Signaling Introduction

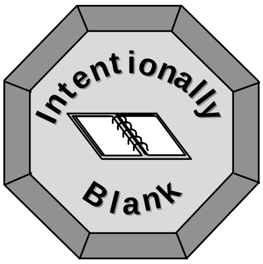
Chapter 4

This chapter is designed to provide the student with an overview of signaling techniques used in the network.

OBJECTIVES:

Upon completion of this chapter the student will be able to:

- give a brief description of the OSI-reference model.
- list what protocols are used on different interfaces.
- describe a signaling network and its elements.
- describe different signaling methods.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4 Signaling Introduction

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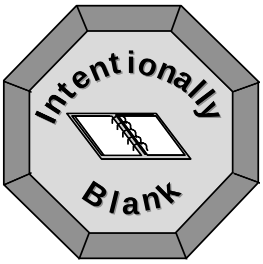
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OSI REFERENCE MODEL

BACKGROUND

At the International Standards Organization (ISO) planning meeting in Sydney 1977, a sub committee was formed for the main purpose of examining the problem of integrating different computer systems. The result was the creation of the Open Systems Interconnection (OSI) model which stresses developing open systems where several manufacturers can integrate their products as opposed to closed systems where manufacturers' products are not compatible with each other. The word *system* can for example, refer to computers, exchanges or data networks.

The ISO sub committee started its work by defining a reference model for interconnection of open systems into which all open systems protocols must fit. This is the OSI reference model which is often described as the seven layer model. The model reached the stage of an International Standard in 1980 and is now used as a common standard for open systems.

In 1984, Comité Consultatif International Télégraphique et Téléphonique (CCITT) which is now called International Telecommunication Union (ITU), released the X.200 recommendation where the OSI model is described in detail.

OSI MODEL

The OSI model abstractly describes the structure for communication between computer systems. It consists of seven hierarchical layers, where each layer provides services for the next layer above. The advantage with this well structured model is that a protocol within one layer can be replaced without affecting the other layers. Another advantage is that the implementation of the functions within one layer is optional for each supplier.

Analogy

This section describes a simple analogy for making this model easy to understand. Suppose that manager A wants to send a classified message to manager B who is working in a different company. See Figure 4-1.

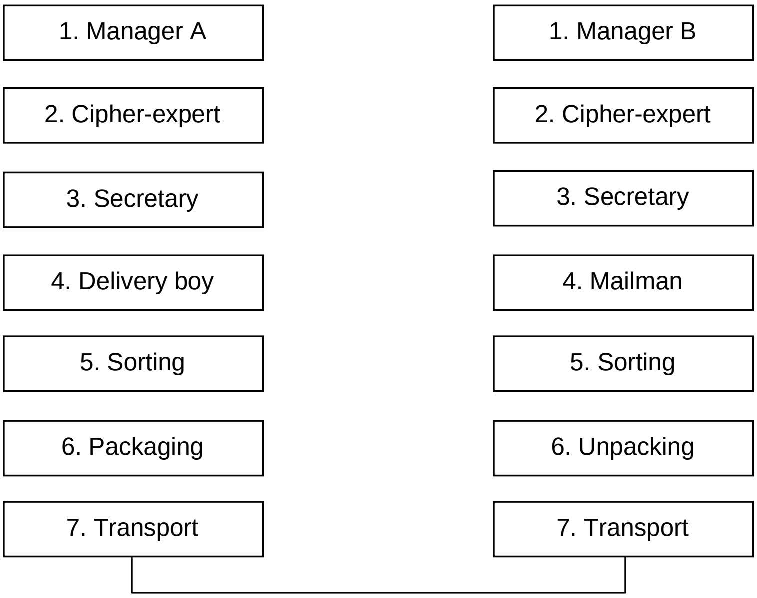

Figure 4-1 Analogy to the OSI model.

1. Manager A writes the classified message and hands it over to his assistant, who is a ciphering expert.
2. The assistant codes the message into a secret cipher and gives the coded message to the secretary.
3. The secretary puts the coded message in an envelope, writes the address and sender on it, and passes it over to the delivery boy.
4. The delivery boy collects the outgoing mail from the different departments in the company and transports the mail to the post office.
5. At the post office the mail is sorted for distribution to different destinations. All mail going to one destination is placed in one pile.
6. After sorting, the mail is put in boxes or mail bags to ensure safe and secure transport to the receiver.
7. Finally, the mail is transported to the destination.
8. At the receiving post office the mail bag is received and registered.
9. The mail bag is opened, and the mail is inspected for detection of possible damages.
10. After the mail has been checked, it is sorted for distribution to different customers (companies).
11. The letter is delivered by a mailman to the correct address.

12. Manager B's secretary opens the envelope and gives the letter to manager B's assistant, who is also a ciphering expert.
13. The ciphering expert decodes the message and presents it to manager B. The message has at last reached its final destination.

Communication process

Each layer has its own specific functions and provides specific services to the layers above. The functions within each layer as well as the interfaces between the layers are defined. The implementation of a function is however optional. For example, the cipher code in the analogy can be exchanged without affecting the other layers.

The physical communication is transferred from layer to layer, where each layer adds information that is removed by the corresponding layer at the receiving end. For instance, the secretary adds the envelope, which is removed by manager B's secretary.

Logically, each layer communicates with the corresponding layer in the other node. Only functions on the same layer can "understand" each other. This is called "peer–to–peer" communication.

DESCRIPTION OF LAYERS

Application Layer

The application layer provides services for support of the user's application. It is responsible for selecting lower layer services and synchronizes the actions of the destination application with its own. Examples of layer 7 functions are file transfer, message handling and operation and maintenance.

Presentation Layer

The presentation layer defines how data is represented, that is, the syntax. The presentation layer transforms the syntax used in the application into the common syntax needed for communication between applications. Layer 6 contains data compression, for example.

Session Layer

The session layer establishes connections between presentation layers in different systems. It also controls connection, synchronization and disconnection of the dialogue. For instance, it allows the presentation layer to determine check points, from which re-transmission starts if the data transmission has been interrupted.

Transport Layer

The transport layer acts as the transport interface for upper layers. It guarantees that the bearer services have the quality required by the application in question. Examples of functions are error correction and detection (end–to–end), and flow control. The transport layer optimizes the data communication by multiplexing or splitting up data streams before they reach the network.

Network Layer

The network layer isolates the upper layers from routing and switching functions in the network. The functions within the network layer establish, maintain and release connections between the nodes in the network, and handle addressing and routing of messages.

Data Link Layer

The data link layer provides an error free point–to–point circuit between network nodes. The layer contains resources for error detection and correction, flow control and re-transmission. It ensures that the messages are sent in the correct order, without errors or duplication.

Physical Layer

The physical layer provides mechanical, electrical, functional and procedural resources for transmission of bits between different nodes. The layer contains functions for converting data into signals compatible with the transmission medium.

For communication between two exchanges only, layer 1 and 2 is sufficient.

For communication between all exchanges in the network, layer 3 must be added because it provides addressing and routing.

An Easy Way to Remember the Different Layers

Application	**A**
Presentation	**P**erfect
Session	**S**ystem
Transport	**T**o
Network	**N**icely
Data link	**D**eliver
Physical	**P**ackets

SIGNALING METHODS

How the signaling information is conveyed between MSC and PSTN depends on what signaling method is available in the PSTN.

CHANNEL ASSOCIATED SIGNALING (CAS)

Channel Associated Signaling (CAS) means that the signaling is always sent on the same connection (PCM link) as the traffic. The signaling is associated with the traffic channel. In a 2 Mb/s PCM link, 30 TSs are used for speech while TS 0 is used for synchronization and TS 16 is used for the line signaling. All 30 traffic connections share TS 16 in a multiframe consisting of 16 consecutive frames. On TS 16, each traffic channel has a permanently allocated, recurring location for line signaling, where two traffic channels share TS 16 in one frame. See Figure 4-2. However, register signaling, for example dialed digits, is carried over the traffic channel.

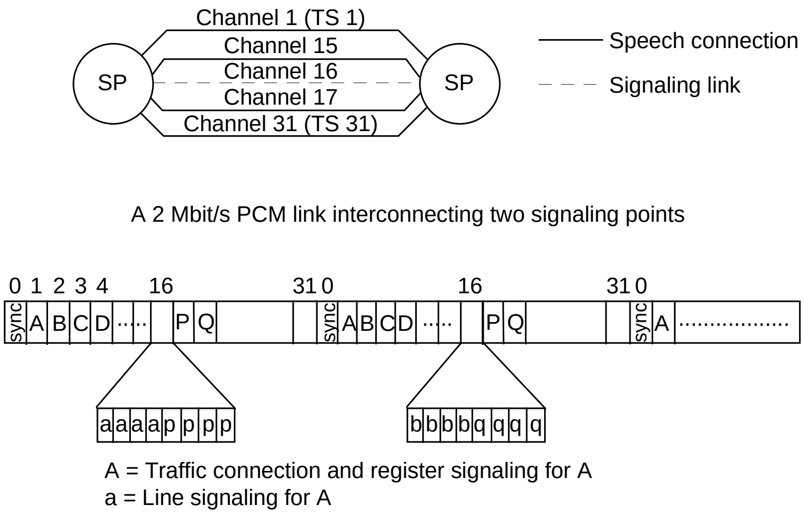

Figure 4-2 Principle for CAS using PCM link with 32 time slots.

COMMON CHANNEL SIGNALING (CCS)

Signaling network components

A signaling network is a network that can be used as an information transmission system for users of different categories. For example, telephony, data, operation and maintenance. A signaling network consists of a number of exchanges (nodes) which communicate via signaling channels. See Figure 4-3.

Signaling Link (SL) - SL is a basic component in a signaling network that connects two signaling points. The SL provides functions for message error control and message sequence control. The number that points out a certain Signaling Link is the Signaling Link Code (SLC).

Link Set (LS) - LS is a set of signaling links between signaling points connected with each other. To help choose the correct Link Set for a certain connection a number called Signaling link Selection (SLS) is used.

Signaling Point (SP) - A SP provides signaling network functions and may transmit and receive messages to and from users in the node. Each Signaling Point gets its own Signaling Point Code (SPC).

Signaling Transfer Point (STP) - A STP is a signaling point that only transfers messages from one signaling point to another. The Signaling Transfer Points are also given their own SPCs.

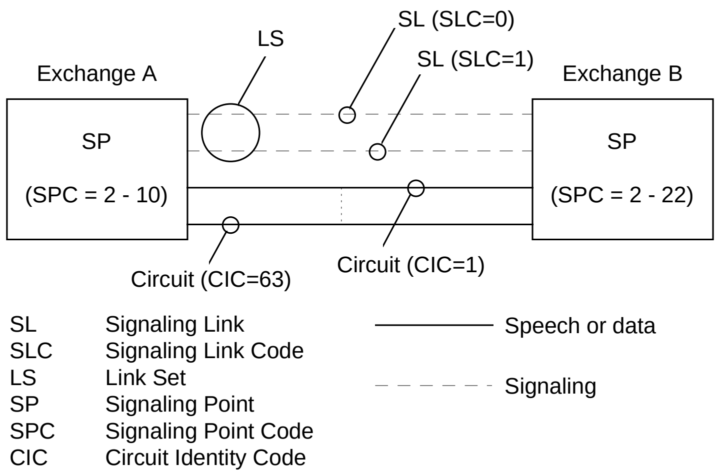

Figure 4-3 A Signaling network showing network components

CCS description

The Common Channel Signaling (CCS), e.g. SS7, is always used if possible. Here, the signaling network is separated from the traffic network. This means that the signaling messages can take different paths than the traffic connection to reach the destination. To avoid confusion, a label is included in every message. The label indicates the traffic connection to which the message belongs. No specific positions are reserved for a certain speech connection as it is for CAS. Whenever there is capacity free on the signaling channel, it can be used for signaling associated to any speech connection. This implies a more efficient use of the signaling channel.

CCS offers a number of advantages. It is a high capacity signaling method and large volumes of information can be transmitted. The set-up time is short implying that one signaling channel can handle signaling for up to 4096 traffic circuits, compared to 30 using CAS. The amount of equipment can be reduced because it is no longer necessary to allocate separate signaling equipment to each speech circuit.

If the signaling message takes the same path as the traffic connection, it is called associated signaling. In case the signaling messages and the traffic connection take different paths, it is called quasi-associated signaling. See Figure 4-4. There is always an alternative signaling path in case of failure or congestion.

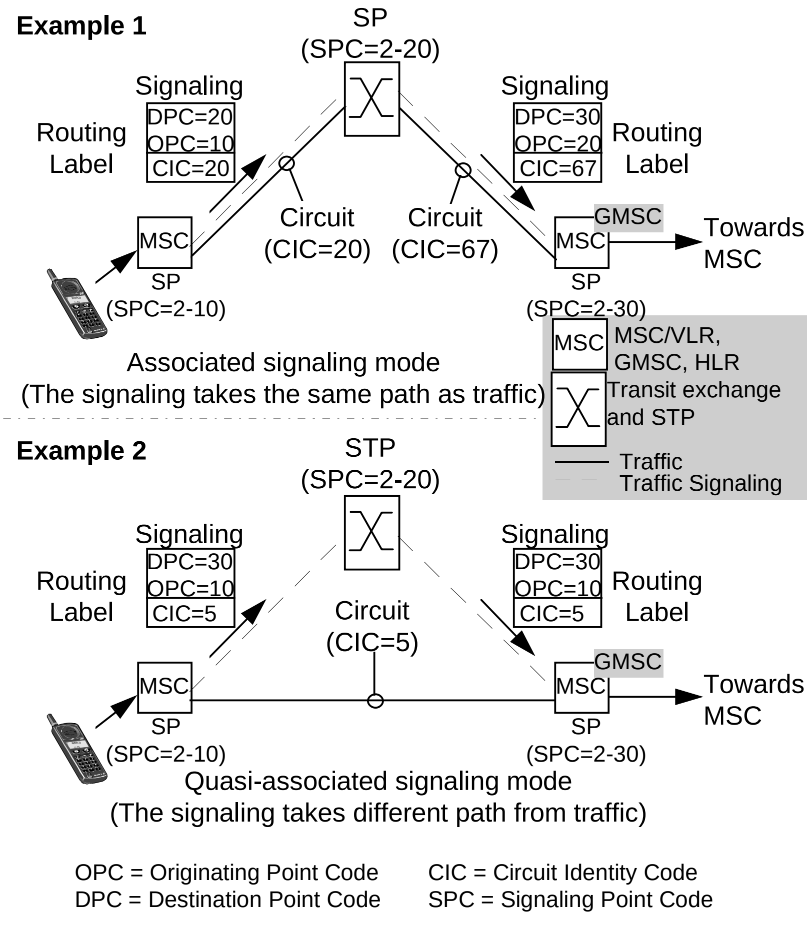

Figure 4-4 Different signaling modes using CCS.

GSM PROTOCOLS AND INTERFACES

DEFINITION

A protocol is an agreement on how to communicate.

INTERFACES

The interface between MSC and BSS is called the A interface, the interface between MSC and VLR the B interface, and the other interfaces are shown in Figure 4-5. Note that the B interface is an internal interface in Ericsson's GSM system because the MSC and the VLR are in the same unit. The A interface is divided into two parts:

- the A interface between MSC and BSC
- the Abis interface between BSC and BTS

The air interface between MS and BTS is called the Um interface.

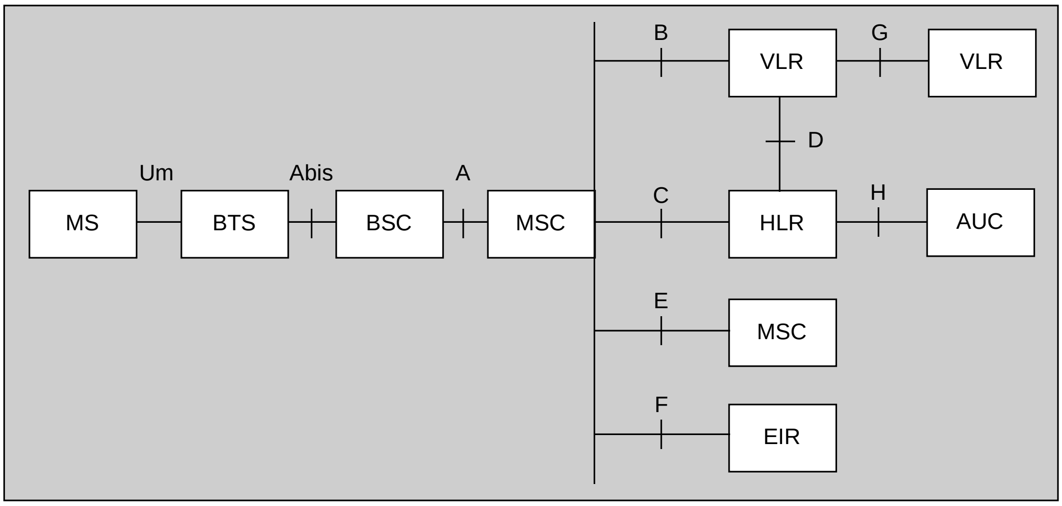

Figure 4-5 GSM interfaces.

PROTOCOLS

In parts of Ericsson's GSM system the ITU Common Channel Signaling System No. 7 (SS7) is used. SS7 has a layered structure with four levels. Figure 4-6 provides an overview of the different protocols used on the various interfaces.

MSC

In the stack on the right hand side of the MSC, (which is the interface to the VLR, HLR, GMSC and the PSTN), the MTP, SCCP, TCAP, MAP and ISDN–UP/TUP reside. Descriptions of these protocols are located in chapters 8, 9, 11, 12. MTP is used as a transport medium and for addressing and routing. It corresponds to layer 1, 2 and parts of layer 3 according to the OSI reference model. SCCP is added to SS7 signaling to keep the signaling model in line with the OSI model. SCCP adds functions for establishing logical connections and also for more extensive addressing and routing. MTP and SCCP together forms the Network Service Part (NSP) and correspond to layer 1-3 in the OSI model.

TCAP and MAP are both layer 7 protocols. TCAP provides functions to communicate with the far end of the signaling chain and to set up multiple dialogues. MAP is a protocol specially designed for mobile communication. It is used for signaling with databases (HLR, VLR, EIR, AUC), for short messages, and for certain signaling messages during a inter MSC handover.

ISDN-UP and TUP correspond to part of OSI layer 3 up to layer 7 (see Figure 4-7) and are used between the MSC and the ISDN/PSTN for call set-up and call supervision.

Note, that in the communication between MSC, BSS and MS only three layers are used.

A interface

Signaling over the A interface, or, between the switching system and the base station system, is done according to the BSSAP (see chapter 10) using the network service part of SS7 for transmission.

Towards the radio interface and the MS, layer 3 is divided into three sub layers:

- Radio Resource management (RR)
- Mobility Management (MM)
- Connection Management (CM).

These sub layers are explained in chapter 6. At this point it is sufficient to note that the CM and MM layers reside in the MSC, and a major part of the RR layer resides in the BSC.

Instead of using ISDN–UP messages towards the MS, these messages are converted into CM messages. As these messages are unique to this environment, they can be more specialized and hence more effectively coded. The conversion from ISDN–UP to CM is performed in the MSC, as well as the conversion between MAP messages and MM messages. Call control messages (within CM) such as registration of supplementary services are also mapped onto a MAP message in the MSC.

The protocol used to transfer the CM and MM messages is the BSSAP. This protocol is also used for direct control of the BSS, for example when the MSC asks for a channel to be allocated by the BSC. BSSAP uses the MTP and the SCCP protocol.

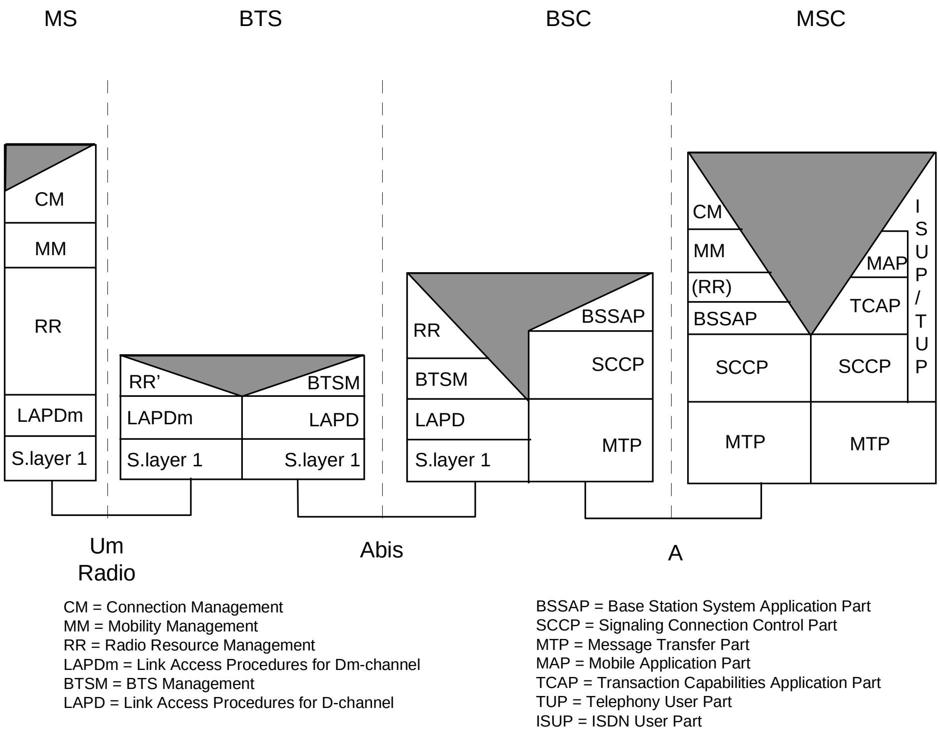

Figure 4-6 Signaling model.

Abis interface

Abis is the interface between the BSC and BTS. The protocol used at layer 2 on Abis is the LAPD (see chapter 7). This is an ISDN protocol and is therefore not described in the GSM recommendations. LAPD has functions for error detection and correction, as well as for frame delimitation. That is, insertion of flags at the beginning and end of a frame.

At layer 3 most messages, including RR messages, pass the BTS transparently. However, some RR messages are closely related to the radio equipment and must be handled by the BTS. The BTS Management (BTSM) entities manage these messages. A conversion to the relevant RR messages is carried out in the BTS. An example of an RR message is the ciphering message, where the cipher key is only sent to the BTS and not to the MS.

Um interface

Layer 2 protocol on Um is called LAPDm (see chapter 6) and is a modified LAPD protocol. The difference between LAPD and LAPDm is that the error correction and detection on Um is a layer 1 function, meaning that these functions are removed from the LAPDm protocol. Another difference is that the message frames on LAPD can be much longer than the frames on LAPDm, as the LAPDm frames must fit into the bursts.

RELATIONSHIP BETWEEN SS7 AND THE OSI MODEL

Layers 1-3 comprise functions for the transportation of information from one location to another, possibly via a number of communication links in tandem. These functions provide the basis on which a communication network can be built. The SCCP together with MTP provide OSI layers 1-3 services.

Layers 4-7 define functions relating to end-to-end communication. These layers are independent of the internal structure of the communication network. Transaction Capabilities provide layers 4-7 services.

Layer 7 represents the semantics of communication, whereas layers 1-6 comprise the means by which the communication may be realized. Application Entities (AE) provide application layers protocols in layer 7.

Figure 4-7 shows how the 4 levels in SS7 relate to the 7 layers in the OSI model. More information about specific SS7 protocols is located in chapters 8, 9, 11 and 12.

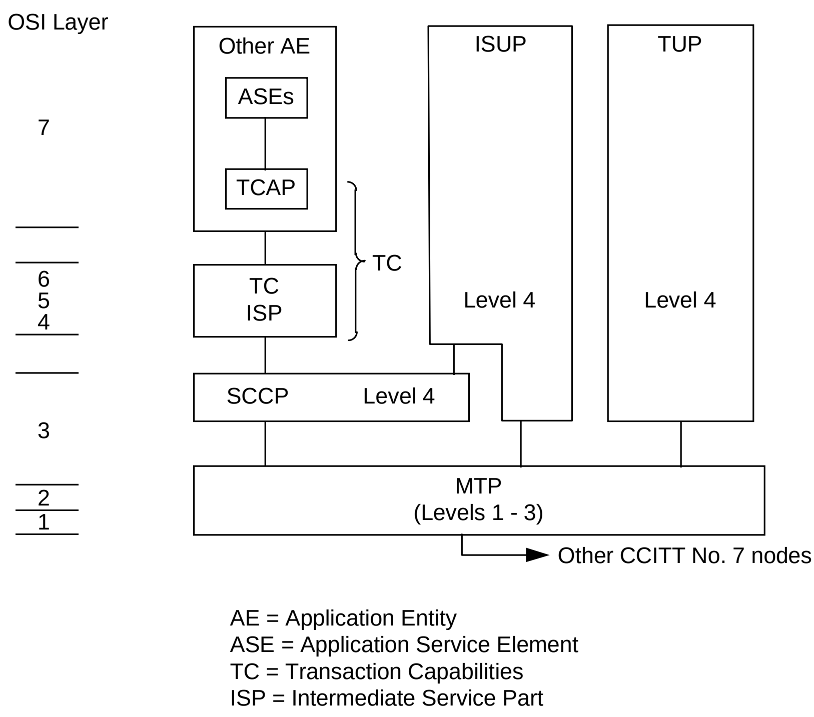

Figure 4-7 Relationship between SS7 functional levels and OSI layering.

The functional view of a SS7 network with a Signaling Transfer Point (STP) included is shown in Figure 4-8. The STP may contain MTP only, in which case no translation of the address is to be performed in the intermediate node.

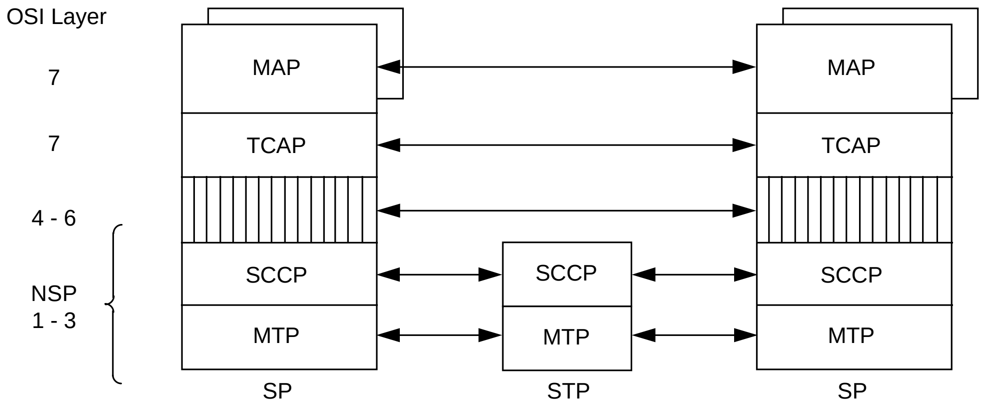

Figure 4-8 Functional view of a SS7 signaling network.