

## SIGNALLING TECHNIQUES

Signalling systems link the variety of switching systems, transmission systems and subscriber equipment's in a telecommunication network to enable the network to function as a whole. Three forms of signaling are involved in telecommunication network:

1. Subscriber loop signaling
2. Intraexchange or register signaling
3. Intraexchange or interregister signaling

Subscriber loop signaling depends upon the type of telephone instrument used. Multifrequency signaling has brought about new services like data in-voice answer, which fall in the class of user to user signaling facilities.

Intraexchange signaling is internal to the switching system and is heavily dependent upon the type and design of a switching system. It varies from one model to another even with the same manufacturer. When inter exchange signaling takes place between exchanges with common control subsystems and is called interregister signaling. In this main purpose is the exchange of address digits which pass from exchange to exchange on a link by link basis. Network wide signaling also involves end to end signaling between originating exchange and terminating exchange and that form is called line signaling.

Signalling techniques falls under two broad classes:

- (1) Inchannel signaling
- (2) Common channel signaling

### INCHANNEL SIGNALING

The rang of CCITT specified in-channel signaling systems reflects the evolution of international signaling requirements to meet the continually changing condition of the international network. The CCITT in-channel signaling systems and the signaling techniques used in each of them along with the envisaged applications are presented. The early systems, SS1, SS2 and SS3 are of historical interest only. At present, interest in the international inchannel signaling is confined to SS4, SS5 and SS5 bits and in the regional systems to R1 and R2. The other signaling system of the interest is the PCM signaling. The international signaling systems SS4, SS5 and SS5 bits adopt in-band signaling using a combination of two voice band frequencies or a single voice frequency. In additional system SS5 and SS5 bits use multi frequency (MF) signaling for interregister signaling. In SS4 there is no separate interregister signaling.

In SS5 the line signalling comprises either a compound of the two VF frequency or a continuous single frequency. Interregister signalling used 2 out of 6 MF code. Initially the system was jointly developed by UK office and the Bell laboratories for dialing over time assigned speech international (TASI) equipped transatlantic cables. This was the first application of intercontinental dialing and of TASI equipment. The system was subsequently specified by the CCITT as a standard in 1964 and has since found increasing application on other parts of the world.

In TASI each channel is equipped with a speech detector which on detecting speech arranges for a circuit to be assigned to that channel. Since this process of speech detection and establishment of trunk channel association takes definite time the speech burst is clipped for that duration. Typical clip duration is about 15ms when a channel is available. It increases under busy traffic conditions when a free channel may not be available immediately. In order to reduce the extent of interpolation a circuit is not disassociated from the channel for short gaps of speech. For this purpose the speech detector are provided with a short hangover time and a circuit is disconnected only when the speech gap is longer than the detector hangover time. The digital counterpart of TASI is known as digital speech interpolation (DSI)

As with speech burst in-channel signalling information also experiences clipping in a TASI environment. This calls for special consideration in designed signalling system for TASI environment. Unless signals are of sufficient duration to permit trunk channel association and reliable recognition at the receiving end there is the like hood of the signal being lost partially or fully. With pulse signalling it has been determined that a 500ms duration is required to account for the extreme trunk channel association condition. Allowing for reliable recognition a pulse of  $850 \pm 200$ ms duration is considered suitable. But pulse signal of such length would slow down the signalling process considerably. The pulse gapes would result in the channel being disassociation thus leading to unnecessary TASI activity. Moreover fixed length pulses cannot take advantage of lightly loaded condition when the channel assignment time is slow

Interregister signalling carrying address information would be far too slow if continuous compelled signalling is adopted. Pulse signalling is preferred here and two different techniques are used to maintain trunk channel association during the signalling period:

1. The address information transmitted en bloc after gathering all the address digits and the gaps between the pulses are ensured to be less than the speech detector hangover time.
2. Address digits are transmitted as and when they arrive and a lock tone is transmitted during the gaps.

The SS5 adopts en bloc transmission scheme whereas SS5 bits uses the lock tone method. The en bloc method facilitates checking of the validity of the address by digital count and avoids expensive intercontinental circuits being ineffectively taken during incomplete dialing. However this method increases the post dialing delay because the digital are accumulated before the signalling begins. The lock tone method permits overlapped operation of digits received and transmitted. It reduces the post dialing delay. The trunk however is not used as efficiently as in en bloc transmission.

The CCITT R2 signalling system combines an out-band line signalling system and an interregister MF signalling system. Conceptually out-band signalling includes D.C low frequency A.C in slot PCM and signalling above the effective speech band. But in practice the term out-band is applied to system based on A.C signalling using frequency above the upper

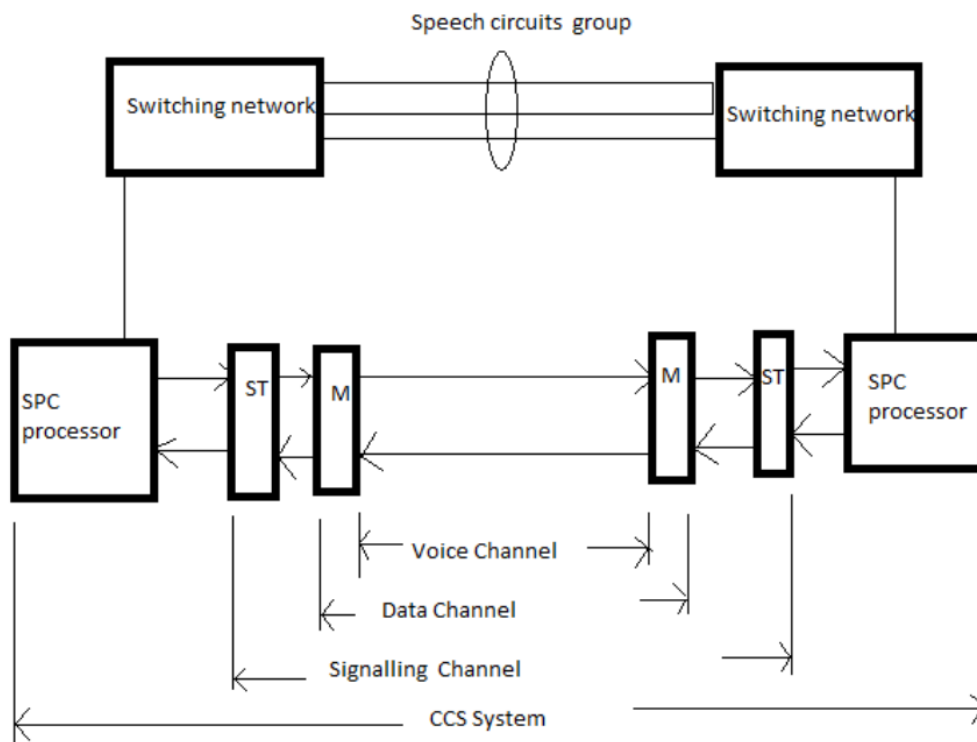
frequency limit of the effective speech band i.e. above 3400 Hz and within the 4 KHz speech channel spacing. Out-band signalling is generally performed only in the FDM transmission environment.

In FDM system incorporating out-band signalling the channel bandwidth is divided into a speech sub-channel and a signalling sub-channel using suitable filters. Usually a single frequency signalling is used. A 4 wire circuit is used for forward and backward signalling paths and for full duplex operation. The frequency is chosen to lie approximately midway between two adjacent channels and the CCITT recommends 3825Hz.

As the signalling frequency must not be extended to the switching equipment out-band signalling is done on link by link basis and end to end signalling is precluded. Since the signalling is independent of speech there is virtually complete freedom in the choice of signalling mode. Signalling may be two states (on/off) continuous tone or pulse signalling. The former is simple to implement but its potential to support a large signal repertoire is limited/ moreover the signal level must be relatively low to avoid overloading of transmission system. A higher level is permissible with pulse signalling and a large signal repertoire can be supported.

**Common Channel Signalling:**

In CCS, signalling is completely separate from switching and speech and in this case signalling is done over a channel that is different from the one which carries the voice or data. Here separate analog voice channel is used for signaling.



**Fig. 36: Basic scheme of CCS [1]**

In the above fig.32, two signalling channels, one for each direction, are used in a dedicated manner to carry signalling information. Since the channels are dedicated for signalling they are

capable of carrying signalling information for a group of circuits. A phase-equalized voice channel is capable of supporting a bit rate of 2.4 k bps with acceptable error rates for signalling. At this bit rate, one CCS link can carry signals for 1500-2000 speech circuits.

The CCS network is basically a **store and forward (S&F) network** where signalling information travels on a link-by-link basic along the route. When the signalling information is received at a node, it is stored, processed and forwarded to the next node in the route.

In CCS, signalling information is transferred as message of varying length usually defined as one or more fixed length is called single units(SUs).A message of one signal unit length is called **single unit message(SUM)** and one with multiple signal units as **multiunit message(MUM)**.

Header	Signalling information	Circuit label	Error check
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(a) Signal Unit Message

Header	Signalling information	Circuit label	Error check
Sub Header	Length	Other signalling information	Error check
Sub Header	Length	Address digits	Error check

(b) Three unit message

**Fig.37: Typical CCS signalling message formats [1]**

There are three types of signalling units (SUs) defined in SS7:

1. Message signal unit(MSU)
2. Link status signal unit(LSSU)
3. Fill-in signal unit(FISU)

All the SUs begin and end with flag field which has the unique bit pattern 01111110. The flags act as delimiters for the SUs. A common flag may be used as the closing flag for one SU and the opening flag for the next if the SUs are transmitted in continuum.

A bit stuffing technique is used inside SU to avoid destroying synchronization problem. In this technique, the transmitter inserts an extra 0 whenever it comes across five consecutive 1's in the data part of SU. The receiver on detecting five 1's deletes the zero following it. Thus only the flag pattern can contain six 1's.

All the SUs in SS7 contain a 16bit error checking field. Cyclic redundancy code (CRC) is used for error checking.

The control field consists of five subfields (i) the backward sequence number(BSN) and the backward indicator (BI) bit together permit piggybacked acknowledgment of the SUs received from the other side. The negative acknowledgment is indicated by inverting the BI bit which remains unchanged for all subsequent positive acknowledgments. The forward sequence number (FSN) identifies the SU uniquely using modulo 128 counts. A retransmission is indicated by inverting the forward indicator (FI) bit which remains unchanged until another retransmission occurs. A value of 0 indicates a FISU, a value of 1 implies a LSSU and a value of 3 to 63 specifies a MSU.

The level 3 signalling network functions relate to message handling and network management. Message handling involves **discrimination, routing and distribution of messages**. The discrimination function analyses the destination code in the address label to decide whether a message is to be routed to another node or distributed to one of the user parts in the local destination node is decided based on an analysis of the type of message information in the SER field. The discrimination function is needed only in STPs.

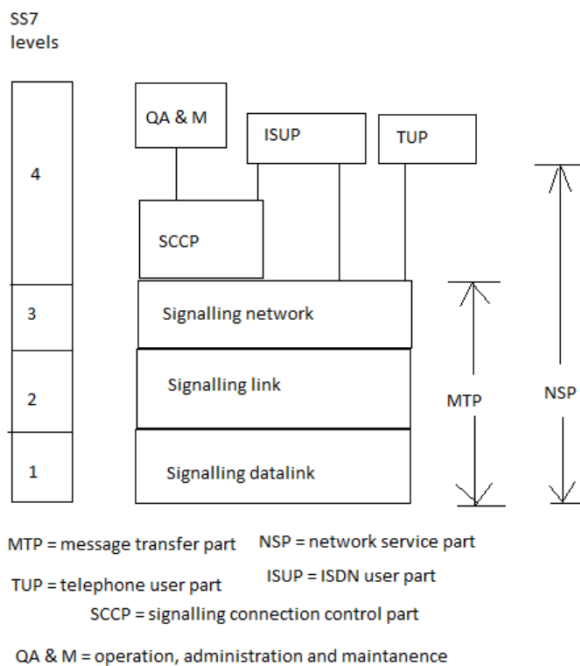
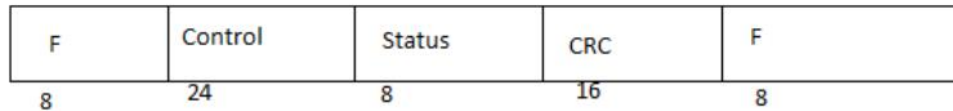


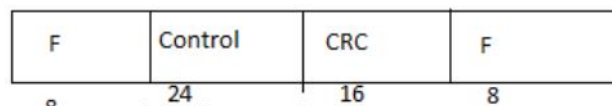
Fig.38: Architecture of SS7 [1]



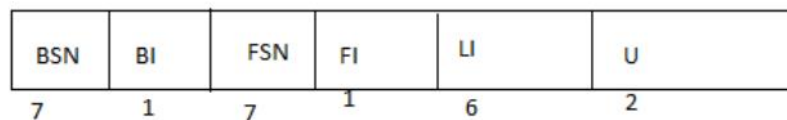
(a) message signal unit



(b) link status signal unit



(c) Fill-in signal unit



(d) Control subfields

F = Flag    CRC = cyclic redundancy code    SIF = signalling information    SER = service information field  
 BI = backward indicator    BSN = backward sequence number    sequence number    LI = length indicator  
 FI = forward indicator    U = unused

**Fig.39: Formats of signalling units [1]**

## OSI MODEL

The Open System Inter connection (OSI) model was developed by the International organization for standardization (ISO). The ISO developed OSI for networking. An open system is a set of protocols that allows two computers to communicate with each other regardless of their design, manufacturer or CPU type. Open system architectures are flexible structures set into fixed frameworks. The concept of an open system approach to networking allows any device or system operating with any protocol to communicate with another device or system using its own protocol. The OSI model defines seven distinct levels in its communication model. In the following paragraphs all this levels are explained in detail.

### OSI Network Architecture

The OSI model divides network communication into seven layers, with each layer performing specific tasks. Each level has a set of specifications and functions that it performs. Any number of communications protocols can operate within a specified level. Related header, trailer information, error detection capabilities and other overhead type are added to the message. The entire message with its overhead denoted as payload. The pay load is then encapsulated into the data portion of the next layer's message format and transported using that level's protocol rules. In the table 3 shown, the specification/functions of the layer are given briefly.

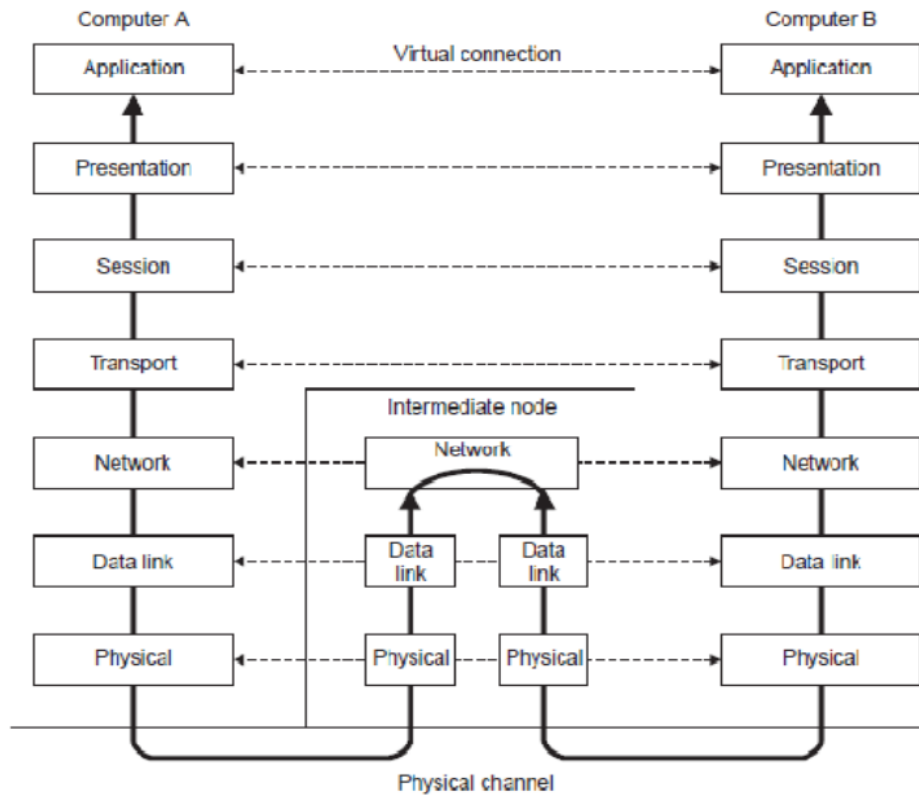
The detailed explanation of each layer is given in the following sections.

LAYER	SPECIFICATIONS
7	<b>APPLICATION LAYER:</b> Performs information processing such as file transfer, e-mail and teletext. Detailed and application specific information about data being exchanged.
6	<b>PRESENTATION LAYER:</b> Defines the format of data to be sent : ASCII, data encryption, data compression and EBCDIC.
5	<b>SESSION LAYER:</b> Management of connections between programs. Sets up a session between two applications by determining the type of communication such as duplex, half duplex, synchronization etc.
4	<b>Transport layer:</b> Delivery of sequence of packets. Ensures data gets to destination. Manages error control, flow control and quality of service.
3	<b>NETWORK LAYER:</b> Format of individual data packets. Sets up connection, disconnects connection, provides routing and multiplexing.
2	<b>DATA LINK LAYER:</b> Manages framing, error detection, and retransmission of message. Access to and control of transmission medium.
1	<b>PHYSICAL LAYER:</b> Medium and signal formed of raw bit information. Electrical interface (type of signal), Mechanical interface (type of connector), converts electrical signal to bits, transmits and receives electrical signals.

The seven layers of OSI are grouped into three layers. The layer 1, 2 and 3 are called network support layers. The layers 5, 6 and 7 are called support layers and layer 4 is transport layer.

Let computer A sends a data stream of bits to computer B. Communication must move from higher layer down through the lower layers on computer A. Each layer in sending machine adds its own information to the message. In receiving computer B, communication must move from lower layer up through the higher layers. At the receiving machine, the message is unwrapped layer by layer.

**PHYSICAL LAYER.** The physical layer is the lowest layer of the OSI model. It defines the mechanical, electrical, functional and procedural aspects of the physical link between networks. Physical layer standards have been widely used for years in point-to-point wide area network applications. (CCITT/ITU has established X-21–X-24 to specify the functions at the physical level of the based circuits. Numerous other standards such as EIA-232 and V-21– V-34 are widely used for various purpose at the physical layers. The physical layer implements an unreliable bit link. A link consists of a transmitter, a receiver and a medium over which signals are propagated. The physical layer data consists of stream bits. The physical layer defines the type of encoding to convert the bit stream into electrical or optical signal to transmit in the medium. At receiver the physical layer converts back into bit stream. The receiver must be in synchronism with transmitter to receive the specific bit pattern. To assist synchronization, the physical layer adds a specific bit pattern called preamble at the beginning of the packet.



**Fig.49: OSI Network architecture [1]**

**DATA LINK LAYER.**The data link layer defines the frame format such as start of frame, end of frame, size of frame and type of transmission. The principal service provided by the data link layer to higher layer is that of error detection and control. This layer is the first software protocol layer of the OSI model. It specifies the data format, sequence, and acknowledgement process and error detection methods. The data link layer accepts information from the network layer and breaks the information into frames. It then adds the destination address, source address, frame

check sequence (FCS) field and length field to each frame and passes each frame to the physical layer for transmission on the receiving side, the data link layer accepts the bits from the physical layer and from them into frame, performing error detection. If the frame is free of error, the data link layer passes the frame up to the network layer. It performs frame synchronization, that is, it identifies the beginning and end of each frame. Existing protocols for the data link layer are :

- 1. Synchronous Data Link Control (SDLC).**Developed by IBM as link access for System Network Architecture.
- 2. High Level Data Link Control (HDLC).**It is a version of SDLC modified by the ISO for use in the OSI model.
- 3. Link Access Procedure Balanced (LAPB).**The modified version of HDLC is LAPB.

The data link layer also performs the flow control and access control. By flow control, if the rate at which the data are absorbed by the receiver is less than the rate produced in the sender, the data link layer imposes a flow control mechanism to prevent overwhelming the receiver. By access control, when two or more devices are connected to the same link, the protocol of data link layer determines which device has control over the link at any given time. Two sub layers defined in the data link are the media access control (MAC) and the logical link control (LLC) layer. MAC performs address management function. LLC manages flow and error control, automatic requests for retransmission (APQ) and handshake processes

**NETWORK LAYER.** If two systems are attached to different networks (links) with connecting devices between the networks (links), there is often a need for the network layer to accomplish source to destination delivery. Thus the function of the network layer is to perform routing. The network layer checks the logical address of each frame and forwards the frame to the next router based on a look up table. The network layer is responsible for translating each logic address (name address) to a physical address (MAC address).

### **TRANSPORT LAYER**

The transport layer provides a mechanism for the exchange of data between end systems. It optimizes the use of network services with providing a requested quality of service to session entities. The size and complexity of a transport protocol depend on how reliable or unreliable the underlying network and network layer services are. Essentially, this layer is responsible for the reliable data transfer between two end nodes and is sometimes referred to as host-tohost layer.

### **SUPPORT LAYERS**

The session layer, presentation layer and application layer are considered as support layers. All these layers explained in the following paragraphs.

**SESSION LAYER.** The session layer establishes a logical connection between the applications of two computers that are communicating with each other. The session layer concerns file management and overall networking functions. Access availability and system time allocations are included in this layer. The session layer can partition a transfer of a large number of messages by inserting synchronous points. Specific responsibilities of the session layers are authentication of user access, fault recovery if a break in service occurs, permitting multiple applications to share a virtual circuit, connection and disconnection of any node from the network.

**PRESENTATION LAYER.** The presentation layer receives information from the application layer and converts into ASCII or Unicode or encrypts or decrypts. This layer is concerned with the syntax and semantics of the information exchanged between two systems.

The three basic forms of protocols used in the presentation layer are

1. Virtual terminal protocol, which is used to allow different types of terminals to support different applications.

2. Virtual file protocol, which handles code conversions' within files, file communication and file formatting.

3. Job transfer and manipulating protocols which controls the structure of jobs and records.

A separate protocol function known as abstract syntax notation (ASN) specifies file datastructure.

**APPLICATION LAYER.** This layer enables users to access the network with applications such as e-mail, FTP and Telnet. It provides user interfaces and support for various services. Specific services are (a) Network virtual terminal (b) File transfer access and management (FTAM), (c) Mail services (d) Directory services (e) Specific User Service Element (SUSE) — deals with actual user requirements for access and use of the network (f) Common application service element (CASE) — This sets guidelines for the applications required quality of service and (g) Specific application service element (SASE) — deals with large amount of data, including database access.

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