the normal burst has 26 bits which represent the unchangeable synchronization pattern. This is enough to maintain the bit and frame synchronization once it has been found with the synchronization and the access bursts. The encrypted bit part of the normal burst is 2 x 58 bits.

Eight different training sequences have been defined. Neighboring radio cells (BTS antennas) are assigned different training sequences so that they can be distinguished by the mobile station.

- Frame structure
  The frame structure is shown in Fig. 5.7.

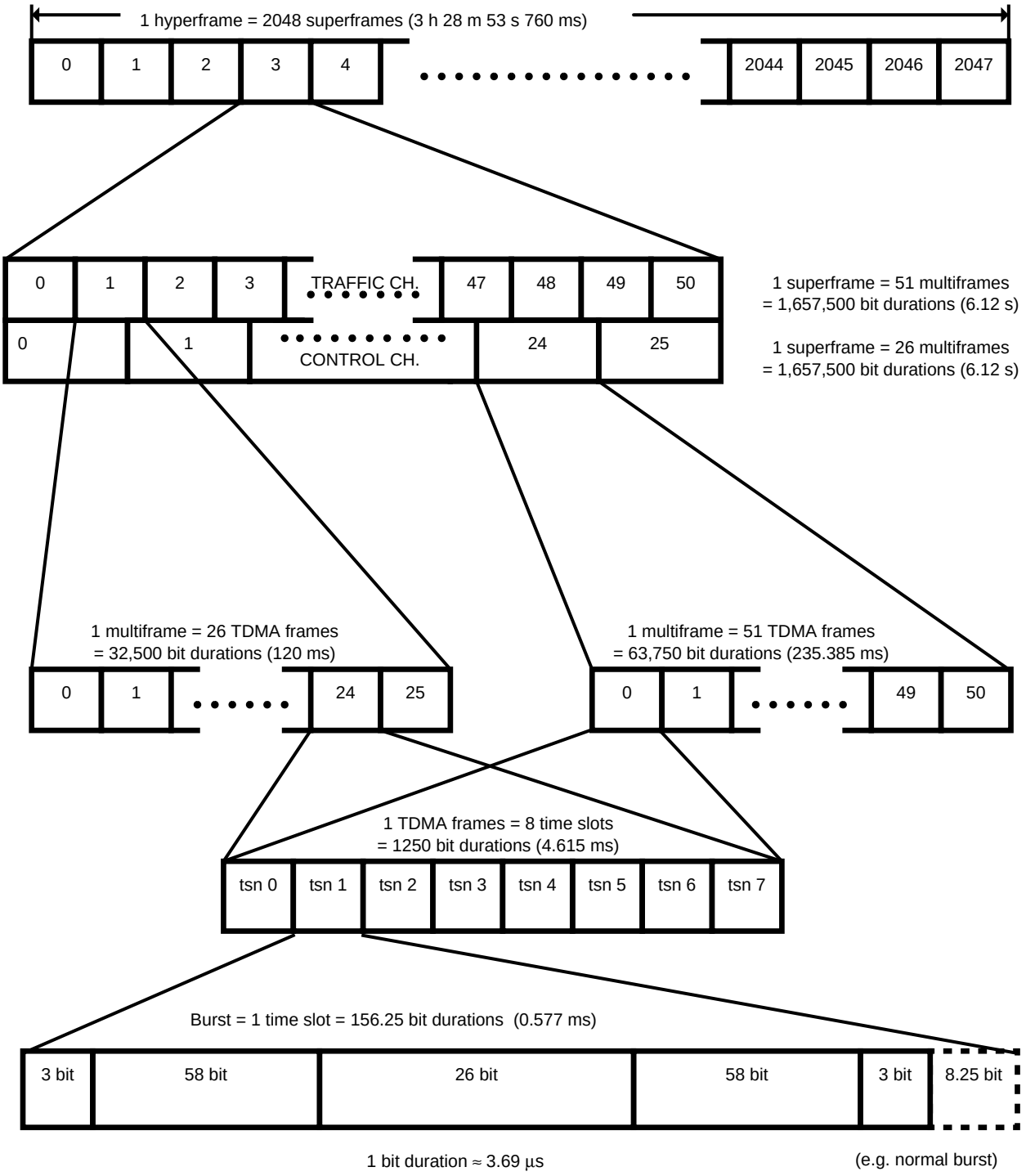


Fig. 5.7 Frame structure of the radio interface of the BSS

Traffic channels and control channels comprise different numbers of multiframes: 51 multiframes in the case of traffic channels, 26 multiframes in the case of control channels. Because the numbers 51 and 26 have no common measures (except the trivial divisor one), traffic and control channels can be active simultaneously at any time, even if their carrier frequencies are different.

5.2 Hardware

5.2.1 Hardware Architecture

The BSS consists of
– base transceiver station equipments (BTSEs)
– base station controllers (BSCs)
– transcoding and rate adaption units (TRAUs)

and and as described in Section 5.1 and shown in Fig. 5.1. A maximum of 60 BTSEs (sites) or 120 radio cells or 120 carriers can be connected to one BSC.

5.2.1.1 Base Transceiver Station Equipment (BTSE) BS-2x and BS-6x

In this Section the *"standard" type BTS equipments (BS-2x and BS-6x)* are described. The *micro BTS equipment (BS-11)* is described in the following Section.

The BS-2x and BS-6x BTSE is controlled by the base station controller (BSC), to which it is connected via the Abis-interface. The BS-2x and BS-6x BTSE may be either remotely located or colocated with the BSC. The traffic channels set up in the different BTSEs are switched transparently to the transcoding and rate adaption unit (TRAU) which - although part of the BSS - will usually be remotely located at the MSC site.

The BTS is defined by GSM standard as a network component which serves one cell, the latter in turn being defined by one distinct base station identity code (BSIC) from the mobile station point of view.

The hardware architecture of the logical BTS is such that it is possible to serve with one physical BTSE several logical BTSs (sector radio cells). This reduces equipment costs by sharing central BTSE hardware equipment.

The BS-2x and BS-6x BTSE normally is connected by one or more 2048 kbit/s PCM links, so-called Abis-interface to the BSC. Each BS-2x and BS-6x BTSE rack is connected to the Abis-interface by means of a line interface, which converts the external PCM signal into an internal data link called bus2 and bus1. Within each BS-2x and BS-6x BTSE rack bus1 connects the transceiver to the other BTS functional blocks.

The **BS-2x and BS-6x BTSE (with separate TX and RX paths)** consists of the following functional blocks (Fig. 5.8):

- BTSE control
- Link interface
- Transceiver
  – baseband & signal processing
  – transceiver and processor
  – power amplifier
- TX combiner (HYCOM, FICOM)
- RX pre-amplifier (RXAMOD)
- RX splitter (RXMUCO)

The **BS-2x and BS-6x BTSE (with duplex equipment)** consists of the following other functional blocks within the TX and RX path (Fig. 5.9 and Fig. 5.10):

- Duplex combiner (DUCOM) or Duplexer and low noise amplifier module (DULAMO)
- Receiver antenna module and multi coupler (RXAMCO)

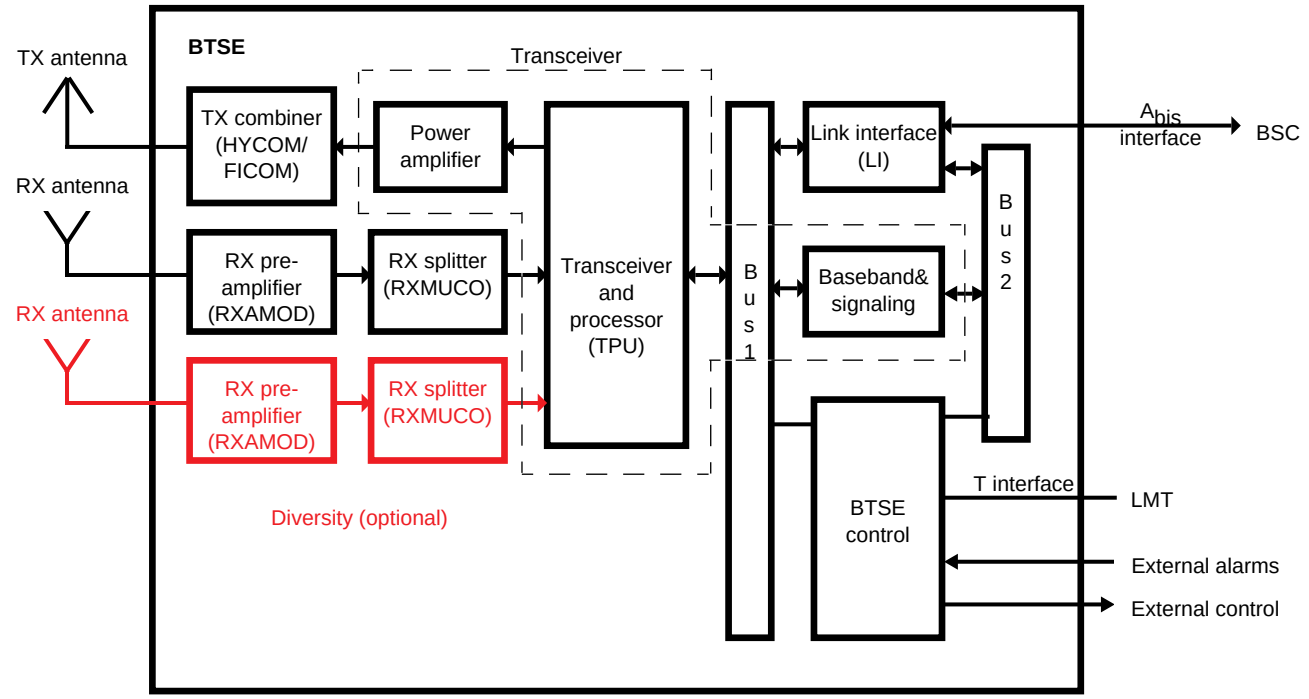


Fig. 5.8 Functional structure of the BS-2x and BS-6x BTSE (with separate TX and RX paths)

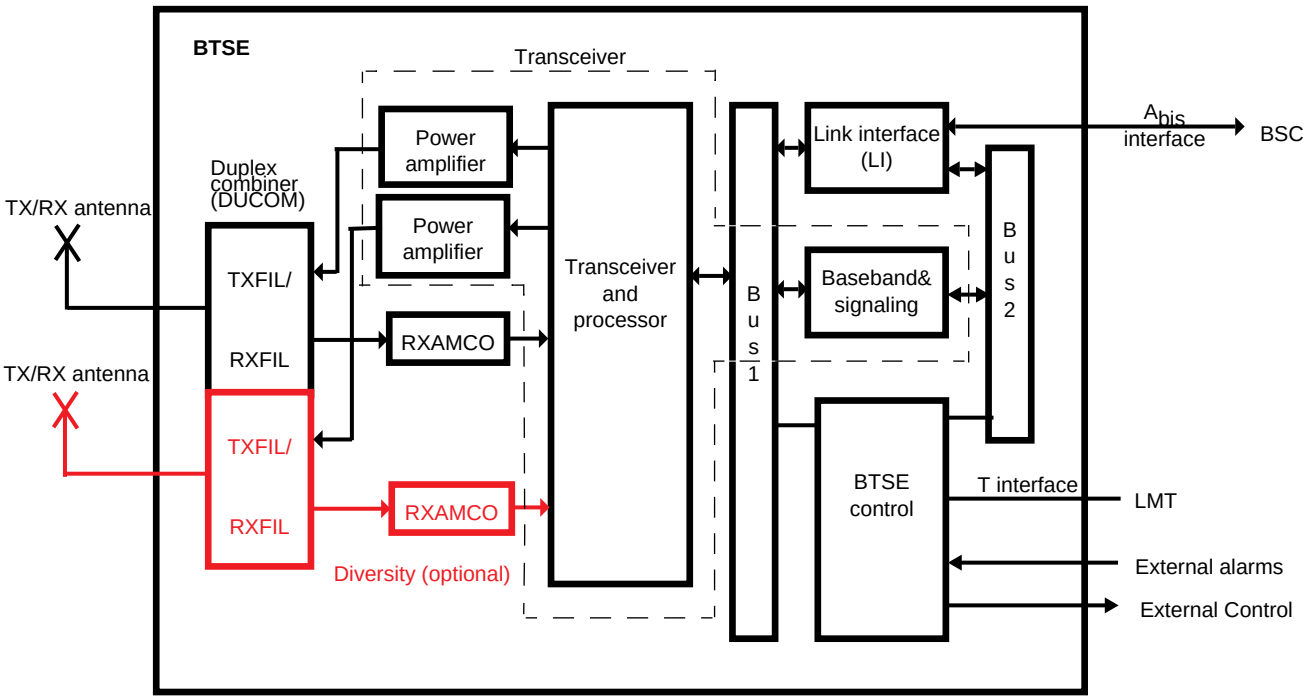


Fig. 5.9 Functional structure of the BS-2x and BS-6x BTSE (with duplex combiner (DUCOM))

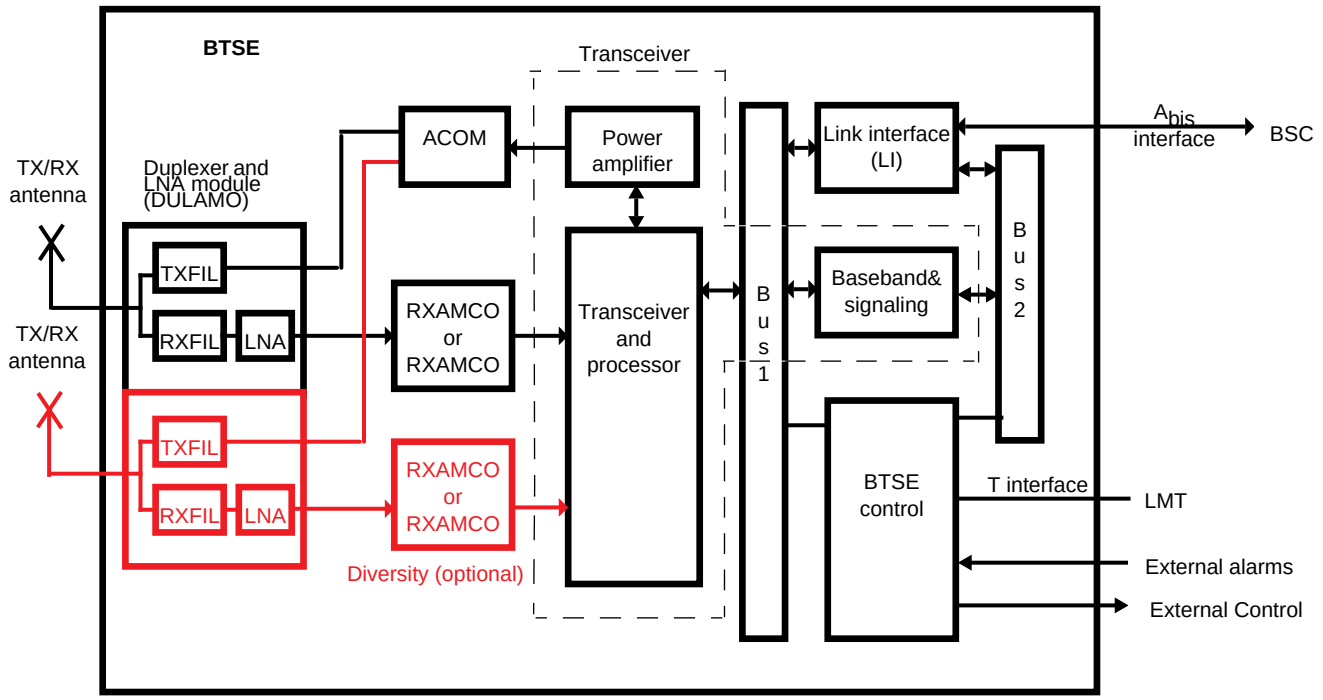


Fig. 5.10 Functional structure of the BS-2x and BS-6x BTSE (with Duplexer and LNA module (DULAMO))

BTSE control

The BTSE control is represented by the core controller (CCTRL) which controls all O&M tasks of an entire BTSE and controls all radio cells (BTS) belonging to one BTSE site. The CCTRL is installed a single time in the master rack.

Link interface

The link interface (LI) extracts the network clock information for the common clock generator and passes all BTSE relevant data to bus2. It provides on OSI layer 1 a PCM30 link to the BSC (Abis-interface). The physical part of the LI may change, depending on the transmission link type which must be supported on the Abis-interface.

Baseband & signal processing

This functional block is represented by the baseband and signal processing unit (BBSIG) which receives the traffic channel from the link interface via bus2 and receives OSI layer 3 messages via bus1. It encodes, encrypts and interleaves signalling and user data in accordance with the channel type used and executes pre-processing of uplink measurements and measurement reports sent from mobile station (MS) and performs power control and handover recognition.

Transceiver and processor

The transceiver is represented by the transceiver and processor unit (TPU) which consists of two main blocks, the TRXA and the TRXD. The TRXA part contains all the analogue signal processing parts and has a transmit and receive part. The TRXD part contains all the digital signal processing parts.

Power amplifier

The power amplifier (PA) provides the required RF power in the downlink path. There are separate low power and high power PA modules for the frequency bands of D900 and D1800. For D900/D1800 there are a low power version and a high power version.

TX antenna combiner (ACOM)

There are two following kinds of TX antenna combiner (ACOM):

- **Hybrid combiner (HYCOM)**
  Hybrid combiner (HYCOM) can be divided in two parts. One part is the hybrid network which uses a hybrid combining technique useable for up to 4 carriers. The other part is the transmit antenna module (TXAMOD) which consists of a transmission band filter and a directional coupler.
  The transmission band filter provides the required suppression of intermodulation products outside the transmit band, and protects the receiver against TX phase noise and spurious emission impacts.
  HYCOM can be used with baseband frequency hopping and with sythesizer frequency hopping.
- **Filter combiner (FICOM)**
  Filter combiner (FICOM) are remote tunable and enable a combination of up to 6 carriers in a rack. FICOM can only be used with baseband frequency hopping.

RX pre-amplifier (RXAMOD)

The RX pre-amplifier is represented by the receiver antenna module (RXAMOD) which is the first part of the receiver. It can be mounted near to the receiving antenna, and therefore is of upmost importance for the receiver performance.

The content is a band filter for the whole receiving band (RXFIL), and a 2-branch low-noise preamplifier.

The parallel architecture provides, in case of malfunction of one low-noise amplifier, a degraded but ongoing operation of the BTSE.

RX splitter (RXMUCO)

The RX splitter is represented by the receiver multi coupler (RXMUCO) which provides a multicoupler for the rack internal distribution of the received signals. The multicoupler consists of an amplifier and a splitter.

Duplex combiner (DUCOM)

The duplex combiner (DUCOM) can be divided in two main parts. One part is a bandpass filter for the transmit path (TXFIL) and a bandpass filter for the receiving path (RXFIL).

Duplexer and noise amplifier module (DULAMO)

The DULAMO consists of a duplexer section (with TXFIL and RXFIL) and a low noise amplifier (LNA). It provides the means to have simultaneously with every type of antenna combiner two antennas per radio cell, a LNA close to the antenna and to take advantage of “on air combining”. DULAMO can be utilized with every type of antenna combining (FICIOM, HYCOM, DUCOM).

Receiver antenna module and multi coupler (RXAMCO)

The receiver antenna module and multi coupler module (RXAMCO) amplifies the RX signal with low noise figure and splits the RX signal into four receiving signals, plus a separate high level output.

5.2.1.2 Base Transceiver Station Equipment (BTSE) BS-11

Here only the HW architecture of the *BTS equipment (BS-11)* is described. It is also called micro BTS. It is obviously different to the architectural concept used in the previous *"standard" type BTS equipments*, which are described in the Section before.

The BS-11 BTSE (micro BTS) is a compact module with a high level integration. The inner cards are in limited number and are not individually replaceable in the field.

The BS-11 BTSE consists if the following functional blocks
– transceivers (TRX1, TRX2)
– site manager (SMU)

Fig. 5.11 and Fig. 5.12 show the functional structure of the BS-11 BTSE (micro BTS), whereas Fig. 5.11 shows the 2-TRX micro BTS with integrated antennas and Fig. 5.12 shows the 2-TRX micro BTS with external antennas.

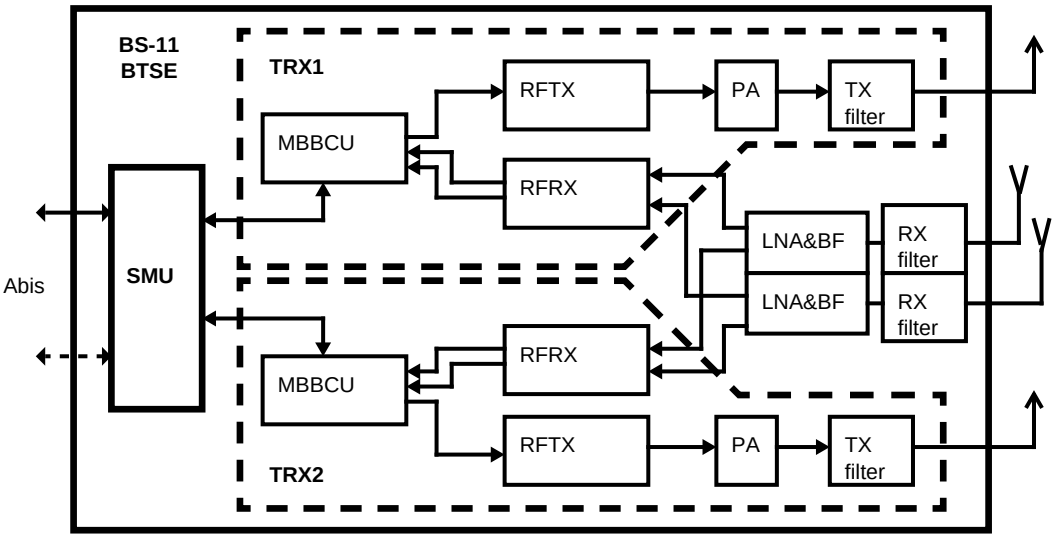


Fig. 5.11 Functional structure of the BS-11 BTSE (with integrated antennas)

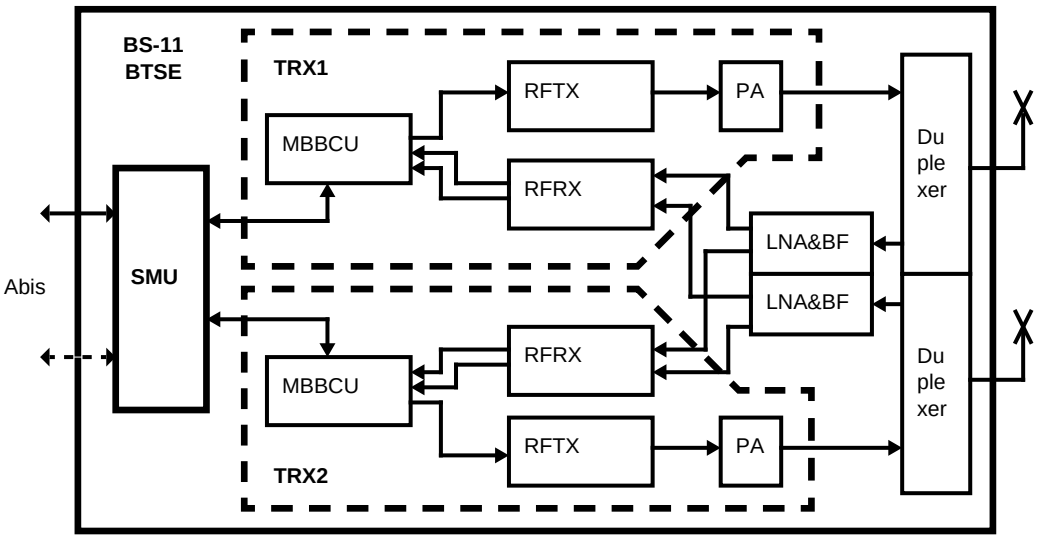


Fig. 5.12 Functional structure of the BS-11 BTSE (with external antennas)

Transceiver (TRX)

The transceiver is composed of the following modules:

– power amplifier (PA)
– radio frequency transmitter unit (RFTX)
– low noise amplifier & band filter (LNA&BF)
– radio frequency receiver unit (RFRX)
– multichannel base band unit (MBBCU)

The main functions of the *power amplifier (PA)* are output band-pass filtering in the defined band, max. output power control, RF power amplifier mixer gain, antenna VSWR alarms and overheating sensor. The output power of the micro BTS always is below 2 W (D900) or 3 W (D1800).

The main functions of the *radio frequency transmitter unit (RFTX)* are reception from MBBCU unit of the 270 kbit/s modulating signal, direct GMSK modulation in the defined frequency band, FR frequency hopping, static power control (downlink), dynamic power control, system timings generation and RF carriers reference clock generation.

The main functions of the *low noise amplifier & band filter unit (LNA & BF)* are selection of the proper RX band, and amplification of the input signal by means of a low noise amplifier.

The main functions of the *radio frequency receiver unit (RFRX)* are reception of radio signal from LNA/Band filter, conversion of radio signal to a first intermediate frequency and AGC control.

The *multichannel base band unit (MBBCU)* is the unit dedicated to the management of the 8 (full-rate) or 16 (half-rate) channels carried by the GSM TDMA frame.

Site manager (SMU)

The site manager unit (SMU) is the interconnection element between the transceivers and BSC. Two interface versions of the SMU exists, depending on the type of line interface required.

The main SMU functional blocks are the site manager processor (SMU card) and the combined line interface SMU combo card (SMUCB). The main functions of the site manager processor are to manage two 16 or 64 kbit/s HDLC links to/from BSC and to process a signaling connection to/from BSC both for radio signaling and O&M signaling. The SMU combo card provides two PCM30 interfaces (or N x 64 kbit/s) with 2048 kbit/s and two ISDN basic access (ISDN BA) interfaces with 144 kbit/s. The selection between the two line SMU interface versions is made by software through the local maintenance terminal (LMT).

The providing of additional ISDN BA interface is an extremely flexible means that Siemens provides to its customers especially when the micro BTS is placed in a location where no classical infrastructure (i.e. PCM lines) can be used, e.g. microwave in indoor applications (hotel lobbies).

Operators evolution to microcells

Introduction of microcells has to be rather regarded as an evolutionary than a revolutionary step, because micro-cellular networks rely on the fundamentals of hierarchical network architecture. This hierarchical network architecture in turn evolves from the various operator network evolution & optimization phases, which represent an ongoing and continuous process during network roll-out. Today operators are concerned with the optimization of their embedded network base and look for mature product solutions to address their needs and to flatten the way to a broader and more flexible network as a goal in future.

The above referred to ultimate goal is the deployment of so-called microcells of cell radii typically < 300 m. This is a matter that requires cost efficient technology which consequently assumes an optimized hardware & software platform to the one implemented today.

Applications of BS-11 BTSE (micro BTS)

The BS-11 BTSE product can be universally used especially in those applications and spots not reached before. Clear advantages are sensed particularly concerning volume when compared to conventional first and second generation products of SBS baseline.

This leads to new application segments primarily in urban and suburban areas:
- airports
- touristic sites, e.g. natural parks
- shopping malls
- train stations
- hotel lobbies
- conference halls
- exhibition halls
- hot spots, e.g. central business districts
- street tunnels

Typical rural deployment of the BS-11 BTSE is also easy thanks to specific outstanding characteristics deemed as prerequisites for deployment in rural applications e.g. low power consumption and the flexibility in terrestrial network interconnection as well as the various power classes offered by the BS-11 BTSE product.

The BS-11 BTSE concept bears in mind economy and features suitability for realization of enhanced and cost efficient micro-cellular networks. This is especially mirrored in site acquisition advantages, installation and serviceability objectives of the BS-11 BTSE.

5.2.1.3 Base Station Controller (BSC)

The BSC is the central component of the BSS. Fig. 5.13 shows the functional structure of the BSC. The BSC supports as well full rate as half rate operation. A half rate upgrade has impact to all main functional parts of the BSC.

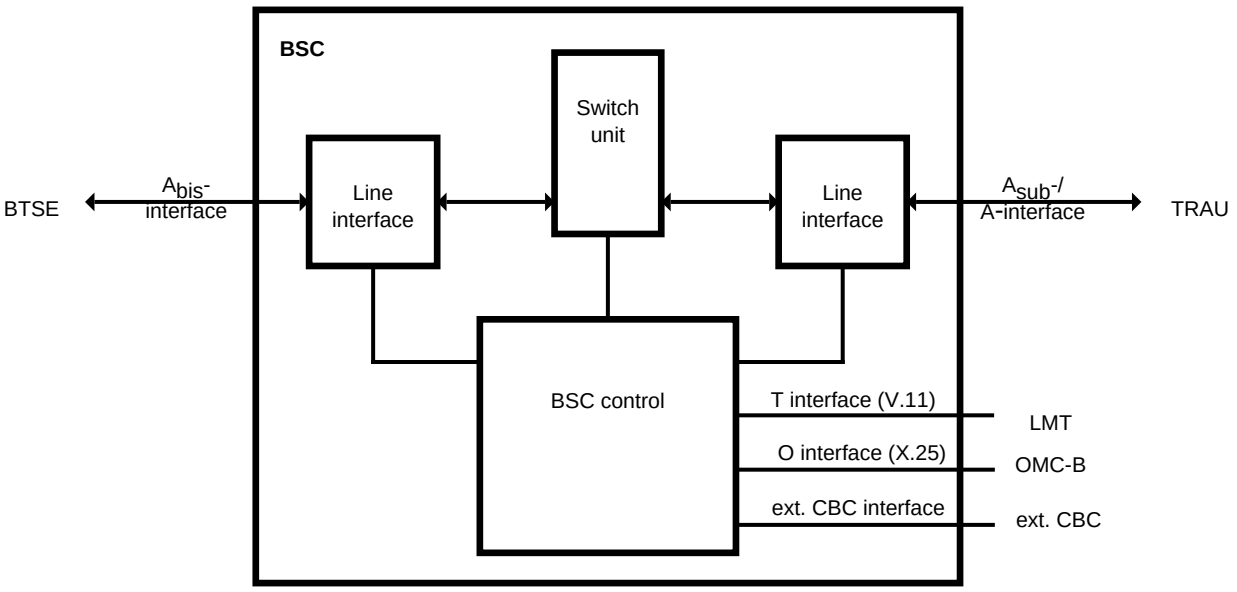


Fig. 5.13 Functional structure of the BSC

The BSC consists of
- BSC control
- line interface
- switch unit

BSC control

The BSC control is a multiprocessor system. It contains two main processors performing call processing and O&M tests, and a set of slave processors for peripheral tasks and for the communication between the components of the BSS. To achieve a high degree of reliability, the main processors are duplicated. As a background storage device a hard disk is provided.

One of the two main processors is the so called administrative processor represented by the main processor control card (MPCC), which controls the connections of the switching unit on the basis of the telephony processor messages. The other of the two main processors is the so called telephony processor represented by the telephony and distributor processor card (TDPC), which is responsible for message exchange with the other network entities via the peripheral pre-processors.

There are two types of peripheral processors. One of them is the peripheral processor for LAPD channels (PPLD) which is responsible for handling the OSI level 2 LAPD protocol (used for signaling on the Abis- and Asub-interfaces). The other type is the peripheral processor for CCS7 (PPCC), which handles CCS7 MTP OSI layer 2 for the signaling towards the MSC (A-interface, via Asub-interface).

Operation and maintenance functions of the BSS can be accessed remotely via a dedicated interface (O-interface) towards an operation and maintenance center for BSS

(OMC-B). Additionally, a local maintenance terminal (LMT) may be connected allowing for operation at the BSC on site. For this there is the O&M interface (IXLT), which allows the main processor control card (MPCC) to be connected to the O&M center by a ITU-T X.25 interface and to the local maintenance terminal (LMT) by ITU-T X.21/X.11 interface using the LAPB protocol. A connection of an external cell broadcast center (CBC) is possible via a separate interface.

Line interface

The line interface (QTLP) provides the connections towards the BTSs (Abis-interface) and TRAU (Asub-interface) via standard 2 Mbit/s digital lines.

Each line interface handles four 2 Mbit/s PCM lines; each PCM line has four physical interfaces (terminal); the active physical interface is selected, on a per channel basis, under software control.

In order to reduce the use of PCM lines and to obtain cost-effective operations, 8x8 kbit/s submultiplexing traffic channels are inserted in one PCM-slot.

If required, the QTLPs can be distributed deliberately between Abis- and Asub-interfaces.

Switching unit

The switching unit (SN16) is a non blocking time-stage able to switch 12.288 unidirectional 16 kbit/s time slots, which are conveyed to/from outside by means of 23 x 8.192 kbit/s highways (for line interface connection; 1 highway is unused) and 4 x 2.048 kbit/s (from signalling terminal connection).

It provides, under the control of the main processor control card (MPCC), traffic connections by linking mobile station time slots with the assigned MSC trunk time slots. This allows, for example, to manage the handover among BTSs covering adjacent radio cells still belonging to the same BSC service area without directly involving the MSC resources.

5.2.1.4 Transcoding and Rate Adaption Unit (TRAU)

Although the transcoding and rate adaption unit (TRAU) logically is part of the BSC, it is designed to be physically located at the MSC site. This helps to save transmission capacity between BTS and MSC site. Fig. 5.14 shows the functional structure of the TRAU.

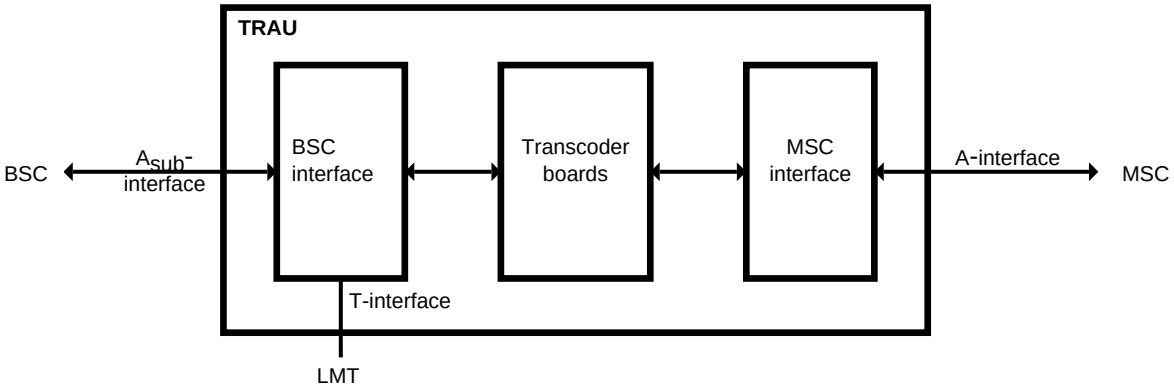


Fig. 5.14 Functional structure of the TRAU

The TRAU consists of the following functional blocks
- BSC interface
- MSC interface
- transcoder boards

BSC interface

The BSC interface is represented by the BSC interface card (BSCI) which houses the central controller of the TRAU and includes an interface towards the BSC using normal PCM links with a 16 kbit/s traffic channel structure. It multiplexes the serial lines generated by the TRAC boards to build the whole lines to be sent to BSC and is transparent for the CCS7 channel (64 kbit/s channel) and for the X.25 link between BSC and OMC-B (64 kbit/s channel).

MSC interface

The MSC interface is represented by the MSC interface card (MSCI) which multiplexes the serial lines generated by the TRAC boards to build the whole 64 kbit/s traffic channel structure to be sent to the MSC and processes the LAPD protocol residing in the control link of the BSC. By using a dedicated serial communication link, it sends to BSCI the messages received from the BSC (directly or via another TRAU) and receives the messages from BSCI that are to be inserted in the link towards the BSC.

Transcoder boards

Transcoder boards are represented by the transcoding and rate adaption card (TRAC) which processes 24 TRAU frames for 24 x 16 kbit/s traffic channels (uplink) with reference to Asub interface side and for 24 x 64 kbit/s traffic channels (downlink) with reference to A interface side. They operate with speech and data on each channel, either at full-rate, half-rate and enhanced full-rate (coding and rate adaption function) and performs DTX/VAD function (for the full-rate channels) and performs the volume control to compensate for possible losses of the speech level on a per call basis.

5.2.2 Mechanical Design

5.2.2.1 Rack Layout

Base transceiver station equipment (BTSE)

- The spectrum of the *"standard" type BTSE equipments (BS-2x and BS-6x)* includes:
  The BS-60 for indoor sites, which has up to 6 transceivers (TRX) per rack. The net volume of one rack with 6 transceivers is approximately 432 liters. This is also available as outdoor versions (BS-61 with cooling system) with integrated power supply, battery backup, line interface equipment (e.g. micro wave equipment) and the relevant climate control, depending on the climatic conditions of the site. The net volume of a BS-61 rack with 6 transceivers is approximately 1716 liters.
  The BS-20 for indoor sites, which has 2 transceivers per rack. The net volume of one rack with 2 transceivers is approximately 209 liters. Similarly to the BS-60/61, this is also available as an outdoor version BS-21 with cooling system. The BS-21 has an integrated power supply and battery backup to facilitate the installation. The net volume of one shelter with 2 transceivers is approximately 399 liters. A special outdoor version BS-22 with 2 transceivers in a compact design of approximately 150 liters is available. The wall mounted BS-22 is qualified for deployment in high frequented public areas like airports, train stations, exhibition halls, street tunnels etc.
  All BS-2x and BS-6x BTSE types have the same wide spectrum of features ranging from various radio cell applications (omni or sectorized) over antenna diversity to the remote receiver antenna pre-amplifier. The application of TX antenna combiners (HYCOM, FICOM, DUCOM) depends on the BS-2x and BS-6x BTSE type. HYCOM and DUCOM are applicable to all BS-2x and BS-6x BTSE types and FICOM are applicable to BS-60/61 types.
  Fig. 5.15 shows an overview of the BTS equipments (including micro BTS).
  The minimum configuration of one BS-2x and BS-6x BTSE site consists of the BS-2x and BS-6x BTSE core module (where the core controller is only required once per BTS site) and one radio cell with at least one carrier (TRX). Fig. 5.16 shows a front view of a BTSE rack (R:BTS) with indoor type BS-60.
- The *micro BTS equipment (BS-11)*
  The BS-11 is a one (or two) transceivers universal BTS (i.e. outdoor and indoor compatible) practically based on more tailored hardware compared to the "standard" type BTS equipments BS-21/BS-22, BS-20, BS-60 and BS-61. The net volume of one device is approximately 28 litres. The BS-11 micro BTS is available with an integrated planar antenna. The BS-11 is wall and pole mountable.

	BS-60	BS-61	BS-20	BS-21/BS-22	BS-11
	6 TRX (indoor)	6 TRX (outdoor)	2 TRX (indoor)	2 TRX (outdoor)	1 (2) TRX (outdoor/ indoor)
No. of TRX per rack/shelter/ cabinet	6	6	2	2	1 (2)

Fig. 5.15 BTSE products ("standard" type BTS and micro BTS equipment)

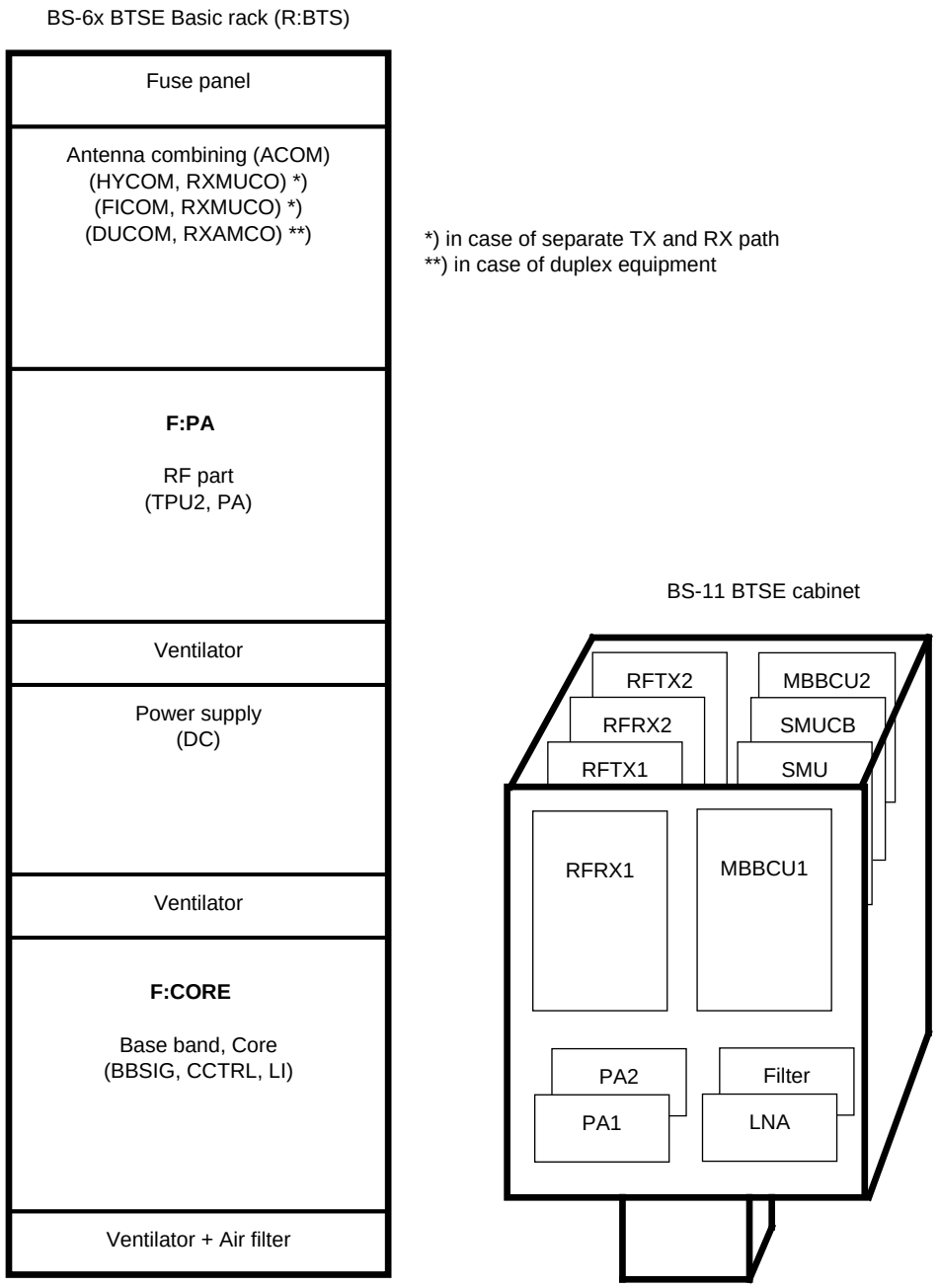


Fig. 5.16 BTSE rack/cabinet configurations (type BS-60 for indoor installation and type BS-11 with integrated antenna)

Base station controller (BSC)

The BSC is contained in a subrack 724 mm high (with base module), 1448 mm high (with base + extension module), 300 mm deep and 600 mm wide. Thanks to its compact design occupying a space of less than 0.26 cubic meters and its low power dissipation the BSC is operated without any fans or air condition. Therefore, the operator has the choice of locating the BSC centrally in telecommunications rooms or remotely in a shelter or in a confined space. These BSC subracks are inserted into Siemens Information and Communication Networks (ICN) standard dimension racks (h x w x d = 2000 x 600 x 300 mm) for adaption to the MSC/VLR site.

The BSC core module is always equipped with the necessary boards to provide the real time processing performance for the maximum BSC configuration. BSC system capacity with respect to the number of link interfaces (QTLP) or pre-processing boards for LAPD signaling (PPLD) can be expanded. This can be done by expanding the base module with the expansion module and inserting additional boards into an already installed expansion module.

This allows a very easy and gradual network growth to more complex and powerful configurations without traffic interrupion. Fig. 5.17 shows a front view of a BSC rack (R:BSC) with basic module and expansion module.

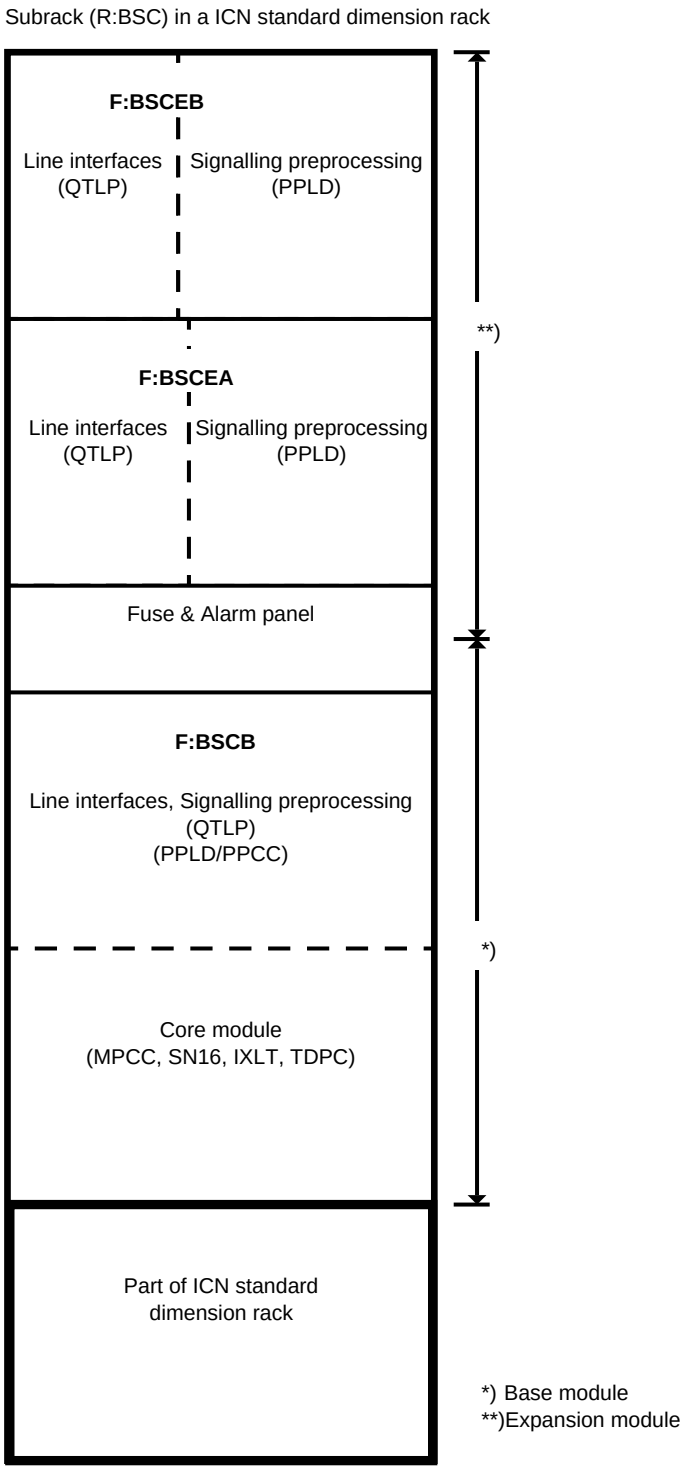


Fig. 5.17 BSC rack configuration

Transcoding and rate adaption unit (TRAU)

The TRAU is contained in a rack with max. 4 TRAU units (shelves) each processing 120 traffic channels. The dimensions are height 2000 mm, depth 300 mm and width 600 mm.

The TRAU configuration is modular on the basis of the number of transcoders that may be installed per TRAU shelf and the number of TRAU shelves that may be installed within one TRAU rack. Fig. 5.18 shows a front view of a TRAU rack (R:TRAU).

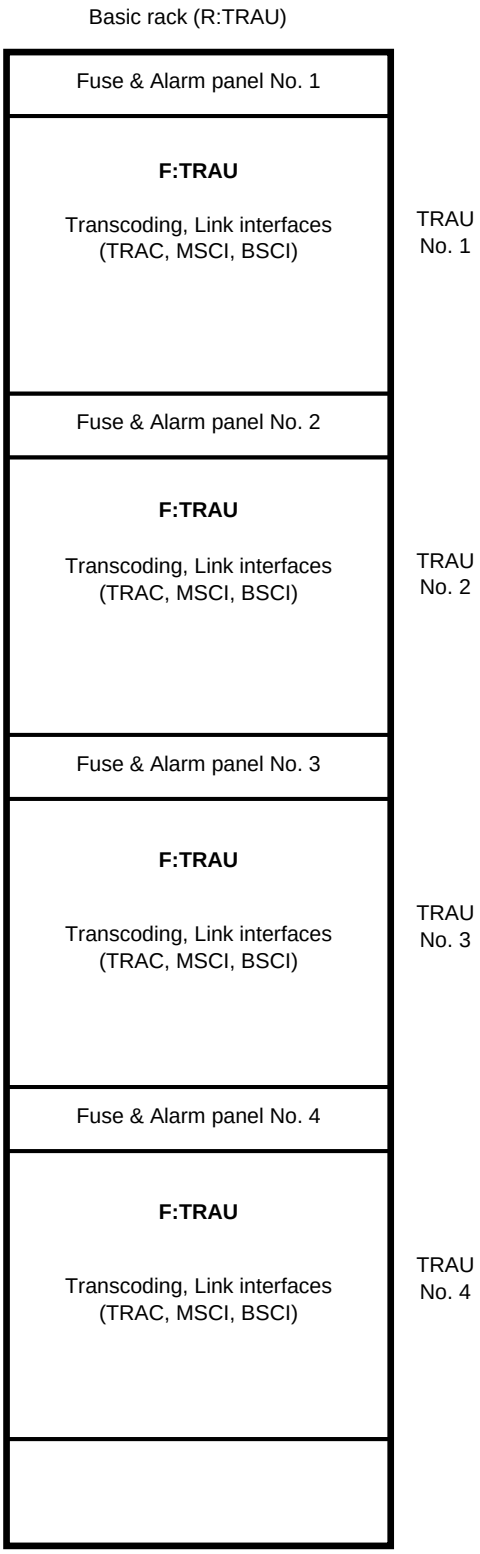


Fig. 5.18 TRAU rack configuration

5.2.2.2 Floor Layout

Base station controller (BSC)

A BSC rack can be positioned anywhere in a room. Integration of the BSC rack into a outdoor cabinet for outdoor installations is currently under investigation.

Base transceiver station equipment (BTSE) BS-2x and BS-6x

The BS-2x and BS-6x BTSE racks can be positioned anywhere in a room, wall or can be pole mounted. Back-to-back installation is possible for BS-20 or BS-60. The outdoor cabinet BS-21 is a separate construction which containes the basic BS-20 rack and the cooling equipment. The outdoor cabinet BS-61 is a separate construction which containes the basic BS-60 rack, the climate control equipment, the power supply and auxiliary equipment (e.g. microwave equipment).

Transcoding and rate adaption unit (TRAU)

The TRAU is always located at MSC sites.

5.3 Software

5.3.1 BS-2x and BS-6x BTSE Software

Fig. 5.19 shows the software architecture of the BS-2x and BS-6x BTSE.

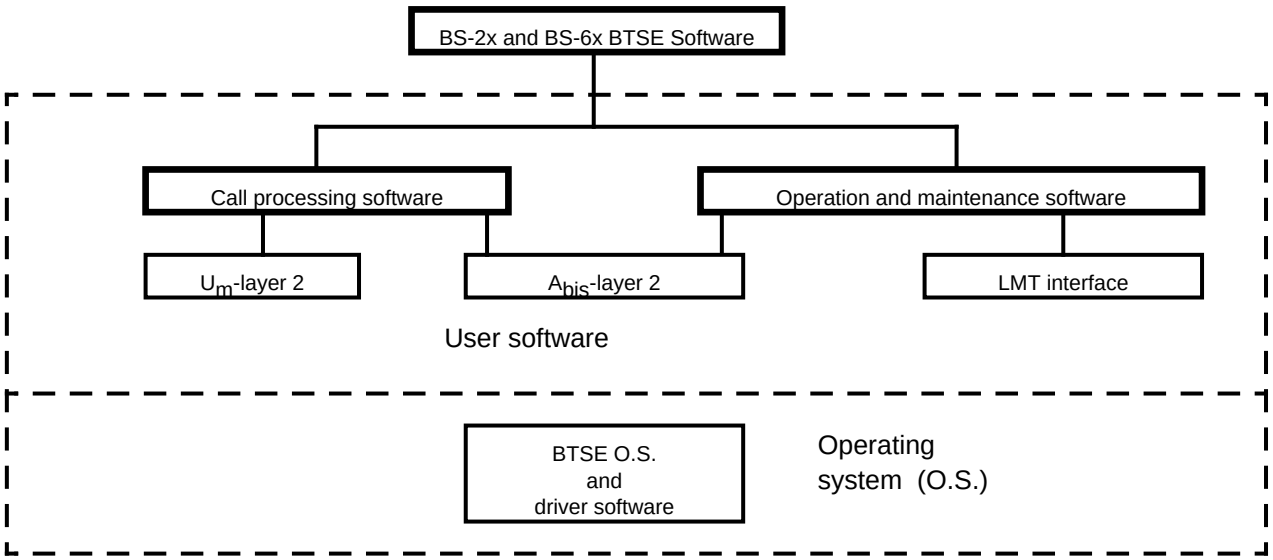


Fig. 5.19 BS-2x and BS-6x BTSE software architecture

The BS-2x and BS-6x BTSE software comprises three main blocks:
– operating system
– radio and terrestrial channel handling (call processing)
– operation and maintenance functions

All the software in the BS-2x and BS-6x BTSE (the basic bootstrap programs excepted) is down-loadable.

Operating system

The operating system provides the following services to the users:
– task scheduling
– task communication with mailboxes and events
– time management
– system calls to control the peripheral hardware
– provides a unique, processor independent, interface to the user by an intermediate layer, even though there is a different OS-kernel for each different processor type

Call processing (Radio and terrestrial channel handling)

Traffic channel handling
This software is decentralized in the boards operating on a per-carrier-basis (the TPUs) and in boards handling the channel related tasks (the BBSIGs). The handling of the Um layers is partly realised through special purpose hardware.

- BBSIG

  Down direction:
  – controls the traffic channel and unpacks the TRAU frames received from the bus2

  - codes traffic data (block and convolutional coding), interleaves, encrypts and maps them on bursts with a format usable by the Um-interface
  - concatenates additional information for power control with the traffic data addressed to a TPU2. This is transmitted through the bus1, which is used as a switch between the BBSIGs and the TPU2s

  Uplink direction:
  - performs demapping, decryption, deinterleaving, convolutional and block decoding. The BBSIG packs at last the traffic data in the TRAU frames

- TPU

  Downlink direction:
  - power control information is passed to the PA (static power control in 6 steps and dynamic power control according to GSM standard)
  - the midamble is inserted to the traffic data and passed to the analogue processing

  Uplink direction:
  - the serial data are at first filtered and equalised in the TRXD, then sent through the bus1 to the BBSIG logically connected to the terrestrial channel according to the frequency hopping scheme

Signaling channel handling

- CCTRL

  Downlink direction:
  - the signaling channels on the Abis interface are routed along the bus2 to the CCTRL, which handles the LAPD protocol
  - a message dispatcher passes Abis layer 2 management and O&M messages to the main processor in the CCTRL
  - it also forwards call control messages to the BBSIGs

  Uplink direction:
  - in the uplink direction the dispatcher manages the access of the different entities to the LAPD channels

- BBSIG
  - the BBSIG software realizes the interworking between the RR sublayer of the Um-interface and the BTSM sublayer of the Abis-interface and also maps the different Um signaling channel types onto the Abis signaling channels. The BBSIG handles the LAPDm protocol and the interface to the Um layer 1 functions

Operation and maintenance functions

O&M functions are:
- software management including downloading
- configuration management
- fault treatment management
- test management
- performance management

The O&M functions are hierarchically organised in the BS-2x and BS-6x BTSE. The CCTRL software controls all O&M functions in the BS-2x and BS-6x BTSE. The O&M information is received and transmitted via the Abis-interface. Each O&M function in the CCTRL has a corresponding local function in each main processor connected to the bus1. There local functions coordinate the same function in the subordinate processors connected to it (on the same board or in a peripheral board).

5.3.2 BS-11 BTSE Software

Fig. 5.20 shows the BS-11 BTSE software architecture. Each software module points to the cards in which is executed.

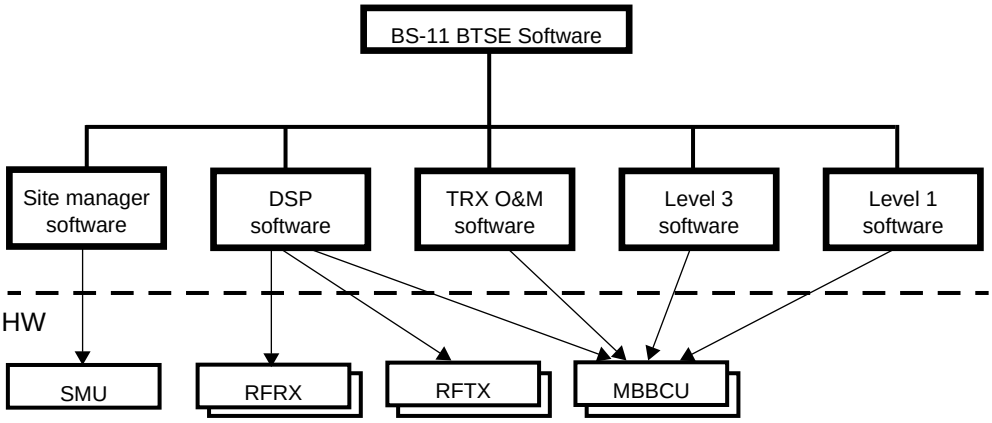


Fig. 5.20 BS-11 BTSE software architecture

The BS-11 software comprises the following blocks:
- micro BTS operating system
- site manager (SM) software
- digital signalling processor(DSP) software
- TRX O&M
- level 3 (L 3) software
- level 1 (L 1) software

Operating system

The operating system is a proprietary system, specially designed for telephonic applications. The main functions are process scheduling in a event-driven mode, event debugging and tracing and process timing.

Site manager (SM) software

The site manager software is subdivided in two main areas: interface module and SM O&M module and is executed by two processors in the SMU, each one dedicated to a MBBCU. The interface module manages the Abis interface to/from BSC, the LAPD protocol for example. The O&M module provides the alarm handling, the configuration handling and the software handling for example.

DSP software

The DSP software is subdivided in 6 modules distributed on 16 DSPs (1 on RFTX, 1 on RFRX and 14 on the MBBCU) for each TRX. At each module is associated a functionality. The functions of DSP software are: RF handling (RX and TX), channel coding/decoding, remote transcoder control, GMSK modulation/demodulation and encryption algorithm management.

TRX O&M software

The TRX O&M software on each MBBCU performs the same software. The functions provided by this software module are related to TRX management, namely alarm handling, configuration handling and status handling.

Level 3 (L 3) software

The L 3 software on each MBBCU is loaded with the same software. The L 3 software is subdivided in two main areas: Application module and O&M module. The applications module provides CCCH signalling, TRX signalling, hand-over management, power control management, power control management and SM interfacing.

Level 1 (L 1) software

The L1 software on each MBBCU performs the same software. The L 3 software is subdivided in two main areas: Application module and interface module. The application module provides LAPDm protocol, radio physical layer handling and RX automatic gain control for example.

5.3.3 BSC-Software

Fig. 5.21 shows the BSC software architecture.

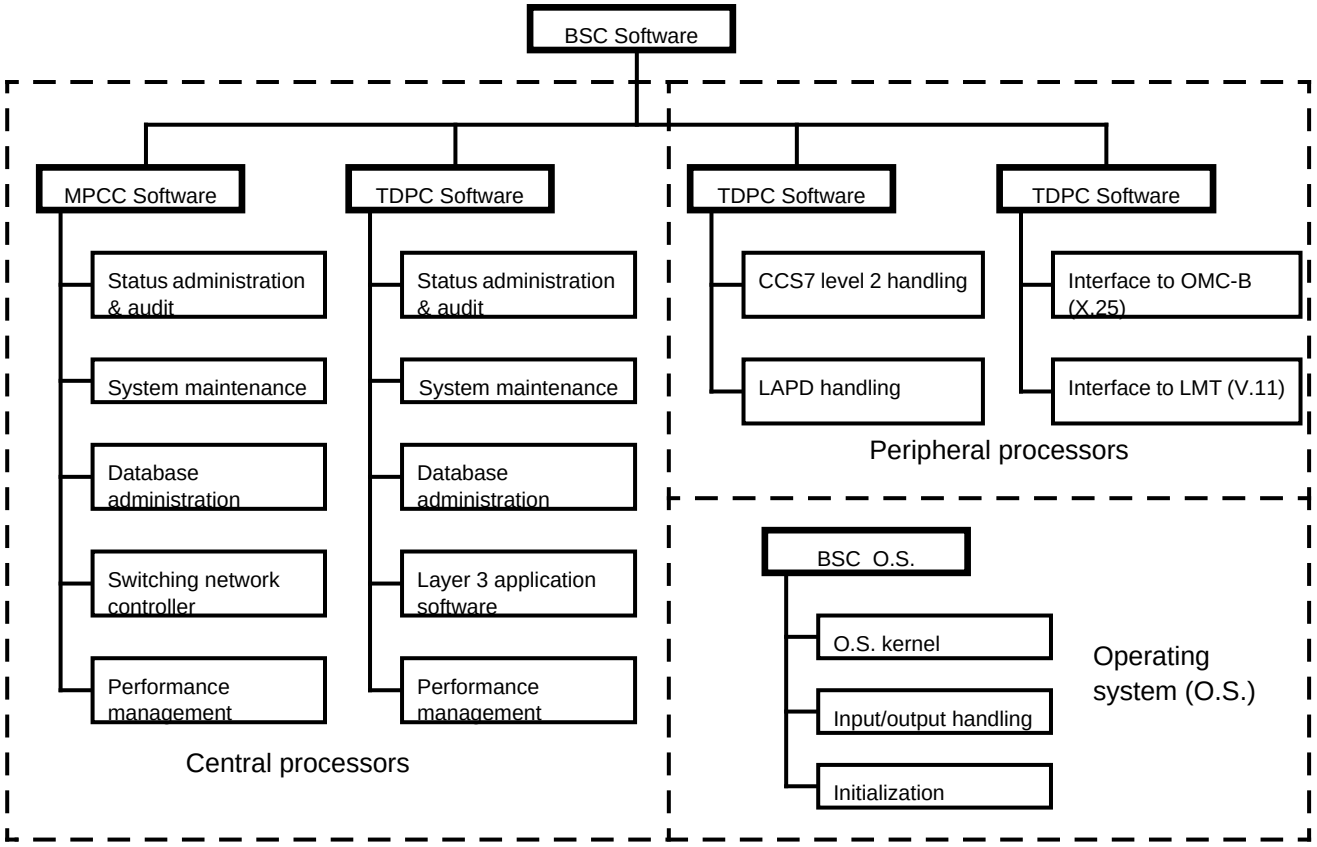


Fig. 5.21 BSC software architecture

The BSC software can be subdivided into 5 main blocks:
- operating system
- MPCC software
- TDPC software
- PPXX software
- IXLT software

Operating system

The OS kernel (real time executive plus, RTE+) manages the following resources:
– CPU time (real time)
– system memory (dynamic allocation of memory areas)
– task communication and synchronization devices (mailbox, event, semaphore)
– system timing

RTE+ also includes special functions related to:
- support the finite state machine model, which accounts for programming the application software using the SDL methodology
- CPU performance monitoring the hardware configuration management system time and date supervision
- input output handling, which includes:
  – OS inter processor communication functions; the communication is supported in the hardware by the provision of a dual ported RAM
  – MML interface (OMC & LMT), supporting:
    - OS initialization
    - software management; this element is responsible for protected memory management

Board functionality
- MPCC software

  It is divided into the following packages:
  – status administration & audit; it controls the operational status of all hardware devices in the system by processing either internally or externally initiated status transition requests. Alarm reporting functions are also implemented in this package
  – system maintenance; it provides hardware recovery functions (fault detection, fault isolation and service restoring) and hardware diagnostic procedures. The MPCC is the master processor in driving all the recovery and diagnostic processes for all system hardware
  – database administration; it provides procedures for initializing the system configuration data and the operational parameters driving the system features
  – switching network controller; it sets up the digital connection between the A and the Abis-interfaces, as directed by the call-processing software in the TDPC processor
  – performance management; its main function is to provide statistical reports of the system behaviour
- TDPC software
  Each software package resident in the MPCC, the switching network controller excepted, has a counterpart in the TDPC which acts as ”slave” to the MPCC resident ”master”.
  For example, a database update process is driven by the database administration software in the MPCC, which may activate a ”slave” process in the TDPC to update the TDPC resident portion of the database affected by the change.

  This means that the TDPC software contains the following packages:
  – status administration & audit
  – system maintenance
  – database administration
  – performance management

In addition, there is the following package: OSI layer 3 application software, providing:

- call processing capabilities; they include all the functions related to call handling procedures, radio/ terrestrial resource management and BSC call management
- functions related to layer 3 (message transfer part (MTP), and signaling connection control part (SCCP)) of the CCS7
- functions related to message reception and transmission to/from Abis-interface and A interface

- PPXX software
  The peripheral processors PPLD and PPCC realize the level 2 of the protocol stacks toward the BTSE and TRAU (LAPD) and the MSC (ITU-T CCS7) respectively.
- IXLT software
  The IXLT processor realizes the OSI stack toward the operation and maintenance center for BSS (OMC-B). It also implements the interface to the local maintenance terminal (LMT).

5.3.4 TRAU-Software

Fig. 5.22 shows the TRAU software architecture.

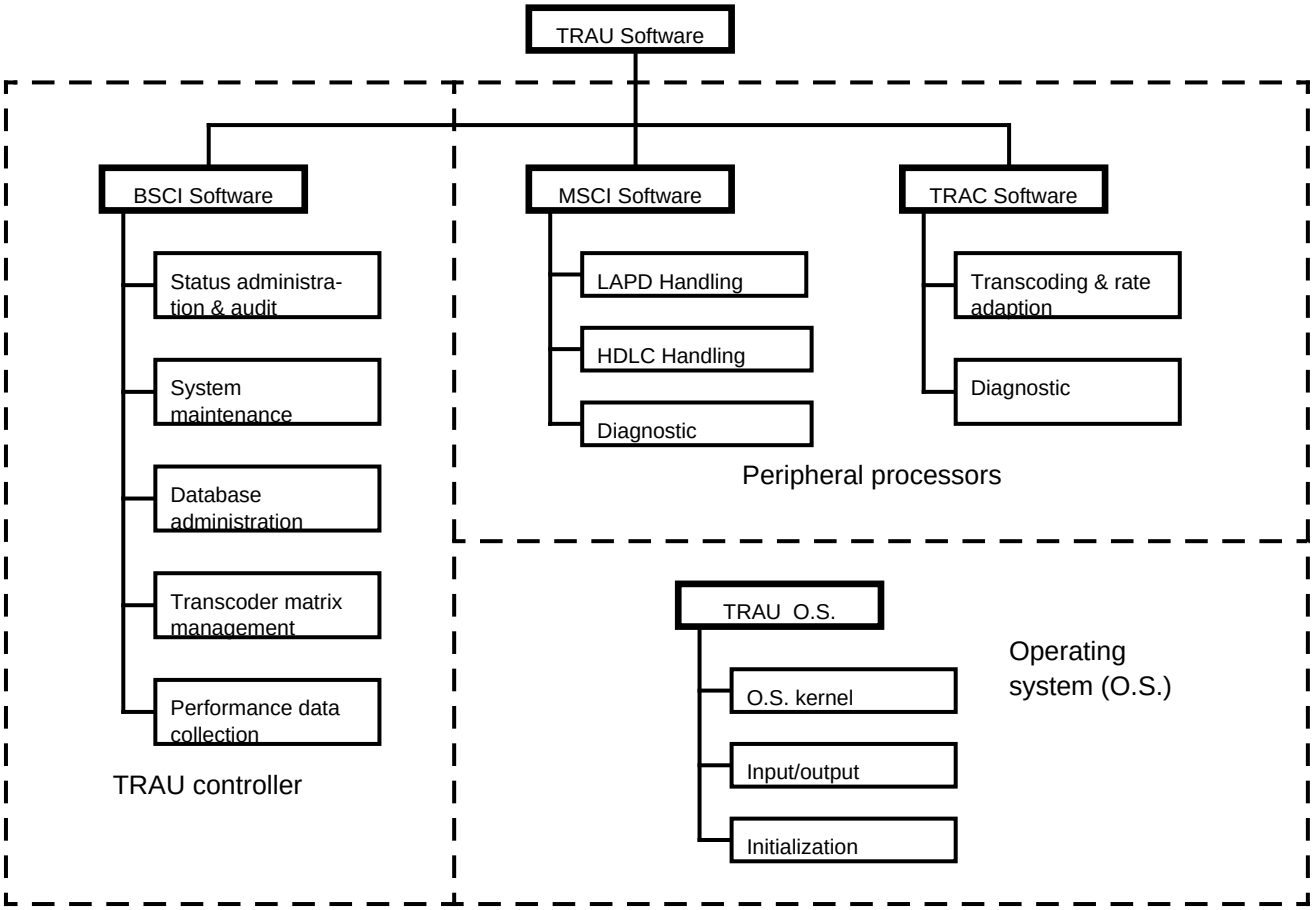


Fig. 5.22 TRAU software architecture

For all processors the software is loadable from the BSC.

The main blocks of the TRAU software are:
– operating system
– BSCI software
– MSCI software
– TRAC software

Operating system

The OS kernel depends on the processor used.

In detail, the different OS kernels are:
– the RTE+ (real time executive plus) on the BSCI;
  it is the same OS kernel used in the BSC
– the RTE (real time executive) on the MSCI and on the TRAC;
  it is a proprietary operating system specifically designed to work in a very hard real time environment. The RTE basic features are: multitasking, task synchronization, timeout handling, message exchange, memory resource management
– a simplified scheduler on the TRAC;
  it is specifically designed to support, in an optimized way, the functionalities of this processor

Board functionalities

- BSCI software
  – houses the central controlling function of the TRAU, which is responsible for
    - hardware configuration
    - fault management
    - test management
    - performance management collection
    - database administration
    - transcoder matrix management
  – interface function from TRAC towards the BSC
- MSCI software

  The main blocks of the MSCI software are:
  – LAPD handling;
    provides a protocol handler for the O&M communication link between BSC and TRAU; the application part is on the BSCI
  – HDLC handling;
    provides a protocol handler for the BSCI-MSCI interface; the application part is on the BSCI
  – diagnostic;
    provides internal diagnostic processes that will run under BSCI processor control
- TRAC software

  It provides the following functions:
  – transcoding and rate adaption
  – discontinuous transmission (DTX)/voice activity detection (VAD)
  – drop-insert operation upon command, independent from that of the other cards, either on the BSC line or on the MSC lines
  – the BSC can configure in any way and without restrictions the correspondence between the channels in the BSC line and the channels in the MSC lines
  – diagnostic;
    provides internal diganostic processes that will run under BSCI processor control

5.3.5 Software Management

In order to fulfill the specific GSM standards about network management procedures the D900/D1800 BSS has a structured software management. The software management includes a strategy about software recovery which is a kind of software fault defence action. The software related recovery actions consists of

– initialization
– downloading or reloading procedures

Initialization

An initialization procedure has the possibility to affect only the involved data areas and is distinguished by

– system restart (bring up initialization), with reload
– full initialization
– lower level initialization

- System restart
  A system restart is the initialization that occurs after a reload.
- Full initialization
  The full initialization is the restart (without reloading) of the affected network element. It can be manually activated (from LMT and/or OMC-B) but can also be activated automatically by the system defence action for specific errors that have occured.
- Lower level initialization
  A lower level initialization is according to a specific software task. It can be manually activated but can also be activated automatically by the system defence action for specific errors.

Downloading, loading/reloading

- Downloading
  Downloading is the procedure of transfering executable files (load image files) from OMC-B/LMT to the BSC hard disks and subsequent to the other BSS network elements. In the OMC-B/LMT there is an installation program that moves the software packages being released in three directories. A directory ” backup” holds a copy of the current running software version for all the BSS network elements, another directory ”fallback” holds a reliable software version for all BSS network elements and a third directory ”new” holds the new software version in case of update/upgrade.
- Loading/reloading
  The loading/reloading procedure affects a data and software image transfer which describes the actual phase of putting code onto processors memory. The loading procedure can be divided into: system bring up and software version changes.
  A system bring up is intended as the (re-)starting of the whole BSS after a power down/power up sequence.
  A software version change is the loading of a new software version while the BSS is running and keeping at minimum the loss of service.

Software image

A software image consists of executable code and/or of data areas. This data is a kind of semipermanent data which can be modified from the operator during the lifetime of the system. Transient data could not be recovered via downloading or reload procedures.

System upgrades

System upgrades, e.g. for the introduction of new features follows the GSM standards which includes

– loading of the new software onto the OMC-B
– downloading the BSS software
– amending the BSS database
– activate the new software and parameter changes
– bringing the BSS back into service

All these activities are operator invoked actions which are provided by the BSS.

6 O&M Subsystem (OMS)

The D900/D1800 network provides the features of a GSM system; it consists of:

– a telecommunication system composed of the base station system (BSS) and the switching subsystem (SSS)
– a telecommunication management network (TMN), represented by the O&M subsystem (OMS)

The open concept of the TMN permits flexible adaptation of the OMS to the needs of the network operators. The D900/D1800 OMS supports centralized and decentralized (i.e. local) operation and maintenance of the nodes of the PLMN.

Protection against faults has been achieved to a great extent by means of built-in measures. If simple faults occur they are eliminated by automatic recovery procedures and the PLMN operator does not need to intervene. In the case of more serious faults, information is supplied to enable the operator to recognize and remove the fault source. In severe cases the affected network element or network node is taken out of operation and the operator is warned. Whenever possible, the system adapts its configuration and continues operation.

6.1 System Architecture

The OMS is realized in operation and maintenance centers (OMCs), which consists of an OMC-B for administration of BSS network elements and an OMC-S for administration of SSS network elements within the PLMN. The operation and maintenance for SSS and BSS are independent of each other. The OMC-B and OMC-S can be combined in the same location. The OMC can also be connected with network components of an operations system (OS) via a PSDN or LAN with TCP/IP protocol (Fig. 6.1). Components of an OS are, for example, the personalization center for SIM (PCS), security management center (SMC) or data post processing system (DPPS).

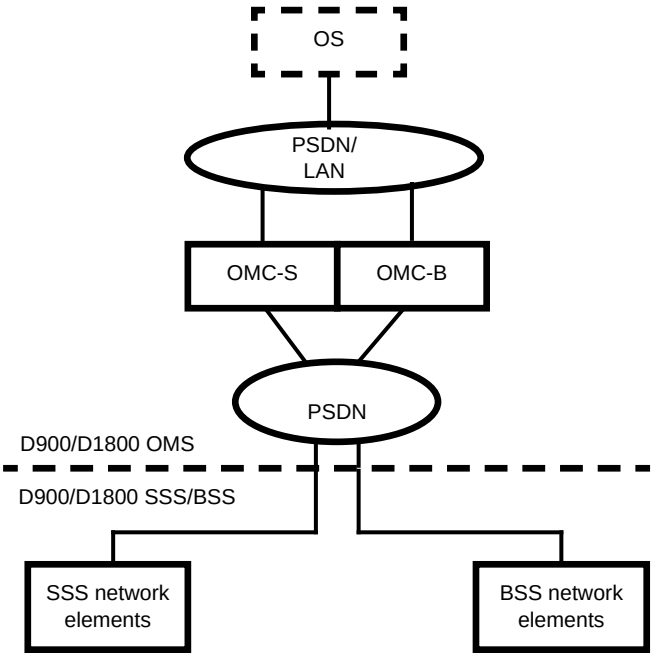


Fig. 6.1 OMS network architecture

Logically, an OMC-S is linked to one or more SSS network nodes, and an OMC-B is linked to one or more BSCs, even if the BSCs are connected to different MSCs.

National OMC

The national OMC provides a means to centralize O&M functions. This is particularly useful for the BSS side of O&M providing a simple means to bring together all information from regional, usually geographically dispersed OMC-Bs. This overlay operation is shown in the hierarchical structure of Fig. 6.2. The national OMCs can be assigned to the OS area and correspond to the OS components of the network management center (NMC) type. The national OMCs allow what is known as a night/weekend service configuration of all the OMC activities. To connect a regional OMC and a national OMC, X.25 connections (PSDN) with an OSI stack and object-oriented information model of the BSS are used.

The national OMC has the same functions as the regional OMCs, including e.g.:
– status management
– configuration management
– fault management
– performance management

Additional functions such as night service configuration, monitoring of trunk lines to the regional OMCs are also included.

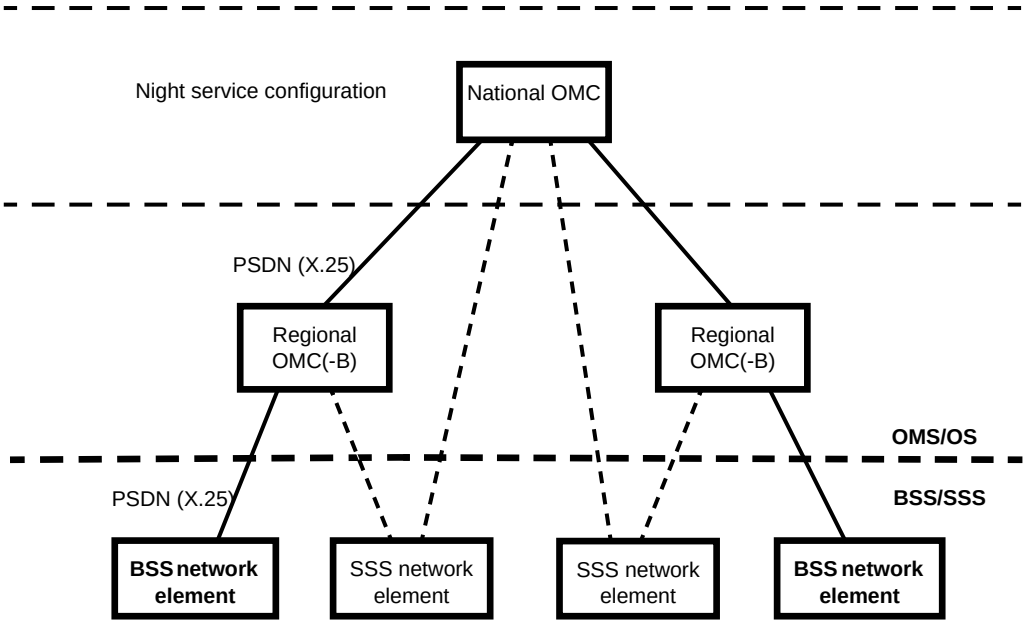


Fig. 6.2 National OMC for OMC-B

6.1.1 Network Components

6.1.1.1 OMC for the SSS and BSS

The structure of the OMC-S and OMC-B is shown in Fig. 6.3.

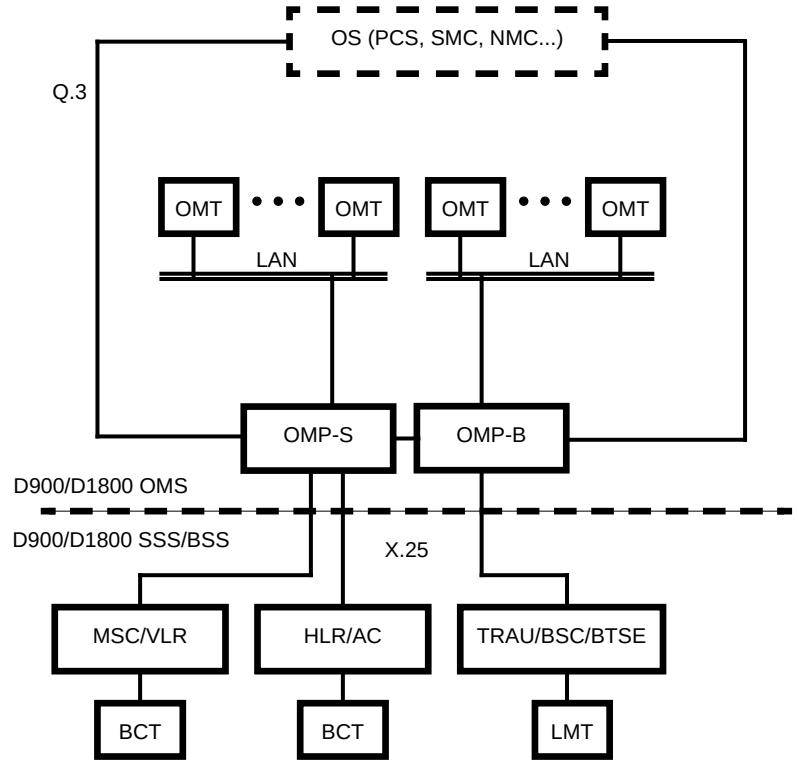


Fig. 6.3 OMC for the SSS and BSS

The operation and maintenance terminals (OMT) and the O&M processors (OMPs) are connected to local area networks (LANs) in the OMC. The OMP-S has access to the network nodes of the SSS and the OMP-B has access to the network nodes of the BSS (the BSCs) via the packet-switched data network (PSDN). As an option the access of the OMC-B to network nodes of the BSS can be realized via MSC PCM30 links (nailed-up connections, NUC). All connections to the PSDN are ITU-T Standard X.25 connections.

6.1.2 Interfaces of the OMS

There are three interfaces from the OMC-S to the SSS or BSS (see Fig. 6.3):

- the interface between the OMP-S and the SSS network nodes (MSC/VLR, HLR/AC, EIR) via an X.25 interface
- the O-interface:
  interface between the OMP-B and the base station control (BSC) via an X.25 interface. Optionally the interface between the OMP-B and BSC can be realized by PCM30 nailed-up connections via MSC (see Section 5.1.2).
- the interface between the OMP and an OS center (PCS, SMC, NMC etc.) via a Q.3-interface. In the case of OMP-S to OS centers optional a TCP/IP LAN protocol is possible.

Additionally there are two O&M interfaces in the SSS and BSS network nodes:
– the interface between the local O&M terminal (BCT) and the SSS network nodes (MSC/VLR, HLR/AC, EIR)
– the T-interface:
direct interface between the LMT and the BSC, TRAU and BTS (see Section 5.1.2).

6.2 Hardware Architecture

6.2.1 Hardware of the OMC-S

OMP-S

A commercial computer (SUN Sparc/Enterprise) with all the security measures that can normally be provided is used as the OMP-S. A number of OMP-Ss can also be used in an OMC-S in order to operate the connected SSS network elements or to guarantee system redundancy. Each OMP-S can be configured for dedicated functionalities, e.g. as file server, mediation server or performance management (PM) server.
Mirrored disks are used to hold identical data on two magnetic disks. This makes it possible to provide a failsafe database in a client-server system (needed with software upgrade for example). A subfunction here is OMP-S switchover on failure of an OMP-S to allow access to important data.

OMT

There are various types of operation a maintenance terminal available. They differ in the hardware used and the type of connection to the OMP-S:

The types of operation and maintenance terminal used are as follows:
– workstation (OMT)
A workstation is a commercially-available computer (SUN Sparc) with a color screen.
– X-terminal (OMTX)
An X-terminal is a color SUN Sparc X-terminal. It is connected to the LAN.
An OMP-S is used as a server.
– TSC terminal
The TSC terminal is available as an option. It gives the manufacturer remote access for maintenance purposes in emergency situations. For the network provider remote diagnosis by the manufacturer can save a great deal of time and money.

The following remote access OMTs can be operated:
– OMTR: Remote OMT by dialing in via the PSDN(X.25) or via the ISDN/PSTN, or via the GSM radio interface itself.
– TSC terminal: Remote OMT via the PSDN(X.25), especially for access by the technical service center (TSC) of the PLMN manufacturer to the PLMN network elements.This allows PLMN manufacturing specialists to participate in the error definition process in emergency situations.

Local O&M terminals in the SSS network nodes:

BCT

Personal computers are used as local O&M terminals (BCT) for installation purposes and for local operation and maintenance work. The BCT are equipped with Windows NT operating system and CD-ROM drives. The operating documentation (including the current description and the various manuals for operation and maintenance) is available on paper and/or CD-ROM.

6.2.2 Hardware of the OMC-B

OMP-B

The OMP-B used is a commercially available computer (SUN Sparc/Enterprise). The OMP-B can be optionally duplicated with hot standby redundancy.

OMT

Following different types of OMTs are available:
– SUN graphical workstations
– X-terminals (SUN Sparc classic X)

The standard configuration has up to 8 graphical workstations or up to 4 graphical workstations and 4 X-terminals connected to OMP-B (to both OMP-Bs in case of redundancy) locally via LAN. Maximum configuration is 8 OMT assemblies.

The following remote access OMTs can be operated:
– OMTR: Remote OMT by dialing in via the PSDN(X.25) or via the ISDN/PSTN. Additionally an interworking is possible of the OMT of a neighboring OMC-LAN into a separate OMC-LAN, or by a remote login of a OMT of an OS network component to the OMP-B via a X.11-LAN connection,
– TSC terminal: Remote OMT via the PSDN(X.25), especially for access by the technical service center (TSC) of the PLMN manufacturer to the PLMN network elements.This allows PLMN manufacturing specialists to participate in the error definition process in emergency situations.

LMT

The same LMT hardware with its T and Tμ interfaces is used for the BSS entities (BSC, BTSE, micro BTS included, and TRAU). It is recommended the use of portable PC with Intel 80386 (or higher) CPU, AT bus, MS-DOS 5.0 (or higher) and Windows 3.1 (or higher). Local maintenance terminals (LMT) are available for operation and maintenance work at the BSS network element (BTSE, BSC, TRAU) site.

- BS-2x and BS-6x LMT
  The proprietary interface T (X.21/V.11) is used for direct access to the BS-2x and BS-6x BTSE, BSC and TRAU.
  The LMT has the capability to identify the mode itself by communicating with the connected BSS network element (BSC mode, BTSE mode, TRAU mode). It is also possible to open a LMT remote session in the BSC from an LMT connected to any underlying BS-2x and BS-6x BTSE or TRAU and configure the BSC and the functional objects of all other BS-2x and BS-6x BTSEs or TRAUs within this BSC area.
  The LMT is used for first installation of SBS software and configuration, fault repairing and removing.

- BS-11 LMT
  The interface Tμ (RS232/V.24) is used for direct access to the BS-11 (micro BTS). Two different SW applications are used (not at the same time), both residing on the LMT PC mass storage. However the former application (suited for the maintenance of the BSC, TRAU, BS-2x and BS-6x BTSE via the T interface) can also be used for accessing the BS-11 in remote mode from the BSC.

6.3 Software Architecture

6.3.1 Software Architecture of the OMC-S

The software supplied for the components of the OMC-S consists of a software platform, basic system and application software (Fig. 6.4). This application software is adapted to the needs of a telecommunication management network (TMN). It consists of processes (in the UNIX sense) for the various requirements of the operation and maintenance applications, e.g. operator inputs or messages from the network nodes of SSS.

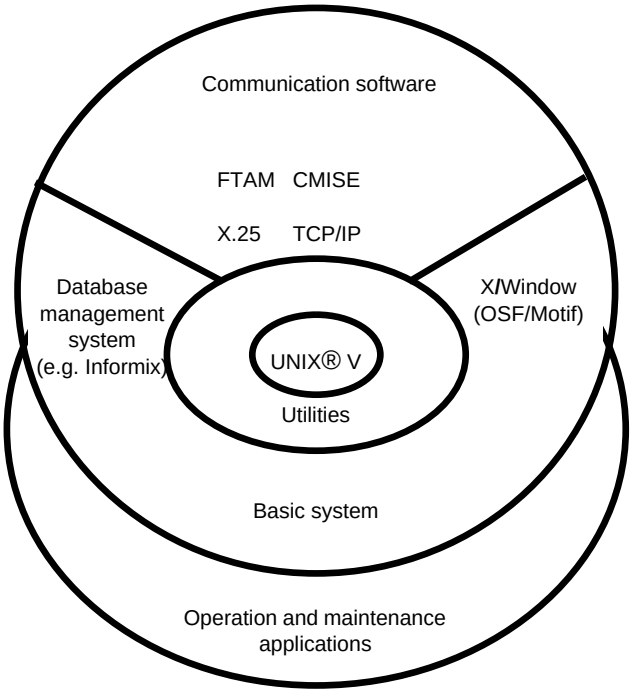


Fig. 6.4 Components of OMS-S software

Software platform

The software platform consists of commercially available software systems complying with international standards. The main components are:

– operating system Solaris®/UNIX®, System V
– network file system
– database management system (Informix, or for some application software units the commercial database product ORACLE®)
– graphics program WINGZ
– window manager OSF-Motif
– window system X/Window

– communications software:
for WAN communication: CMISE, FTAM in accordance with OSI standards (i.e. based on X.25); for LAN communication: TCP/IP

Basic system

The basic system includes the following parts:
– installation
– recovery
– central functions which allow general access to utilities
– LAN and WAN communication
– file transfer functions to the network elements of the SSS or to the OS

Application software

The application software is divided into the following groups:
– basic applications
– applications for the OMS
– applications for the SSS
– mediation functions (MF)

- Basic applications

  The basic applications include:
  – security management (access protection mechanisms)
  – graphical user interface (GUI)
  – online help system
  – time synchronisation in OMC-S with the SSS networks elements
  – command logging
  – computer and database structure
  – usage of a more comfortable windows manager (common desktop environment (CDE))
  – OMC-S process supervision
  – printer interfaces
  – OMC management/configuration
  – connection possibilities of OMT
- OMS applications

  OMS applications include:
  – configuration management (CM)
  – fault management (FM)
  – OMS status display (OSD)
- SSS applications

  SSS applications include:
  – MML management
  containing among other things the input of extended MML (EMML) or basic MML (BMML), which is used for operation of the SSS network nodes and the automatic operator (ATOP), which supports the recording of input commands in a prepared file
  – fault management (FM)
  containing among other things the graphic system status display (SSD) is used to monitor the SSS network nodes. Additionally the SSD can also be used to control the Siemens BSS network elements.

  - performance management (PM)
    Analysis and graphical display of the traffic measurement data of the SSS with an independent software package (SPOTS).
  - SSS manual on OMT
  - graphical user interface (GUI)
- Mediation functions (MF)
  The mediation functions (MF) convert the Q.3 interface (TMN) between OS and OMC-S into the Qx interface between OMC-S and the network elements. Due to the mediation functions, the OS has access to the necessary data of the network elements or network nodes of the SSS.

  There are mediation functions for the following, for example:
  - subscriber administration
    (dialog of subscriber data between the SSS network elements HLR/AC and the OS with the dialog service CMISE)
  - fault management
    (dialog of alarm messages between the SSS network elements and the OS with the dialog service CMISE)
  - control and administration of data for call charging
    (transfer of call charge data between MSC and the OS with the file transfer method FTAM)
  - transfer of S-tickets for juridical interception
    (between MSC and the OS with dialog service CMISE)

6.3.2 Software Architecture of the OMC-B

The OMC-B software architecture has been designed according to the standards and recommendations established by the OSF (Open Software Foundation) in order that the software will be as hardware platform independent as possible.

The software supplied for the components of the OMC-B has nearly the same structure as the software supplied for OMC-S (see also Fig. 6.4). The structure of the **software platform** (e.g. operating system Solaris®/UNIX®, database product ORACLE®) and **basis system** is the same in principle. Differencies are given in the application software like shown in the following.

Application software

The application software is divided into the following groups:
- basic applications
- applications for the OMS
- applications for the BSS
- mediation functions (MF)

- Basic applications

  The basic applications include:
  - security management (access protection mechanisms)
  - graphical user interface
  - online help system
  - time synchronisation in OMC-B with the SSS networks elements
  - command logging
  - computer and database structure
  - usage of a more comfortable windows manager
    (common desktop environment (CDE))

  - printer interfaces
  - OMC management/configuration
  - connection possibilities of OMT
- OMS applications

  OMS applications include:
  - configuration management (CM)
  - fault management (FM)
- BSS applications

  BSS applications include
  - configuration management (CM)
    which contains the management of the network resources (e.g. radio channels)
  - fault management (FM)
    which contains the measures necessary to detect and remove faults
  - performance management (PM)
    which contains the supervision and evaluation of the traffic load and the performance of the BSS network
  - software management (SWM)
    which contains the management and control of the software and the databases of the BSS
  - BSS manual on OMT
  - graphical user interface (GUI)

  The basis of the OMC-B application is a hierarchiy of geographical maps, functional panels and rack layouts on which current status of all ”managed objects” is displayed. Further this gives the possibility to step in every fault management, configuration management or software management application with the most user guidance.
- Mediation functions (MF)
  The mediation functions (MF) convert the Q.3 interface (TMN) between OS network components (e.g. a network management center (NMC)) and OMC-B into the Qx interface between OMC-B and the BSS network elements. Due to the mediation functions, the OS has access to the necessary data of the network elements or network nodes of the BSS.
  There is a mediation function for fault management (dialog of alarm messages between the BSS network elements and the OS), for example.

7 Functions

The services of the PLMN or CSC bases on the network functions. They cover
– basic functions of call handling
– mobile-specific functions of call handling

7.1 Basic Functions of Call Handling

Call types

- GSM subscriber
  The basic call handling functions establish calls between a GSM subscriber (GSM mobile subscriber and on CSC GSM-RITL subscriber) and another subscriber in a PSTN, an ISDN, a PSDN or a GSM subscriber in the same or another PLMN.

  The following call types are possible:
  – mobile originated call (MOC)
  – mobile terminated call (MTC)

  A special case based on the two basic call types is also possible:
  – mobile to mobile call (MMC)
- Fixed network subscriber (wired ISDN/analog subscriber) at the CSC
  For fi xed network subscriber at the CSC subscriber only the conventional call handling functions for fixed network subscribers are needed, i.e. no mobile-specific functions.
- IN/CAMEL call handling
  All kinds of subscribers of a PLMN or CSC are provided with call handling functions for various IN/CAMEL applications.

Number portability for fixed and GSM subscribers

The feature “number portability” allows subscribers to change the network without changing their number and local area code (LAC) or national destination code (NDC) (for GSM subscribers this means without changing their MSISDN. The GSM subscribers IMSI will be changed). This feature supports porting of fixed network subscribers (PABX subscribers included) and GSM subscribers. Porting-in means GSM subscribers and fixed network subscribers can be ported from a foreign network to the own network by keeping their old number. Porting-out means GSM subscribers and fixed subscribers can be ported-out from own network by keeping their old number.

By introducing the number portability functionality in the PLMN, new subscribers from other PLMN as well as from fixed networks can be attracted. Especially the ability of porting subscribers from fixed networks to PLMN by keeping the subscribers number is a possibility to attract a lot of new mobile subscribers to the PLMN.

Full-rate and half-rate channel connections

In a GSM Phase-1 PLMN only full-rate channel connections are supported, i.e. the useful data is transmitted on the GSM radio interface at a speed of 22.8 kbit/s. GSM Phase 2/2+ will support half-rate channel connections (transmission speed of 11.4 kbit/s).

The D900/D1800 SSS and BSS supports the half-rate channels for voice services. For data services, half-rate channels are supported by the BSS but not by the SSS.
If the MSC is used as a gateway MSC to a satellite network (GSC), the MSC supports both full-rate and half-rate channel connections for data services.

The D900/D1800-BSS permits “dual-rate” operation, i.e. full-rate (FR) and half-rate (HR) operation at the same time. If a full rate channel operation is upgraded to full rate and half rate channel operation, changes to the hardware must be made in the BSC and TRAU and changes to the software in the BTS, BSC and TRAU. In particular, the half-rate transcoders which operate at a user data rate of 6.5 kbit/s (compared with 13 kbit/s for full-rate operation) have to be upgraded in the TRAU.

Enhanced full-rate channel connections

The D900/D1800 SSS and BSS provide the necessary signaling for using GSM Phase 2+ compatible mobile stations with enhanced speech quality Codec versions, which have a better connection quality compared to that in fixed networks. The PLMN operator can activate/deactivate this support (enhanced full-rate channel, EFR) in the PLMN and so control the use of new speech quality Codec version.

Handling of GSM subscriber telecommunications services

The bearer services are used only for pure data services. They provide the necessary fundamentals for the operation of these pure data services. The teleservices define both voice and also data services. Supplementary services expand the functionality of the basic telecommunications services (bearer services and/or teleservices).

The GSM telecommunications services that are possible in the D900/D1800 are listed in Section 3.

GSM Phase 2+/Phase 2/Phase 1 (Fallback)

The D900/D1800 offers the services supplied in GSM Phase 2 or GSM Phase 2+ and GSM Phase 1. In the case of GSM Phase 2/2+ this means that it supports typical Phase 2/2+ telecommunication services such as multi-party service (MPTY) or closed user group (CUG). The GSM Phase 2/2+ signaling is supported by the CCS7 user parts BSSAP, MAP and TCAP. The MSC offers a ”fallback” from Phase 2/2+ handling to handling in accordance with the Phase 2 features.

User informations

Audible tones, announcements and displays inform the calling subscriber in the D900/D1800 network (GSM subscriber or wired ISDN/analog subscriber) and the subscriber in the ISDN/PSTN about the status of the call setup.

Generation of call data records

Detailed call data is generated for the GSM mobile subscriber or for the GSM-RITL subscriber or wired ISDN/analog subscriber during every call transaction. The call data recordings can be used for charge registration, network management and supervision purposes. After the call data recordings have been generated they can be provided with customer-specific data record formatting.

For charge data recording there are two basic procedures available in the MSC or the CSC:

- Automatic charge data recording
  The call charges for all subscriber types in the D900/D1800 can be recorded by automatic charge data recording. An exception to this rule are subscribers with prepaid charges (PPSC subscriber/debit subscriber).
  Automatic charge data recording generates at least one regular charge data record for every successful call or the use of a service.

Depending on the kind of subscriber of the D900/D1800, two different kinds of call data records are generated.
– *mobile call record (MCR) data records* for GSM subscriber (mobile and RITL)
– *automatic message accounting (AMA) data records* for fixed network subscribers at CSC (wired subscribers)

The charge data recording by the D900/D1800 IN network node M-SSP is usually also performed by automatic charge data recording. More about this is described below under IN charge data.

- Pulse metering
  For the ISDN/analog subscribers at the CSC, meter pulses can be created for each call or for activating/using supplementary services.

  In the CSC the pulse metering methods employed are as follows:
  – SPM (single pulse metering)
  – MPM (multiple pulse metering)
  – PPM (periodic pulse metering)
- IN charge data
  The introduction of highly-developed intelligent network (IN) services in a GSM PLMN requires an expansion to the previous D900/D1800 charging concept. The basic idea is for both parties involved, i.e. the IN service user (calling line) and the service subscriber (called line) to share the charges accrued in a variety of very flexible ways. The question of “Who pays for what ?” must always be answered in a service-independent and service-subscriber-specific arrangement.

  There are basically two ways of charging for IN calls:
  – charge recording via the SCP/SMP
  – charge recording based on the M-SSP
- Customer-specific data record formatting
  If necessary the regular charge data (MCR/AMA or pulse metering data) can be converted into a customer-specific data record format before being transferred to a particular data post-processing system (DPPS). In the data post-processing system the data records are handled according to their use (e.g. for calculating the total charges to the GSM subscriber served or to monitor the location of the GSM subscriber).
- Hot operation
  The term hot operation covers all cases in which MCR/AMA data records are additionally generated and/or formatted and transmitted to a dedicated processing center via the packet switched public data network (PSPDN) while a call is still in progress or immediately after it has ended. There are the following two applications for this:

  The four applications involved here are as follows:
  – hot billing data record recording
  – emergency call trace data record recording
  – IMSI trace data record recording
  – interception data record recording

Distance related charging

This function - distance related charging, DRC - records charges directly from the calls, especially from mobile-to-mobile calls (MMC), dependent on the distance between A subscriber and B-subscriber. In this way a call for the GSM mobile subscriber is cheaper if the call partners are nearer to each other (e.g. within a city with one city tariff) compared to a connection from opposite ends of a country. Even the combination of

distance related to e.g. calender/time of day is conceivable for a tariff. local information about the call partners is provided for data post-processing.

Interadministration procedures for billing/revenue accounting (IACHASTA and IARA)

The new IACHASTA (Interadministration charging and statistics) function is a flexible procedure for charge accounting between different PLMNs and permanent networks within a country, or between different countries.

It is also possible to use the features of the old function IARA (Interadministration revenue accounting), but not simultaneously with IACHASTA. The IACHASTA procedure is a further development of the IARA procedure. The PLMN operator can either choose the new IACHASTA procedure or the old IARA.

The principle of both procedures is:
– suitable metering procedures for recording the connection traffic
– suitable output formats of the metered data

Both procedures can either be used in the GMSC or in the gateway switching center of the PSTN/ISDN.

7.2 Enhanced Functions of Call Routing, Charging and User Information

Flexible routing of calls in the SSS (SDDPFC)

The standard procedure provided to handle "normal" call setups assumes that, for a terminating call a digit translation will be affected first. After this a particular destination will be reached, for example via a specified destination and route, or a defined procedure will be triggered by means of a particular traffic type.

In the case of calls involving GSM subscribers (including GSM-RITL subscribers) and where the defined features are available the call data can be modified prior to the digit translation. This produces one of the following results:
– modification of the entry data for digit translation and routing control, followed by the start of the normal procedure (i.e. digit translation, etc.)
– modification of the data for call charge registration
– bypassing digit translation by means of direct transition to an IN service
– control (i.e. application or prohibition) of specific features

A consequence of this flexible routing of calls in the SSS (subscriber-dependent digit processing and feature control, SDDPFC) is therefore that specifications derived from other entries in the database of SSS network nodes can be modified. In other words, it can lead to partly or completely different behavior than would have been expected under normal circumstances. For precisely this reason, this powerful and highly useful feature should be used with greatest of care!

A-number dependent routing, charging and barring in the SSS

These SSS functions expand the flexible routing of calls in the SSS (subscriber dependent digit processing and feature control, SDDPFC) with a feature control (FC) element.

It consists of the part functions:
– A-directory number dependent routing
– A-directory number charging (zoning)
– “black list” for barring connections

Approximately 20000 different directory numbers can be saved in the database in relazion to this function. The operator can administrate individual A-directory numbers which begin with the same digit combination. The input in the database of e.g. 1234 allows the same routing/call charging/blocking of all A-directory numbers which begin with 1234.

Possible uses for this part function are:

– routing of special subscriber groups by means of abbreviated numbers which can only be used by subscribers who are administrated in the database for routing dependent on A-directory numbers.
– routing or zoning of special subscriber groups (e.g. all customers of a certain service provider) via selected trunks. In this way, the service provider can only select special (long distance carriers) for his customers
– preventing the routing of certain subscribers with the PLMN and the blacklist function, if the PLMN operator is also acting as transit operator for other networks.

IMSI/MSISDN dependent routing

The feature “IMSI/MSISDN dependent routing” allows the PLMN operator to create a lot of new applications by routing calls IMSI/MSISDN dependent. Thus routing becomes much more flexible and offers new possibilities by using this feature.

It allows to set up different groups of GSM subscribers inside the PLMN by structuring the IMSI or MSISDN or something which is much more interesting, it is possible to treat roaming subscribers different dependent on the PLMN they are coming from.

IMSI/MSISDN evaluation is done by SDDPFC translator prior normal digit translation. This feature is not designed to evaluate whole IMSI or MSISDN numbers but should be used to evaluate just parts of the numbers to identify from which country and/or PLMN the GSM subscriber is coming from (evaluating of MCC and MNC of IMSI or CC and NDC of MSISDN) or to determine a certain group of own subscribers by evaluating a few more digits after MNC/NDC. It is also possible to evaluate whole IMSI or MSISDN numbers, but the max. amount of IMSI or MSISDN numbers which can be evaluated is about 2000.

GSM subscriber data specific routing

The feature “GSM subscriber data specific routing” allows the PLMN operator to create a lot of new applications by routing calls GSM subscriber dependent. Certain groups of subscribers can be set up. Every subscriber group can be routed different even if the same number is dialed. Thus routing becomes much more flexible and offers new possibilities by using this feature.

It allows to set up different groups of GSM subscribers inside the PLMN by using the GSM subscriber category or some national supplementary service values. Digit translation of any number dialed by a GSM subscriber belonging to a certain group can be done by considering the group membership. Dependent on the group membership of a subscriber it is necessary to set some data which can be considered by digit translation. GSM subscriber data evaluation is done by SDDPFC translator prior normal digit translation.

Number length dependent routing

The feature “number length dependent routing” makes it possible to route calls depending on the length of the called party address digits. Thus it gives the possibility

to transform ambiguous digit-combinations into non-ambiguous combinations using the number length as a additional indicator.

This feature gives the possibility to enhance the PLMN numbering plan by allowing ambiguous codepoints. It is possible to evaluate the length from 1 to 16 digits. Length evaluation is done by SDDPFC translator prior normal digit translation.

GSM subscriber data specific charging generation

The feature “GSM subscriber data specific charging generation” gives the possibility to decide if, for calls to certain destinations performed by certain GSM subscribers, a ticket should be suppressed.

This feature allows to set up different groups of subscribers inside the PLMN. This can be done by using the GSM subscriber category, national supplementary service values or ranges of IMSI/MSISDN. Dependent on those groups (and in combination with the call type and the digits) it is possible to control if a ticket should be suppressed for a certain call. Respectively IMSI/MSISDN evaluation.

GSM subscriber specific advice of charge

With the feature “GSM subscriber specific advice of charge” it is possible to consider the tariff model of the PLMN the GSM subscriber belongs to for “advice of charge”.

The reason is that there are different tariff models existing within the PLMN and up to now advice of charge couldn’t consider all those different tariff models. Because of this advice of charge was a maximum of offered just for one certain tariff model. By using this feature, advice of charge can be offered to every GSM subscriber within the PLMN.

Multilingual announcements

The feature “multilingual announcements” allows the PLMN operator to offer announcement to the GSM subscribers in their preferred languages. The selection of the correct announcement language is done by the MSC dependent on the GSM subscriber. For operator services it is furthermore possible to connect an operator who is speaking the language of the calling GSM subscriber even if every subscriber is dialling the same operator service number. So not every operator within the PLMN has to speak several languages.

IN influenced management of call legs (Leg management)

Leg management provides the functionality for creating, connecting, disconnecting and releasing of call legs under the control of the SCP. A leg is a representation of a communication path towards an addressable network entity, as viewed by the SCP. A leg is thus a party in the call, and should be handled with a minimum of influence to other legs. There exist several properties which can be associated to legs (for example user busy monitoring).

7.3 Mobile-Specific Functions of Call Handling

The mobile-specific functions of call handling comprise the functions which result from the architecture of the GSM PLMN network. These functions apply to GSM mobile subscribers and to GSM-RITL subscribers provided a function is not explicitly mentioned for one particular type of GSM subscriber.

They include:

- Security functions
  - authentication
  - confidentiality functions
  - checking the international mobile equipment identity
- Mobility management
  - roaming
  - location registration
  - IMSI attach/detach
  - handover (including GSM900/GSM1800 Multiband Handover)
  - interrogation, paging for a MTC
- Directed retry
- Discontinuous transmission (DTX)/voice activity detection (VAD)
- TRAU volume control
- Cell-oriented routing of service numbers
- GSM-subscriber-related routing of service numbers
- Off air call set-up (OACSU)
- Transmit-power control
- Frequency hopping
- Single-cell and multi-cell operation as a radio network architecture tool
- Concentric cell
- Extended radio cell (distance)
- Call release for excessive distance
- Hierarchical cells structure
- Queuing and priority
- Local overload handling

Authentication

Authentication is an important part of the security measures which prevent unauthorized access of GSM subscribers to the GSM network and its telecommunications services. The following subscriber-specific algorithms and keys are used for authentication: A3, A8, Ki, Kc. Authentication means that each individual GSM subscriber is assigned parameters (Ki and triples, consisting of RAND, SRES, Kc) and version numbers of A3 and A8, and in particular SRES for the actual authentication comparison in the VLR.

Confidentiality functions

The confidentiality functions ensure

– GSM subscriber identity confidentiality (TMSI reallocation)
– confidentiality of the user data on the GSM radio interface (ciphering). The following subscriber-specific algorithm and key are used: A5, Kc.
  Kc changes with each authentication and is thus individual to the GSM subscriber.
  A5 is present in the PLMN in a maximum of 3 versions (i.e. A5/1, A5/2 and A5/0 (no ciphering)).

Checking the international mobile equipment identity

Checking the international mobile equipment identity (IMEI) in the PLMN for an MOC or MTC establishes whether the mobile equipment used is registered and approved in the PLMN.

Roaming

- GSM mobile subscribers
  Roaming means that the GSM mobile subscriber can move freely within a public land mobile network (PLMN) or in the international GSM service area.

  The following roaming restrictions are possible within the framework of what is known as a subscriber agreement:
  – *roaming in all GSM PLMNs nationally and internationally*
  – *roaming only for the MS's own national GSM PLMN and all other international GSM PLMNs*
  – *roaming exclusively in the own PLMN (HPLMN)*
  – roaming in a defined selection of PLMNs: *Roaming areas* are defined which each contain one or more PLMNs. Assigning this type of roaming area to a GSM mobile subscriber restricts the subscriber to precisely the given PLMNs.

  Basis of this subscriber agreement (subscription restriction) is a roaming agreement between the home PLMN (HPLMN) and the diverse visited PLMNs (VPLMN).

  The following further roaming restrictions are possible:
  – *fully regional roaming*
    In addition to the above roaming restrictions, roaming can be restricted within a PLMN to specific areas (fully regional roaming, in accordance with GSM Phase 2). For this the GSM mobile subscribers for a PLMN are assigned to up to 10 roaming zones. A roaming zone is project-dependent and is either defined as a combination of radio cells or location areas.
  – *national roaming*
    National roaming includes the option of restricting the use of telecommunications services for GSM mobile subscribers who are domiciled in another PLMN in the own VLR area.
- GSM-RITL subscribers
  For GSM-RITL subscribers in a CSC roaming is basically governed by the same principles as for GSM mobile subscribers. The only difference is the roaming restrictions applicable from the outset for all GSM-RITL subscribers, e.g. roaming is only allowed within a defined location area.
- GSM CAMEL subscribers
  Due to CAMEL definition the basis of the applicability of those CAMEL services in diverse visited PLMN (VPLMN) is a separate roaming agreement between the HPLMN and the VPLMN.
  During location update of foreign PLMN GSM CAMEL subscribers, the CAMEL roaming agreement status of the GSM subscribers PLMN has to be checked in the visited VLR. Here the PLMN operator can administer in a separate table all PLMN whose roaming GSM subscribers are allowed to subscribe CAMEL in operator PLMN.

Location registration

The main function of roaming is location registration, which involves the following procedures:
– location update

– location cancellation

The location update procedure provides the VLR and HLR with the information on the current location of the GSM subscriber.

The location cancellation procedure removes the GSM subscriber data from the old VLR.

IMSI attach/detach

If the GSM subscriber has inserted/removed his chip card (and hence his IMSI) into/from the mobile station or switched the mobile station off/on, the IMSI attach/detach function informs the VLR of the activated/deactivated status of the mobile station.

Handover

Handover is the passing on of a call from radio cell to radio cell. The physical connection path between MS and base station system (BSS) or between MS, base station system and switching subsystem (SSS) is changed. A distinction is drawn between the following types of handover:

Internal handover (BSC-controlled handover)
– intra-cell handover
– inter-cell handover

An additional special form of BSC-controlled handover is represented by the following function:
– speed sensitive handover algorithms for introducing underlay BSS network layer (with micro radio cell geometries) or overlay BSS network layer (with umbrella radio cell geometries)

External handover (MSC-controlled handover)
– intra-MSC handover
– inter-MSC handover

A special additional form of MSC-controlled handover is represented by:
– GSM900/GSM1800 multiband handover

Mobility management for a MTC

The following additional mobility management functions must be performed for an MTC:
– interrogation
  i.e. the gateway MSC requests the location data of the GSM subscriber from the HLR
– paging and searching
  i.e. the radio cell in which the GSM subscriber is currently located is found

Directed retry

The directed retry procedure allows the PLMN to select the optimal cell for the MS. The process of directed retry involves the assignment of an MS to a radio channel on a radio cell other than the serving radio cell. Directed retry occurs, if the BSC is not able to support a traffic channel (TCH) request for a particular MS in the required radio cell immediately. Directed retry enables a handover from a stand-alone dedicated control channel (SDCCH) to a traffic channel (TCH) into an overlapping neighbor radio cell or into an umbrella radio cell. So a directed retry handover is initiated to finish the call setup in another radio cell than the requested one. As a result directed retry increases the number of successful call setup whenever there is an alternative radio cell available.

Directed retry, as described here is a MSC feature. The MSC controlled directed retry covers the cases inter-BSC and inter-MSC. BSC and MSC must support this feature. The BSC has to send an appropriate message with handover cause directed retry.

Directed retry is already realized in the BSC, as a BSC controlled feature, for the case, where the new radio cell is under the domain of the same BSC.

Discontinuous transmission (DTX)/voice activity detection (VAD)

The discontinuous transmission (DTX) and its functions voice activity detection (VAD) and comfort noise insertion (CNI) for full rate channels are specified with the purpose to minimize the power consumption of the MS and, at the same time, to reduce the interference level on the radio interface. During a normal conversation, the participants alternate so that, on the average, each transmission direction is occupied about 50% of the time. If transmission is switched on only for those frames that contain speech and is switched off during all other intervals then the power consumption in the MS is reduced considerably and the interference level in the network is reduced.

TRAU volume control

The transcoding function for voice provides a special loudness control in order to comply with the limits specified by ITU-T G.111, compensate for loudness variants due to analog/digital respectively digital/analog convertions within the mobile stations and compensates for loudness variants in possible analog network lines between subscribers.

Cell-oriented routing of service numbers

Cell-oriented routing of service numbers (with special short codes) offers the possibility of routing certain MOCs to different destination numbers depending on the location of the GSM subscriber (i.e. originating cell of the MOC).

GSM-subscriber-related routing of service numbers

GSM-subscriber-related routing of service numbers (with short codes) offers the facility of routing certain MOCs to a personal service application in a service center, depending on the number of the calling GSM subscriber.

Off air call set-up (OACSU)

If the off air call set-up (OACSU) feature is used, the assignment of a suitable traffic channel (TCH) at the GSM radio interface is always delayed until the called subscriber accepts the incoming call. The call is not delayed for the subscriber who is called, although the call can sometimes be diverted temporarily to a recorded message unit, until the call has been fully established, i.e. also through-connected via the GSM radio interface. This allows radio resources to be saved at the GSM radio interface if multiple calls are to be set up at the same time.

Transmit-power control

The transmit-power control should minimize the transmit power required by MS and BTS and at the same time guarantee good reception quality. The transmit-power control reduces the noise when there are connections on neighboring channels.

Frequency hopping

The frequency hopping function permits the dynamic switching of radio links from one carrier frequency to another. With frequency hopping every logical channel changes the

physical channel transmission frequency from one TDMA frame to the next. As a result, slow fading is reduced and the effect of interference frequencies is kept low. Frequency hopping also improves the S/N ratio allowing to increase the radio cell size and improve service quality.

D900/D1800 has the following two types of frequency hopping:
– baseband frequency hopping
– synthesizer frequency hopping

Single-cell and multi-cell operation as a radio network architecture tool

On the basis of the basic provision of the BTSE (a BTSE currently comprises up to 6 carrier frequencies (RFCH)), both single-cell and multi-cell operation are possible. Both single-cell operation and multi-cell operation can be used for a wide variety of antennas with omnidirectional and sectoral (bidirectional) structure and thus allow flexible radio cell layout structures.

Concentric cells

Concentric radio cells comprises the formation of a GSM radio cell from two logical radio cells with different frequencies (f1, f2) and a common radio cell mid-point (BTS location). The transmission power of the smaller (inner) radio cell is considerably reduced, resulting in a smaller cell radius. The difference between both concentric radio cells is governed by the distance and/or varying field strength level.

An advantage of the concentric radio cells is a lower co-channel interference relating to repeated radio frequency channels of the same frequency with the appropriate distance (frequency re-use), which causes an increased frequency re-use. Particularly when being used in areas where countries border, and where only a few radio frequencies are available, this function brings enormous advantages due to the large degree of frequency re-use.

Extended radio cells (distance)

The purpose of this feature is to overcome the 35 km radius of the normal GSM radio cell range. It enables the PLMN operator to increase the maximum MS-BTS distance up to approximately 100 km. The limit of 35 km is due to the maximum allowed transmission delay, which is limited to ensure that the BTS will receive information from the MS in the assigned time slot. The main benefit of extended radio cells is that the coverage area of a PLMN can be increased with minimum site cost. Applications for extended radio cells are: low density areas, rural areas, roads or sea side radio cells.

Call release for excessive distance

The BSS feature “call release for excessive distance“ requires to trigger the release of a call or on the other hand refuses access to a radio cell when the MS distance has exceeded a pre-defined threshold value.

Hierarchical cells structure

The total traffic can be accepted in hierarchical radio cell structures distributed over several radio cell levels. A PLMN operator can, for example, implement a triple layer radio cell network, using the largest cell for overall coverage on the top layer (umbrella radio cell). The normal radio cell (typical range greater than 1 km) is used as the middle layer and the radio micro-cells as the lowest layer for covering areas of highest traffic density.

The hierarchical radio cell structure provides the following possibilities: each adjacent/serviced radio cell can assigned by the PLMN operator to a radio cell layer, graduated according to priorities in a range from 0 - 15. Prioritizing the radio cells makes it possible to place a large part of the traffic in the radio micro-cells.

Queuing and priority

Queuing is performed in the SSS when a traffic channel is requested if all traffic channels in the BSS are busy. The traffic channel assignment is marked and assigned as soon as a traffic channel becomes free in the BSS. In this way the traffic channel capacities in the BSS are used more efficiently by increasing successful assignment of call attempts.

Queuing requests for traffic channels are not handled on a “first come, first served” basis, but using a far more beneficial procedure based on a priority strategy.

Local overload handling

Several overload levels are defined for local overload control. The countermeasures to be taken depend on the prevailing overload level, the type of call and the authorizations of the GSM subscriber. The highest overload level restricts all traffic. It is applied during a system recovery.

The maintenance functions observe the events which influence traffic volume conditions. The PLMN operator is informed of the existing overload condition.

7.4 Functions for Expanding PLMN Capacity

On the assumption that a PLMN is already in operation, D900/D1800 provide various possibilities for expanding the PLMN capacity.

7.4.1 Standard Functions for Capacity Expansion

The following which have already been described elsewhere belong to the standard functions for expanding capacity to a certain extent:

– use of BTS antennas in omnidirectional/sectoral radio cell structure in multi-cell operation
  This antenna type of operation provides optimum coverage of the service area.
– directed retry
  These functions provide for more effective traffic per connection channel.
– frequency hopping and transmit power control
  These functions provide a more effective frequency re-use.
– discontinuous transmission (DTX)/voice activity detection (VAD)

7.4.2 Supplementary Functions for a Capacity Expansion

Supplementary functions which assist a more comprehensive capacity expansion, are described below.

Dual-rate operation or triple-mode operation

Dual-rate operation in D900/D1800 means the function of halfrate and full-rate channel connections at the GSM radio interface. An additional function is enhanced full-rate channel connections (triple-mode operation). A greater traffic volume relating to the

PLMN area is achieved by a greater number of connection channels per frequency carrier.

Hierarchical radio cell structures

D900/D1800 have a hierarchical radio cell structure in the BSS with one or more underlay networks. The lowest network layer consists of many microcells, and a top layer network consists of macrocells, which each cover several microcells relating to the PLMN area. A hierarchical radio cell structure is also needed for multiband operation. A greater traffic volume relating to the PLMN area is achieved due to a larger number of BTS per PLMN area.

GSM900 Extended-band operation

D900/D1800 has a GSM900 extended-band operation. GSM extended-band operation means supporting the GSM frequencies (900 MHz band) via the GSM900 primary band up to the limits of the home PLMN. A greater traffic volume relating to the PLMN area is achieved due to a larger band width per PLMN area.

Multiband operation

D900/D1800 has multiband operation GSM900/GSM1800. Multiband operation means the support of GSM900 frequencies in the 900 MHz band and GSM1800 frequencies in the 1800 MHz band within the home PLMN. A greater traffic volume relating to the PLMN area is achieved due to a larger band width per PLMN area.

Concentric radio cells

D900/D1800 can use concentric radio cells. Two concentric, logical radio cells are equivalent to one GSM radio cell. A greater traffic volume relating to the PLMN area is achieved due to a greater frequency re-use.

7.5 Fraud Prevention/Interception Functions

To prevent and minimize the fraudulent usage of the mobile radio functions, the D900/D1800 incorporates the following fraud prevention functions.

Barring a mobile subscriber SCI from forwarding calls to international diversion directory numbers (service directory numbers)

To prevent mobile subscribers from initiating calls that generate high costs (e.g. premium rate), it is possible to use a special feature that works on the basis of operator determined barring (ODB).

In the HLR, this feature prevents GSM subscribers from registering (on SCI basis) a call forwarding operation to a corresponding service directory number which has been barred for the GSM subscriber by ODB. This means that the GSM subscriber can no longer initiate this type of call forwarding. The mechanism employed to prevent SCI registration (to a service directory number barred with ODB) is the same as that used in the tables for the “Barred directory numbers for call forwarding” feature.

Monitoring connections in the MSC forwarded with call forwarding (CF) and call transfer (CT)

When this monitoring feature is activated, (manageable) thresholds become valid at the same time which determine how many calls which have been forwarded by an individual

GSM subscriber using CF and/or CT can exist at the same time. For one GSM subscriber, a maximum of 10 forwarded calls can exist at the same time.

Variable starting time criterion for charge registration of mobile subscribers with AOCC (AOCC time stamp)

Thanks to an advance in the supplementary service functionality of AOCC which leads to a change in the starting time criterion for charge registration in the MSC, a reliable charge data record can be generated in the MSC for the above-mentioned areas of abuse.

This implementation of the extended supplementary service functionality of AOCC is a proprietary solution that constitutes a deviation from the GSM standard which cannot be used by Phase-1 mobile stations. Depending on the particular project, it is possible to incorporate either the AOCC solution that conforms with the GSM standard or the proprietary AOCC solution.

Fraud prevention for the first second of a call

The “fraud prevention for the first second of a call” feature allows the PLMN operator to bill connections that last less than a second. This is done by generating charge data records as soon as the B-subscriber lifts the handset.

Restricting the call duration

A real-time comparison in the MSC can be used to restrict a call when a defined threshold of a charge unit or call duration is reached.

Display of current GSM subscriber data in the VLR

This function permits the PLMN operator to monitor the GSM subscriber data currently managed in a VLR. This data is identified via the relevant IMSI for this purpose.

Juridical interception

Juridical interception involves using a monitoring function to trace calls from/to a GSM subscriber so that user and signaling information is provided in uncorrupted form via separate stub connections to a monitoring center in the ISDN/PSTN.

7.6 Special Operation and Maintenance Functions

These operation and maintenance functions enable the PLMN operator to manage data throughout the network simply and to control functions which influence or control the GSM subscriber traffic. For the most part, the network-wide management and control of the facilities of the GSM subscriber functionality are performed in the SSS.

Administrative functions in the SSS

D900/D1800 provides the operator with various management functions (e.g. subscriber management, routing management, call charge management). The management functions are implemented via MML commands or command files generated with them.

These commands can be introduced either locally or remotely. Remote introduction is implemented via the OMC-S or OS. TMN interfaces with corresponding services (e.g. CMISE, FTAM) are available for this. An example of a TMN application is the management of GSM subscriber data in the HLR with the aid of the dialog service CMISE.

The following sections highlight special SSS management functions which are relevant for all PLMNs.

Functions resulting from special identification handling

- Single numbering and multi-numbering

  There are basically two possibilities for assigning a GSM subscriber several telecommunications services:
  - single numbering
    i.e. all the MTC-capable services (e.g. telephony and telefax, but not the short message service) are assigned to a GSM subscriber's directory number
  - multi-numbering
    i.e. each telecommunications service is assigned its own GSM subscriber number
- Double subscriber
  The function of double subscriber allows two different GSM subscriber numbers (MSISDN and IMSI) to be set up. The numbers are different as far as numbering schemes and telecommunications services are concerned, but are linked administratively in the PLMN to represent one double subscriber.
- Multiple NDC for a PLMN
  The function of multiple NDC for a PLMN allows the PLMN operator to introduce MSISDN with different NDCs in one or more HLR/AC nodes.
- Dialing without national destination code NDC (for GSM mobile subscribers at the MSC)
  It is possible to define for a particular project whether any GSM mobile subscriber within the own PLMN can dial any other GSM mobile subscriber with the same NDC without having to dial the NDC.
- Dialing without local area code LAC (for GSM-RITL subscribers or wired subscribers at the CSC)
  It is possible to define for a particular project whether within the own local network defined by the LAC any subscriber (who was created with a LAC) can reach any other subscriber who has the same LAC without actually dialing the local area code.

IMSI tracing in the SSS and BSS tracing

- IMSI tracing in the SSS
  The IMSI tracing feature is for collecting trace data from the SSS in the MSC in IMSI trace data records relating to certain mobile subscribers. This is in order to send them to a selected processing center in the predominant operating system (OS).

There are two types of IMSI trace data records:
– normal IMSI trace data records
– priority IMSI trace data records

- BSS tracing
  The project-specific BSS tracing feature triggers from the SSS an additional tracing procedure in the BSS. This is in order to collect the connection data belonging to BSS, in addition to the data collected by IMSI tracing in the SSS relating to a mobile subscriber connection (IMSI). As long as both features (IMSI tracing in SSS and BSS tracing) are installed, both features can be activated with an O&M task in the OMC-S.

Security-related AC-operator functions

In addition to the security measures for setting up calls (e.g. subscriber authentication, confidentiality of user data on the GSM radio interface) there are further security procedures available on the system operator side with regard to the AC. One important measure is intended to prevent unauthorized access to security-related data in the AC by means of encryption. The following additional algorithms and keys are used for this AC-key-management:
– A7, K7p, K7s, A9 (for security application service (SAS))
– A4, K4, A2, K2 (for (re)encryption of Ki)

Roaming restrictions for GSM mobile subscribers on the basis of the PLMN subscription restriction

The *subscription restriction* allows the PLMN operator to determine the PLMN levels in which the GSM mobile subscriber is allowed to use the telecommunication services.

In the HLR, it is possible to define additional *roaming areas* which, based on the initially defined subscription restriction, further restrict the use of the services on the basis of entire countries, PLMNs or individual VLR areas. Roaming areas may be defined as "permitted" or "barred" areas in the form of a list. This list contains numbers (E.164-addresses or parts thereof) in the form of a positive or negative list.

Further additional roaming restrictions are now only possible via the “*regional subscription*” feature. The subscription restriction (including assignment of roaming areas) forms the basis for the assignment of zones for regional roaming restrictions: The assignment of zones is only relevant if the mobile subscriber is allowed to roam in the corresponding area.

Operator-determined barring (ODB) of GSM functions

The PLMN function ”operator-determined barring (ODB)” allows the PLMN operator to regulate GSM subscriber access to the GSM network with its service functions. This is done by barring certain call categories initiated by the GSM subscriber.

Exchange procedure for new GSM subscriber chip cards (SIM)

Some chip cards have a useful life of only 3 years. The PLMN operator can replace old chip cards and their data records with chip cards containing new data records if required. To support this, the D900/D1800 provides an automatic exchange procedure for new chip cards.

Additional operation and maintenance functions:
– barred directory numbers for call forwarding
– deletion of GSM subscriber data from the VLR

- unstructured supplementary service data (USSD) text management
- management of mobile subscriber profiles in the HLR
- user specific HLR access
- bulk HLR subscriber administration (group commands for HLR and GSM subscriber expiry date)

7.7 Signaling Functions

Common channel signaling system CCS7 is used in the D900/D1800 network for the signaling functions between the SSS network node (MSC/VLR, HLR/AC, EIR) and between MSC/VLR and BSC.

The CCS7 user part INAP (IN user part) or CAP (CAMEL application part) provides signaling functions needed for exchanging messages between IN/CAMEL network elements M-SSP (MSC/VLR with IN functionality) and the SCP (signaling control point) / CSE (CAMEL service environment). For application of an external IP the extended EDSS.1 signaling system is used of the appropriate interfaces at the M-SSP.

To connect GSM mobile subscribers or GSM-RITL subscribers of a CSC, a special signaling system complying with the GSM standard is used on the GSM radio interface between MS and BSS.

To connect wired analog subscribers of a CSC, the signaling systems pulse dialing or multi-frequency dialing (dual tone multi-frequency, DTMF) are used.

The EDSS.1 signaling system is used for connecting wired ISDN subscribers via a primary rate access (PA) to ISDN PABXs or via an ISDN basic access at the CSC.

The X.25 signaling system with OSI layer structure is used for signaling between the OMC in the OMS and the network elements of the BSS and SSS and for Q.3 interfaces between OMC to the OS. For conections between OMC-S and OS-S network components, it is also possible to use signaling with TCP/IP.

7.8 Functional Sequence of Basic Call Types

The basic call types of the D900/D1800 are illustrated here in the form of examples to explain in more detail the functional sequence and the flow of information in D900/D1800.

Mobile originated call (MOC) of a GSM mobile subscriber to another network

A location registration and thus an authentication must have taken place at the start of an MOC.

1. The MS sends the call setup information dialed by the GSM subscriber to the MSC.
2. The MSC requests call information (in the main relating to possible relevant restrictions) from the VLR via the GSM subscriber identified with the IMSI.
3. If the MSC is equal to a GMSC, the MSC sets up the call to the fixed network exchange (local exchange, LE) after allocation of a traffic channel and from there to the called subscriber in the fixed network. If the MSC is not equal to a GMSC, the MSC sets up the call to the gateway exchange (GMSC) after allocation of a traffic channel, and subsequently to the fixed network exchange (local exchange, LE) and from there to the called subscriber in the fixed network

Fig. 7.1 shows the call procedure of an MOC to a fixed network subscriber.

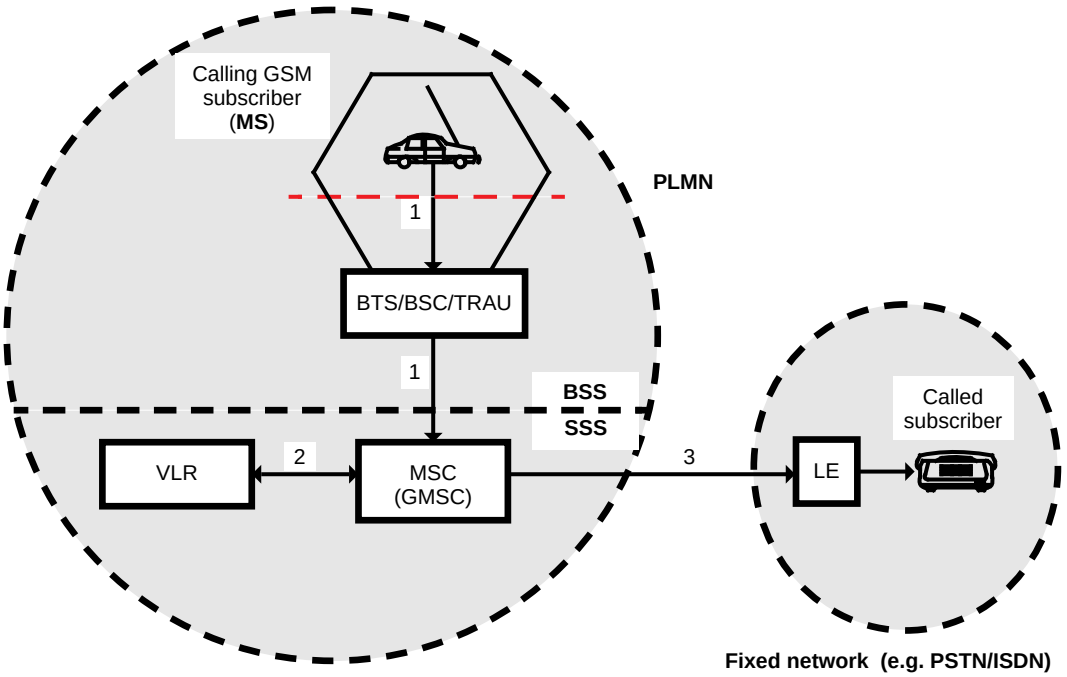


Fig. 7.1 Call procedure of an MOC to a fixed network subscriber

Mobile terminating call (MTC) of a GSM mobile subscriber from another network

1. A call for a GSM subscriber arrives at the GMSC.
2. With the aid of the dialing information (MSISDN), the GMSC determines the HLR and sets up a signaling connection to it (interrogation).
3. The HLR sends a request to the VLR in whose location area the called GSM subscriber is currently located.
4. The VLR sends the required GSM subscriber roaming number (MSRN) back to the HLR. The HLR passes on the MSRN to the GMSC.
5. Based on the MSRN, the GMSC sets up the call to the MSC, i.e. the MSC in whose area the GSM subscriber is located at that time.
6. Since the MSC does not know the GSM subscriber up to this point, the MSC requests from its VLR the GSM subscriber information for the call setup.
7. The MS is now called by paging at all BTS/BSC of the location area, since the cell in which the MS is located is not known to the MSC.
8. This information is passed to the MSC in the response to the paging.
9. Finally, the call to the MS is set up

Fig. 7.2 shows the call procedure of an MOC to a fixed network subscriber.

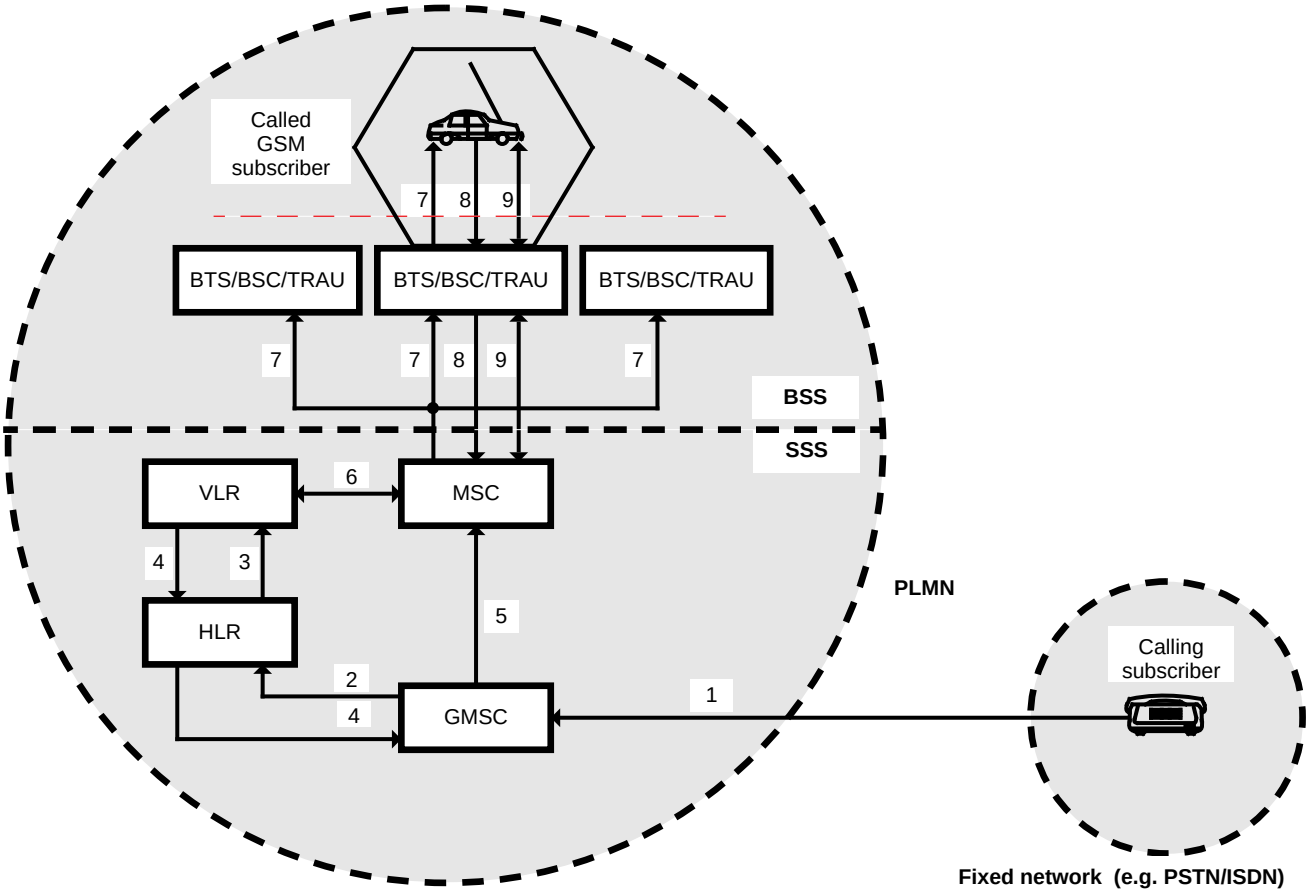


Fig. 7.2 Call procedure of an MTC (with call origin in the fixed network)

Mobile-to-mobile call (MMC) of a GSM mobile subscriber

1. The MS sends the call setup information (MSISDN) dialed by the GSM subscriber to the MSC1.
2. The MSC1 requests GSM subscriber information from the VLR1.
3. The MSC1 ascertains the HLR from the dialing information (MSISDN) and establishes a signaling connection to it (interrogation).
4. The HLR transmits a request to the VLR2 where the called GSM subscriber is located at that time.
5. The VLR2 sends the requested mobile subscriber roaming number (MSRN) back to the HLR. The HLR forwards the MSRN to the MSC1.
6. Based on the MSRN, the MSC1 sets up the call to the MSC2 in whose area the called GSM subscriber is located at that time.

Steps (7) to (10) are the same as steps (6) to (9) in Fig. 7.1 and Fig. 7.2.

Fig. 7.3 shows the call procedure of an MMC.

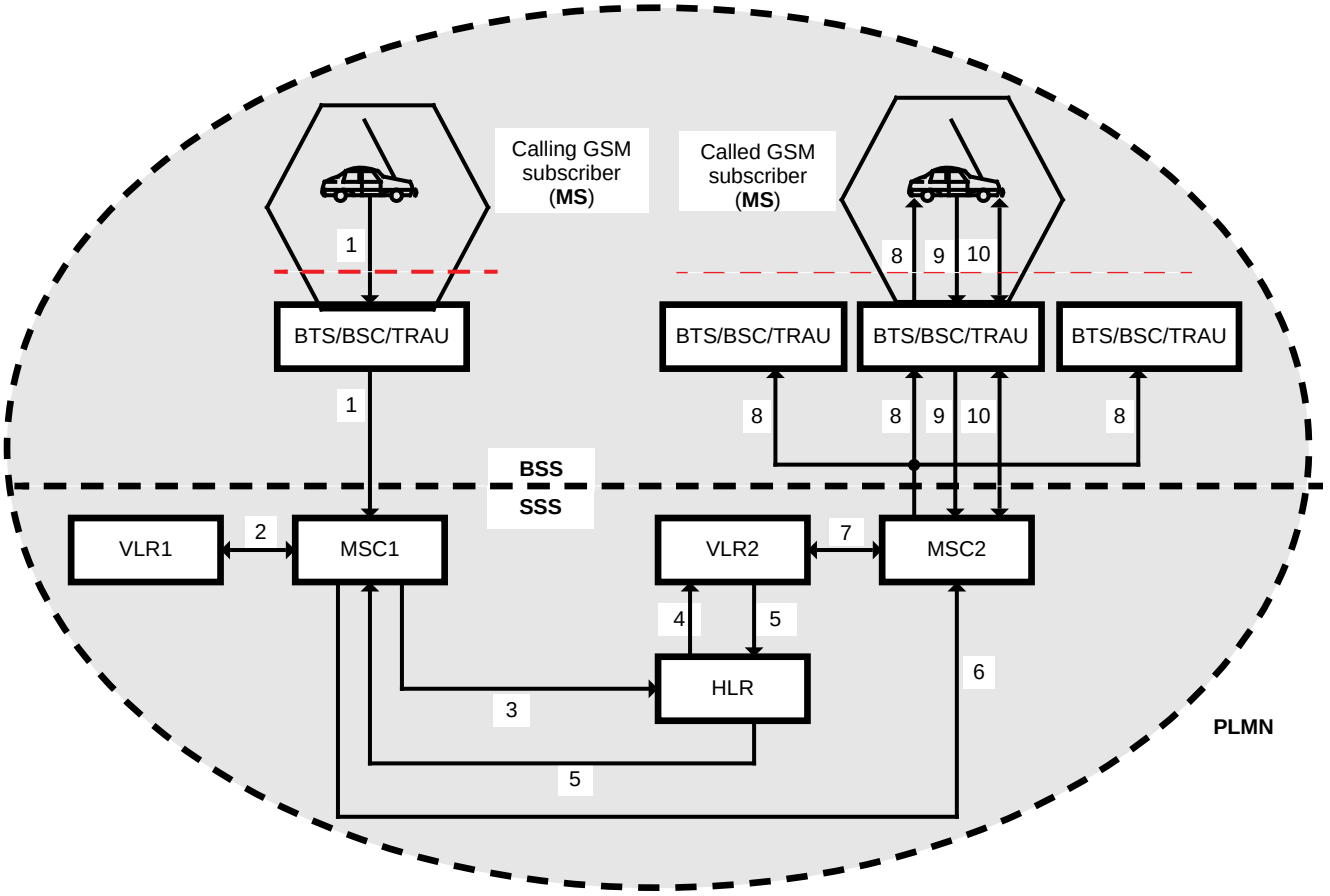


Fig. 7.3 Call procedure of an MMC

Calls to/from GSM-RITL subscribers in the CSC

For GSM-RITL subscribers in the combined switching center (CSC) the setting up of calls is basically governed by the same procedures as those employed for GSM mobile subscribers. The sequences described above also apply to GSM-RITL subscribers without restriction. The difference between GSM-RITL subscribers and GSM mobile

subscribers is merely in the roaming restrictions. For GSM-RITL subscribers roaming is only allowed within a defined location area.

Calls to/from wired ISDN/analog subscribers in the CSC

Following sequence describes the call of a wired ISDN subscriber (via PABX) to the GSM subscriber at the shared CSC.

1. The ISDN terminal sends the call setup information (MSISDN) dialed by the subscriber to the CSC.
2. The CSC checks the subscriber authorization.
3. The CSC ascertains the HLR from the dialing information (MSISDN) and establishes a signaling connection to it (interrogation).
4. The HLR transmits a request to the VLR in whose location area the called GSM subscriber is located at that time.
5. The VLR sends the requested mobile subscriber roaming number (MSRN) back to the HLR. The HLR forwards the MSRN to the CSC.

Steps (6) to (9) are the same as steps (6) to (9) in Fig. 7.2.

Fig. 7.4 shows an example of a call procedure of a wired ISDN subscriber (via PABX) to the GSM subscriber at the shared CSC.

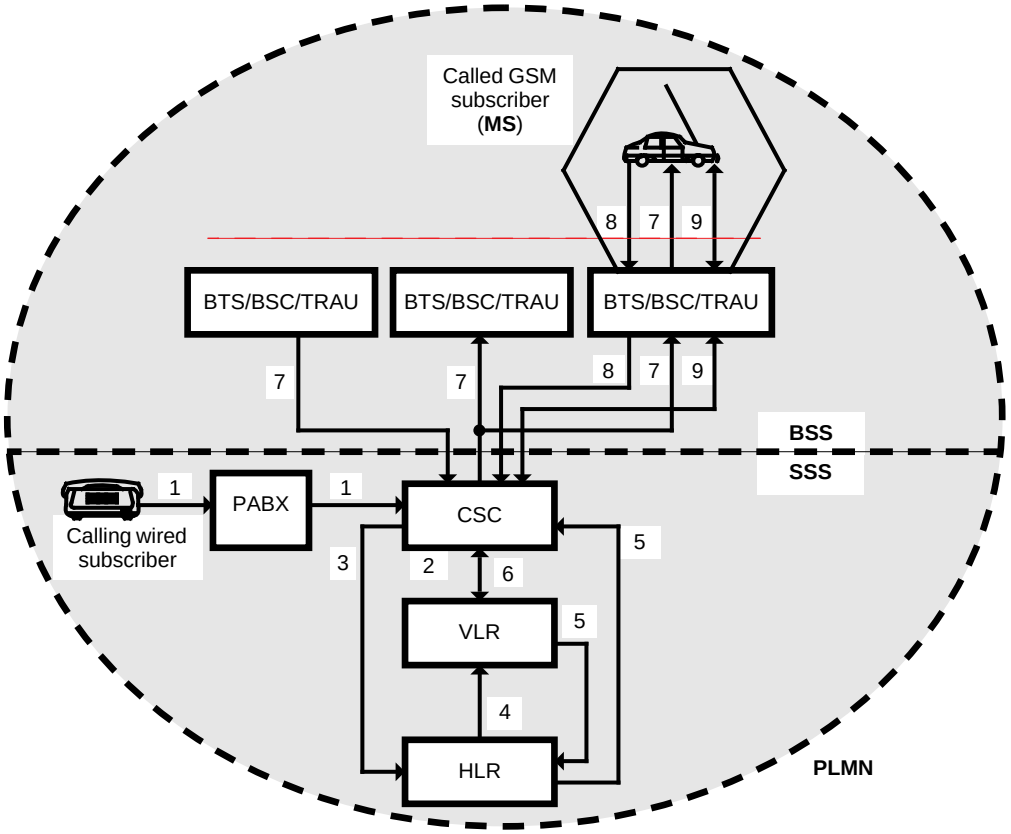


Fig. 7.4 Call procedure of a fixed ISDN subscriber to the GSM subscriber at the shared CSC

Calls to IN/CAMEL applications

Depending on the IN service category, the call procedures are different like the following.

Call procedures (for a basic IN service or some kind of subscriber-specific IN service

1. The IN service request is by dialing an IN number (e.g. a freephone (e.g. 130) number).
2. The digit translation in the M-SSP recognizes that a dialed directory number belongs to an IN service (IN triggering).
3. The M-SSP initiates the transaction (SCCP) dialog to the SCP (in the case of the televoting service the vote is passed on from the IN service user to the SCP for processing) using the ETSI core INAP protocol.
4. The SCP interrogates the database and handles the complete service logic.
5. The SCP sends the result of its database interrogation to the M-SSP.
6. On the basis of the information that it obtains from the SCP, the M-SSP executes normal routing and continues with the call setup to the destination defined by the SCP.

Call procedures (for most subscriber-specific IN/CAMEL service for GSM subscribers)

1. Example: The GSM subscriber is roaming inside the HPLMN and has a subscription to a CAMEL service.
In the case of subscription, a CAMEL service mark (CSI) is provided in the VLR by the HLR during location update (for an MOC) and during HLR interrogation (for an MTC).

1. The IN/CAMEL service request is within the context of call setup by internally setting of the CAMEL service mark (CAMEL subscription information, CSI).
2. The originating CSI (O-CSI) in the VLR indicates that the call setup process shall be suspended and an initial contact with the SCP/CSE shall be made. The call setup phase causes the M-SSP to trigger, i.e. an IN/CAMEL service is recognized. The M-SSP checks whether or not the IN/CAMEL service is supported and activated.
3. The M-SSP initiates the transaction (SCCP) dialog to the SCP/CSE using the ETSI CAP protocol. The service key and the SCP/CSE address (stored in the CSI) are used for routing and transmission to the SCP/CSE.
4. The SCP/CSE interrogates the database and handles the complete service logic. The SCP/CSE sends the result of its database interrogation to the M-SSP.
5. On the basis of the information that it obtains from the SCP/CSE, the M-SSP executes normal routing, generally with the originally-dialed directory number and continues with the call setup to the called subscriber.

Fig. 7.5 shows an example of a MOC call procedure for a subscriber-specific IN/CAMEL service for GSM mobile subscriber roaming in the HPLMN.

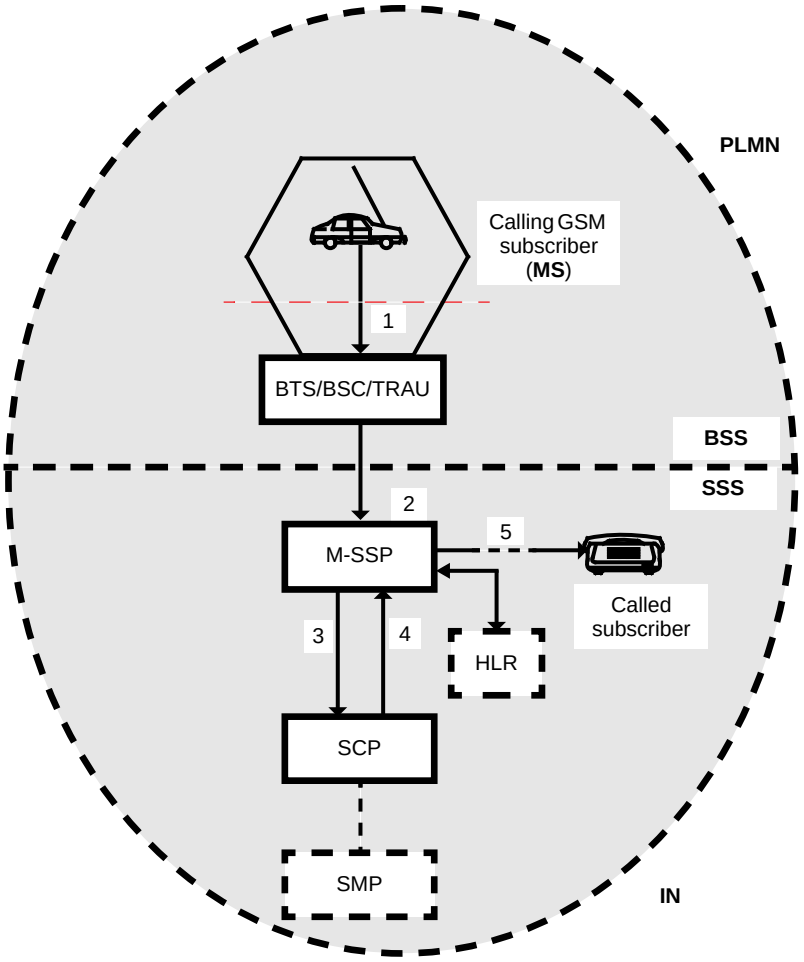


Fig. 7.5 MOC call procedure to IN/CAMEL applications, when GSM subscriber is roaming inside the HPLMN

2. Example: The GSM subscriber is roaming outside the HPLMN and has a subscription to a CAMEL service.
In the VLR a CAMEL service mark CSI is provided during location update of HLR (for an MOC) in the case of subscription and the HLR interrogation (for an MTC).

1. The IN/CAMEL service request is within the context of call setup by internally setting the CAMEL service mark (CAMEL subscription information, CSI).
2. The originating CSI (O-CSI) in the VLR indicates that the call setup process shall be suspended and an initial contact with the home SCP/CSE shall be made. The call setup phase causes the M-SSP to trigger, i.e. an IN/CAMEL service is recognized. The M-SSP checks whether or not the IN/CAMEL service is supported and activated.
3. The M-SSP initiates the transaction(SCCP) dialog to the SCP/CSE using the ETSI CAP protocol. The service key and the home SCP/CSE address (stored in the CSI) are used for routing and transmission to the home SCP/CSE.
4. The SCP/CSE interrogates the database and handles the complete service logic. The SCP/CSE sends the result of its database interrogation to the visited M-SSP.
5. On the basis of the information that it obtains from the home SCP/CSE, the visited M-SSP executes normal routing, generally with the originally-dialed directory number and continues with the call setup to the called subscriber.

Fig. 7.6 shows an example of a MOC call procedure for a subscriber-specific IN/CAMEL service for GSM mobile subscriber roaming outside the HPLMN.

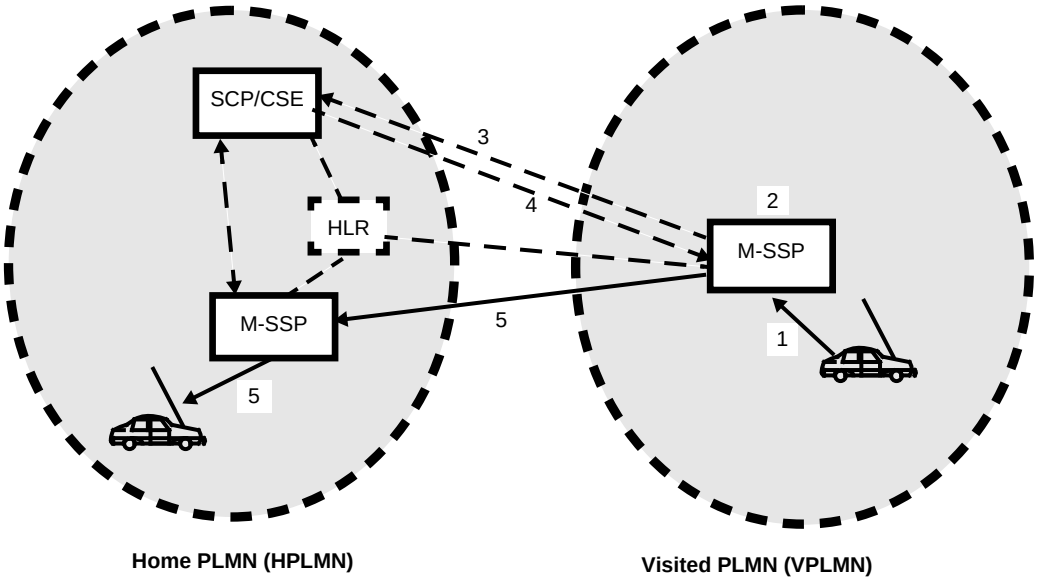


Fig. 7.6 MOC call procedure to IN/CAMEL applications, when GSM subscriber is roaming outside the HPLMN

8 Product Support

Quality and reliability alone do not guarantee successful introduction and durability of a system in a network. There also has to be extensive product support, such as that offered by Siemens for D900/D1800.

The range of support covers:
– project engineering
  (network/network node planning, project execution)
– manufacturing
– installation and commissioning
  (installation, commissioning, acceptance, network integration)
– technical services
  (technical assistance, updating, upgrading, inventory record keeping, repair service, spare parts supply, software supply)
– training
– operating documentation

Separate agreements can be made for each area of product support, defining which responsibilities will lie in the hands of the manufacturer and which will be assumed by the PLMN operating company and to what extent the operating company requires the advice or support of the manufacturer. These agreements also cover the areas of product support for which separate centers are to be set up in the PLMN, what documentation will be supplied to the PLMN operating company and how much training is to be given.

A number of typical areas of product support are described briefly below as examples.

Project engineering

- Network/network node planning
  The more carefully networks and nodes are planned, the greater the benefit that can be achieved with the available investment.
  Siemens possesses a wealth of experience and software tools specific to D900/D1800 for planning nodes and networks. If the operating company so desires, Siemens can also offer any support required in connection with deliveries of equipment, from the planning of node buildings to complete turnkey projects.
- Project execution
  Siemens project engineers produce project plans for nodes, coordinate the details of the project with the operating company and draw up an implementation schedule for the project. This covers the ordering of all hardware and software components and organizational tasks in connection with delivery, installation and cutover as well as generation of the data base and provision of documentation. If appropriate, the parts of the project for which the operating company is responsible and other project support tasks described in this section are also included in this schedule.

Manufacturing

D900/D1800 hardware is designed as a modular system consisting of modules, module frames, racks and plug-in cables, and production is to a large extent automated. This allows whatever proportion of manufacturing is most cost-effective to be transferred to the country of the operating company.

Siemens offers support in all phases of planning, introduction and execution of manufacturing as well as in procurement of automatic production and testing equipment and the related data processing facilities (software tools).

Installation and commissioning

The racks are delivered equipped with modules, the cables fitted with connectors. All these units have already been tested before leaving the factory. As a result, rapid and error-free installation work is ensured in the node where no soldering or wire-wrap connections will be necessary. Cutover of a SSS node involves loading the application program system (APS) and the database from magnetic tape to the system. The cutover of a BSS network element involves downloading the software images and database via OMC-B (central) or via LMT (local). Before the system is ready for acceptance, all system functions are tested thoroughly by means of test programs in accordance with the procedures documented in the Installation Test Manual (ITMN).

- Acceptance
  At the delivery of the D900/D1800 from Siemens to the operating company an Acceptance Test Manual (ATMN) is available, describing the recommended method for carrying out the acceptance test. The test steps specified in the ATMN cover all hardware and software functions and include a visual inspection of the entire installation of hardware and software and the faultless of the installed hardware.
  The ATMN is splitted in a unit acceptance and a system acceptance.
  The acceptance test of the software in a BSS or SSS node can then be restricted to the node-specific data in each case. For this purpose a Unit Acceptance Test Manual (ATMN) is available.
  Since the application program system (APS) in SSS nodes and software images in BSS network elements are always the same in all nodes with the initial feature packages, it is sufficient for the operating company to perform a once-only system acceptance test.

Technical services

The main purpose of technical services is to maintain the quality of service, ensure system availability and introduce new service features in existing nodes. Technical services cover the following areas:

– technical assistance
– updating
– upgrading
– inventory record keeping
– repair service
– spare parts supply
– software supply

Software tools (service toolsets) provide data processing support for these areas.

To meet the needs of the customer as quickly and economically as possible, the technical services are offered at three levels:

– operating company
– manufacturer's regional agent
– central services, Munich

As an example, technical assistance is used here to indicate the cooperation between the three levels of technical service center (TSC):

– the TSC 1 (at the operating company) detects faults, records them, saves error symptoms and continuously analyzes the performance of the system. If the operating company requires assistance from the manufacturer's regional agent, faults are reported to the latter.

– the TSC 2 at the Siemens regional agent analyzes the faults reported by the operating company's TSC. If central services in Munich are needed to clear the fault, the TSC performs a preliminary diagnosis enabling the fault to be reproduced.
– the TSC 3 ensures a thorough fault diagnosis, determines, in conjunction with the system development department, the corrective measures to be taken and arranges for any necessary changes to be incorporated. In this way, the worldwide experience of the technical assistance personnel in Munich can be employed to the benefit of the operating companies.

- Repair
  For repair of defective modules, the most cost-effective method is to carry out exact fault location using the appropriate test procedures and test equipment and to replace the faulty component in parallel with the manufacturing operation. If it is in accordance with the plans of the operating company, a repair center separate from module manufacturing can be set up.

Training

For the operating company’s personnel involved with D900/D1800 there are training programs tailored to the activities which they will be undertaking. This training takes the form of both courses and on-the-job training. The communication networks training center in Munich offers a wide range of courses. In addition to System D900/D1800, these courses also deal with wireline network communications (e.g. ISDN network nodes) and information and broadband networks (e.g. , ATM network nodes), transport networks and call center solutions. Depending on what is agreed with the operating company, the courses can also be held in the country concerned. In a number of countries there are already regional training centers set up by the operating companies. Siemens trainers can also be posted to the country where D900/D1800 is to be used or the trainers from the operating country can attend courses in Munich.

Operating documentation

In addition to highly-optimized hardware/firmware and software, in additional to future-oriented service features for reducing operating costs and improving profits, operating documentation, even in a monetary sense, has become an inseparable part of the product. The structure and usability of the operating documentation must grow to precisely meet the various requirements and changing circumstances in which it is used. In addition to the historically-evolved media of paper and microfiche, modern operation of communications systems requires use of CD-ROM and other electronic information media on a variety of operating platforms not just in the operation and maintenance OMC, but also locally in the network elements concerned.
The operating documentation concept is based on a top-down (Fig. 8.1.).

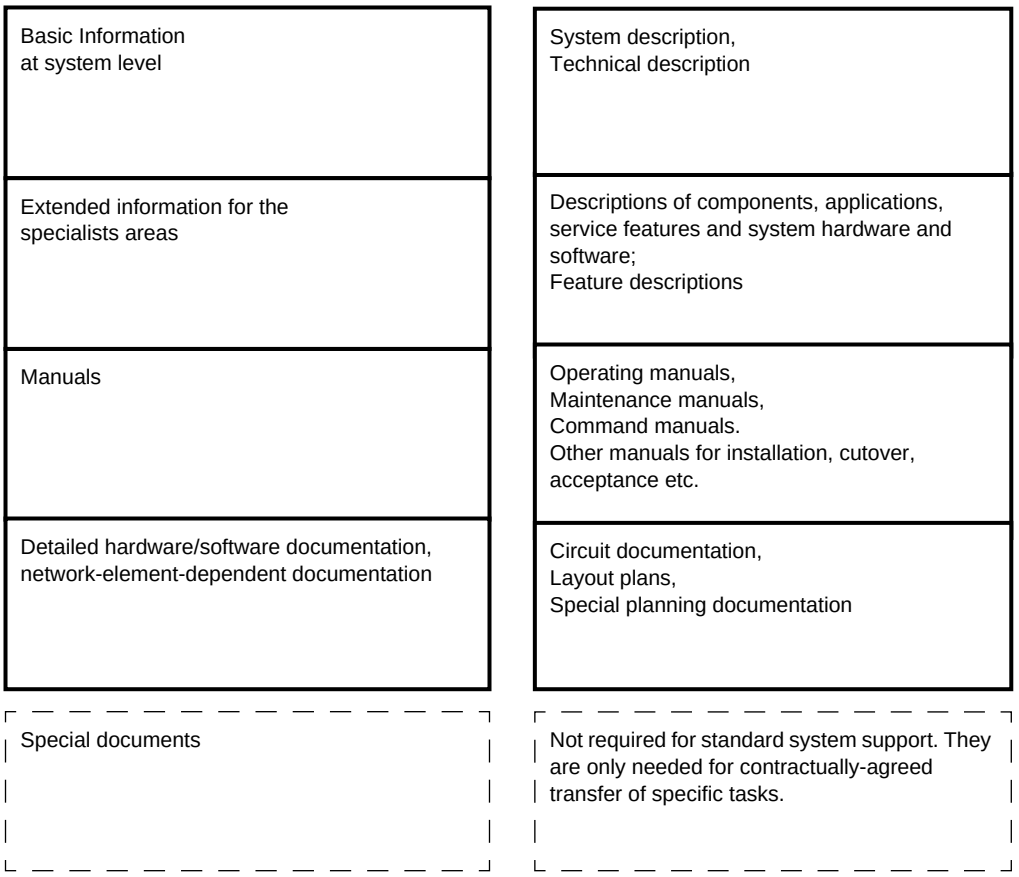


Fig. 8.1 Top-down structure of the operating documentation

- Documentation types

  The mobile radio operating documentation consists of the following types of document, for which the characteristics are tailored to how the documentation is to be used:
  – descriptions
  – manuals
  – detailed documentation

  Descriptions

  Descriptions provide information about the system, about the network elements and about configuration components, i.e. overview and background knowledge of the system to the depth required for understanding the system and the operating concept.

  Examples of descriptions are this System Description (SYD) or Technical Description (TED), subsystem descriptions and feature descriptions.

  Manuals

  Manuals contain concrete instructions, procedures and commands for executing O&M tasks.

  The “Operator Guidelines (OGL)” for example provide an introduction to the general principles of operation and maintenance SSS and BSS network nodes and describe the way in which the relevant manuals for SSS network nodes are organized. Examples of other manuals are Operating Manuals (OMN), Command Manuals (CML),

Maintenance Manuals (MMN) or Emergency Manual (EMCYMN).

Detailed documentation

Specific applications (for example production, repairs services) are dealt with in detailed documentation. The customer does not need these documents for normal operation; they remain with the service organizations.

D900/D1800 operating documentation is also notable for the following features:

– it is clearly laid out and written in an educational way to make for ease of understanding and learning
– it is always up-to-date by virtue of a well-organized modification service
– it uses uniform English abbreviations in all languages

It is sensible for the operating company to set up a documentation center so that operating documentation can be continuously updated and distributed as efficiently as possible.

9 Quality Assurance

One of our company goals is to provide the market with products and services which offer our customers the greatest benefits throughout the entire useful life of the products. The term ”products” covers devices, equipment, systems with hardware and software (including OEM products) and the related services such as the technical service, documentation, training, etc. In order to achieve the targeted objective, the appropriate quality assurance measures have been taken in the product management, sales, development, production and service process. The quality assurance measures applied enable statements to be made about quality at an early stage, for example during the development phase. The most important quality assurance measures are:

– management commitment
– definition of quality aims
– definition of quality figures
– definition, qualification and monitoring of processes
– provision of resources
– improvement of quality by means of preventive measures
– product and market observation
– training
– quality audits

Documentation of the quality assurance system

The requirements for documentary evidence of quality assurance are described in the requirements standards for quality assurance systems drawn up by the International Organization for Standardization (ISO 9000 Series). The requirements of the ISO 9000 Series are contained in the guidelines for demonstration of implementation, which is demanded for a quality assurance system. The standards are divided into quality assurance elements. Applying and meeting these quality assurance elements is an integral part of our delivery contracts.

Product-related documents relevant to quality lay down the following:

– responsibility/tasks
– processes/procedures
– tools and resources
– documentation and results
– interfaces to other organizational units

In the Information and Communication Networks (ICN) Group our quality is regulated by ISO standard 9001. The Business Units in the ICN Group, particularly Communication on Air (CA) have been very successful in obtaining the quality certificate from the German Institute for Quality Management Systems Certification DQS.

9.1 Hardware Quality Assurance

Development guidelines and Siemens quality specifications, which define among other things the requirements for the components employed, together with the system specifications and the precisely-defined hardware engineering production plan (HEPP), constitute the instruments of quality assurance during development. A systematic inspection monitors the quality of incoming components. The fully equipped and soldered modules undergo a visual check and a series of electrical tests on computer controlled automatic test equipment. The automatic test equipment is also available for simple and low-cost fault clearance on replaced modules. Racks are equipped as required prior to delivery and also tested automatically in the system test bed. The subsequent run-in test subjects the system to thorough tests under extreme operating conditions. This excludes the possibility of premature failures during actual operation.

For transport of the fully-equipped racks to the site, special protective covers are employed and these also prevent damage when the racks are being installed. If equipment is shipped abroad, additional packaging is used to protect the racks from climatic effects. A transportation device is provided so that the racks can be moved around safely at the installation site. The protective covers are not removed until the racks have been correctly positioned.

9.2 Software Quality Assurance

SSS software

The use of the ITU-T high-level languages CHILL and SDL during development and testing is a significant factor in the excellent quality assurance of the extensive D900/D1800 software. The use of CHILL makes all aspects of producing software much easier and much faster. The administrative separation of development and test departments ensures that software is evaluated objectively.

BSS (e.g. BS-2x and BS-6x BTSE) software

In BS-2x and BS-6x BTSE the languages ANSI-C and ITU-T SDL are used. Extremely time critical-parts such as digital signal processing are written in assembler. The usage of SDL and automatic code generators simplifiy and accelerate the production of software products. The organizational separation of the development and testing departments ensure that the software is checked objectively.

Software development stages

Software development is governed by a precisely-defined software engineering production plan (SEPP). Inspections are undertaken after each of the predefined development stages. This target-oriented procedure goes a considerable way towards ruling out software errors. The inspection phases after individual development stages are as follows:

- Design verification
  SSS software
  For each software product, specialists perform precise checks on whether the detailed feature specifications have been adhered to. All interfaces are then coded in CHILL, compiled and stored by the compiler in the project library. This contains all available parameters, procedures and other interface-defined objects.

The inherently consistent project library constitutes an important prerequisite for creation of an error-free APS.

BSS (e.g. BS-2x and BS-6x BTSE) software

The messages interchanged within the system are coded in the C languages, translated from the compiler, and stored in the project library. This contains the bit-precise description of all messages interchanged in the system.

- Checking of coded modules

  Software modules undergo a code review and an off-line test. In the code review, specialists check whether the code is functionally correct and whether it adheres to programming conventions. Where necessary, they identify possible malfunctions or incompatibilities with real-time conditions and suggest possible reductions of memory requirement and runtimes.

  SSS software

  The code review is followed by the off-line test of the modules on a commercial data processing system and a bit-by-bit comparison with the interfaces stored in the relevant project library. This completes the development and testing of the individual software modules.

  BSS (e.g. BS-2x and BS-6x BTSE) software

  Off-line test: The off-line test is realized in several steps. First every module is tested in a commercial data processing system to check that it is functioning and that the interface is upheld. In a “whitebox integration test” the software runs in a real hardware environment. Test tools developed for this purpose only simulate the interfaces and observe the software. The interchanged messages are recorded automatically and compared with the messages stored bit-precisely in the project library. In this way the interworking of all modules in the software is checked.

- System integration test

  SSS software

  In this stage of development, experienced test engineers use carefully constructed test specifications to check that the APS as the sum of its modules runs without error. The system integration test is undertaken partly on a commercial data processing system, partly on the switching processor, and represents the final stage of actual software development.

  BSS (e.g. BS-2x and BS-6x BTSE) software

  In this stage of development, experienced test engineers use carefully constructed test specifications to check that the software image as the sum of its modules runs without error. The system integration test is carried out in the real hardware environment. System interfaces are simulated by commercial interface simulators. The system integration test is the last step in the actual software development.

- System test

  The system test is undertaken by a department independent of the developers and is run on the coordination processor. The system test shows how the complete software behaves in the system. The system behavior must remain stable under load and react in a controlled manner when hardware faults are simulated. Load generators generate all types of call, simultaneously checking and measuring the call failure rate.

  In the automated regression test, programs simulate operating devices, process command files and check system reactions for correctness. The coordination processor and a data processing system run in parallel for this test. The data processing system compares outputs from the coordination processor with its stored nominal outputs and records any deviations.

10 Abbreviations

AC	Authentication Center
ACOM	Antenna Combiner
AGC	Automatic Gain Control
AMA	Automatic Message Accounting
AOC	Advice of Charge
AOCC	Advice of Charge - Charging level
AOCI	Advice of Charge - Information level
APS	Application Program System
ASCI	Advanced Speech Call Items
ATM	Asynchronous Transfer Mode
ATOP	Automatic Operator
BA	Basic Access
BAIC	Barring of All Incoming Calls
BAOC	Barring of All Outgoing Calls
BAP	Base Processor
BBSIG	Baseband and Signal Processing
BCT	Basic Craft Terminal
BDCG	Bus Distributor Module with Clock Generator for DSU
BIC-Roam	Barring of All Incoming Calls when Roaming Outside Home PLMN Country
BMML	Basic MML
BOIC	Barring of All Outgoing International Calls
BOIC-exHC	Barring of All Outgoing International Calls except to Home PLMN Country
BSC	Base Station Controller
BSCI	BSC Interface Card
BSIC	Base Station Identity Code
BSS	Base Station System
BSSAP	Base Station System Application Part
BSSMAP	Base Station System Management Application Part
BTS	Base Transceiver Station
BTSE	Base Transceiver Station Equipment
BTSM	BTS Site Management
CAMEL	Customized Application for Mobile Network Enhanced Logic
CAP	Call Processor
CAP	CAMEL Application Part
CBC	Cell Broadcast Center
CCBS	Completion of Call to Busy Subscribers

CCG(A)	Central Clock Generator A
CCNC	Common Channel Signaling Network Control
CCNP	Common Channel Signaling Network Processor
CCS7	Common Channel Signaling System No. 7
CCTRL	Core Controller
CD ROM	Compact Disc Read Only Memory
CDA	Circuit Duplex Asynchronous
CDE	Common Desktop Environment
CDS	Circuit Duplex Synchronous
CFB	Call Forwarding on mobile subcriber Busy
CFNRc	Call Forwarding on mobile subscriber Not Reachable
CFNRy	Call Forwarding on No Reply
CFU	Call Forwarding Unconditional
CLI	Command Line Interface
CLIP	Calling Line Identification Presentation
CLIR	Calling Line Identification Restriction
CM	Configuration Management
CMISE	Common Management Information Service Element
CML	Command Manual
CMY	Common Memory
CNI	Comfort Noise Insertion
COU	Control of Use
COUC	Conference Unit C
CP113C	Coordination Processor 113C
CP113CR	Coordination Processor 113CR (Rural Version)
CRP8	Code Receiver for Pushbutton Dialing, 8 Receiver Modules
CSC	Combined Switching Center
CSDN	Circuit Switched Data Network
CSE	CAMEL service environment
CT	Call Transfer
CUG	Closed User Group
CW	Call Waiting
D1800	Digital Mobile Radio Communication Network, GSM1800 Standard
D900	Digital Mobile Radio Communication Network, GSM 900 Standard
DAS	Digital Announcement System

DCN	Data Communication Network
DEC120	Digital Echo Compensator
DLU	Digital Line Unit
DLUB	Digital Line Unit B
DLUC	Control for DLU System (in DSU/DLUB)
DRC	Distance Related Charging
DSP	Digital Signaling Processor
DSU	Data Service Unit
DTAP	Direct Transfer Application Part
DTMF	Dual Tone Multi-Frequency Signaling
DTX	Discontinuous Transmission
DUCOM	Duplex Combiner
DULAMO	Duplexer and Low Noise Amplifier Module
EDSS.1	European Digital Subscriber Signaling System No. 1
EFR	Enhanced Full-Rate channel
EIR	Equipment Identity Register
EM	External Memory
EMCYMN	Emergency Manual
ETSI	European Telecommunications Standards Institute
EWSD	Digital Electronic Switching System
F:xxx	Module Frame for xxx
FAC	Final Assembly Code
FDMA	Frequency Division Multiple Access
FICOM	Filter Combiner
FM	Fault Management
FPH	Freephone Service
FR	Full-Rate
FTAM	File Transfer and Access Management
GCG:DLUB	Group Clock Generator for DLUB
GMSC	Gateway MSC
GMSK	Gaussian Minimum Shift Keying
GPN	Group Processor N
GPRS	General Packet Radio Service
GSC	Gateway MSC (in Satellite Networks)
GSM	Global System for Mobile Communication
GUI	Graphical User Interface
HDLC	High-Level Data Link Control
HEPP	Hardware Engineering Product Plan
HLR	Home Location Register
HPLMN	Home PLMN

HR	Half-Rate
HSCSD	High Speed Circuit Switched Data Service
HYCOM	Hybrid Combiner
IACHASTA	Interadministration Charging and Statistics
IARA	Interadministration Revenue Accounting
ICN	Information and Communication Networks
IMEI	International Mobile Equipment Identity
IMSI	International Mobile Subscriber Identity
IN	Intelligent Network
INAP	IN Application Part
IOC	Input/Output Control
IOP	Input Output Processor
IOP:AUC	Input/Output Processor for Authentication Center
IP	Intelligent Peripheral
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISO	International Organization for Standardization
ISP	Internet Service Provider
ISUP	ISDN User Part
ITU-T	International Telecommunication Union, Sector Telecommunication Standardization
IVR	Interactive Voice Response
IWE	Interworking Equipment
IWF	Interworking Function
IXLT	O&M Interface
Kc	Cipher Key
Ki	Individual Authentication Key
LAI	Location Area Identity
LAN	Local Area Network
LAPD	Link Access Protocol D
LE	Local Exchange
LI	Link Interface
LMSI	Local Mobile Subscriber Identity
LMT	Local Maintenance Terminal
LNA	Low Noise Amplifier
LNA&BF	Low Noise Amplifier & Band Filter
LTG	Line/Trunk Group
LTGG	Line/Trunk Group G
LTGN	Line/Trunk Group N
LTU:S	Line/Trunk Unit:Supplementary

MAP	Mobile Application Part
MB(B)	Message Buffer B
MBBCU	Multichannel Base Band Unit
MCR	Mobile Call Record
MCS	Mass Calling Service
MDD	Magnetic Disk Device
MF	Mediation Function
MFC:R2	Multifrequency Code Signaling (R2)
Micro BTS	Micro Base Transceiver Station
MMC	Mobile to Mobile Call (inter MSC)
MML	Man Machine Language
MMN	Maintenance Manual
MOC	Mobile Originated Call
MOD	Magneto-optical Disk
MPCC	Main Processor Control Card
MPM	Multiple Pulse Metering
MPTY	Multi Party Service
MS	Mobile Station
MSC	Mobile-Services Switching Center
MSCI	MSC Interface Card
MSRN	Mobile Station Roaming Number
M-SSP	Mobile SSP
MTC	Mobile Terminated Call
MTD	Magnetic Tape Device
MTP	Message Transfer Part
NDC	National Destination Code
NMC	Network Management Center
NUC	Nailed-Up Connections
OACSU	Off Air Call Setup
OCANEQ	Operationaly Controlled Equipment for Announcement
OCE:SPM	Operationally Controlled Equipment for Announcement, Stored Program Control and Memory
O-CSI	Originating CSI
ODB	Operator Determined Barring
OEM	Original Equipment Manufacturer
OGL	Operator Guide Line
OMC	Operation and Maintenance Center
OMC-B	Operation and Maintenance Center for BSS
OMC-S	Operation and Maintenance Center for SSS
OMN	Operation and Maintenance Manual

OMP-B	Operation and Maintenance Processor for BSS
OMP-S	Operation and Maintenance Processor for SSS
OMS	Operation and Maintenance Subsystem
OMTX	X Terminal
ORACLE	Commercially database product
OS	Operations System
OSD	OMS Status Display
OSF	Open System Foundation
OSI	Open Systems Interconnection
OSS	Operator Specific Services
PA	Power Amplifier
PA	Primary Access
PABX	Private Automatic Branch Exchange
PAD	Packet Assembler/Disassembler
PCR	Preventative Cyclic Retransmission
PCS	Personalization Center for SIM
PH	Packet Handler
PLMN	Public Land Mobile Network
PM	Performance Management
PPCC	Peripheral Processor for CCS7
PPLD	Peripheral Processor for LAPD Channels
PPM	Periodic Pulse Metering
PPS	PrePaid Service
PPSC	PrePaid Service Center
PSDN	Packet Switched Data Network
PSTN	Public Switched Telephone Network
QTLP	Quad Trunk Line Interface
R:xxx	Rack for xxx
RAND	Random Number
RAS	Remote Access Server
RF	Radio Frequency
RFRX	Radio Frequency Receiver unit
RFTX	Radio Frequency Transmitter unit
RITL	Radio-in-the-Loop
RR	Radio Ressource Management
RSS	Radio Subsystem
RX	Receiver
RXAMCO	Receiver Antenna Module and Multi Coupler Module
RXAMOD	Receive Antenna Module

RXFIL	Bandpass Filter for Receive Path
RXMUCO	Receiver Multi Coupler
S/N	Signal to Noise
SAS	Secure Application Service
SBS	Siemens Base Station System
SCE	Service Creation Environment
SCI	Subscriber Controlled Input
SCP	Service Control Point
SDDPFC	Subscriber Dependent Digit Processing and Feature Control
SDL	Specification and Description Language
SGCB	Switch Group Control B
SILTG	Signaling Link Terminal Group
SIM	Subscriber Identity Module
SIVAPAC	Siemens Variable Packaging System
SLMA:FPE	Subscriber Line Module Analog for DLUB, Feature programmable, Module E
SLMD	Subscriber Line Module Digital
SM	Site Manager
SMC	Security Management Center
SMD	Surface Mounted Device
SMP	Service Management Point
SMS	Short Message Service
SMSC	Short Message Service Center
SMU	Site Manager Unit
SMUCB	Site Manager Combo Card
SN(B)	Switching Network B
SN16	Switching Unit with 16 kbit/s Submulti-plexing
Solaris/UNIX	Commercially Operating System Product
SPM	Single Pulse Metering
SPOTS	Support of Planing, Operation&Mainte-nance and Traffic Analysis System
SRES	Signed Response
SSP	Service Switching Point
SYP	System Panel
TAC	Type Approval Code
TCAP	Transaction Capabilities Application Part
TCP/IP	Transmission Control Protocol/Internet Protocol
TDMA	Time Division Multiple Access
TDPC	Telephony and Distributor Processor Card
TED	Technical Description

TIS	Teleinfo Service
TMSI	Temporary Mobile Subscriber Identity
TPU2	Transceiver and Processor Unit
TRAC	Transcoding and Rate Adaption Card
TRAU	Transcoding and Rate Adaption Unit
TRX	Transceiver
TRXA	Analogue Signal Processing Part
TRXD	Digital Signal Processing Part
TSC	Technical Service Center
TU	Test Unit
TUP	Telephone User Part
TV	Televoting
TX	Transmitter
TXAMOD	Transmit Antenna Module
TXFIL	Bandpass Filter for Transmit Path
UMTS	Universal Mobile Telecommunications System
UN	Universal Number
USS1	User-to-User Signaling Service 1
USSD	Unstructured Supplementary Service Data
VAD	Voice Activity Detection
VLR	Visitor Location Register
VMC	Voice Mail Center
VMS	Voice Mail System
VPN	Virtual Private Network
WAN	Wide Area Network
WAP	Wireless Application Protocol

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