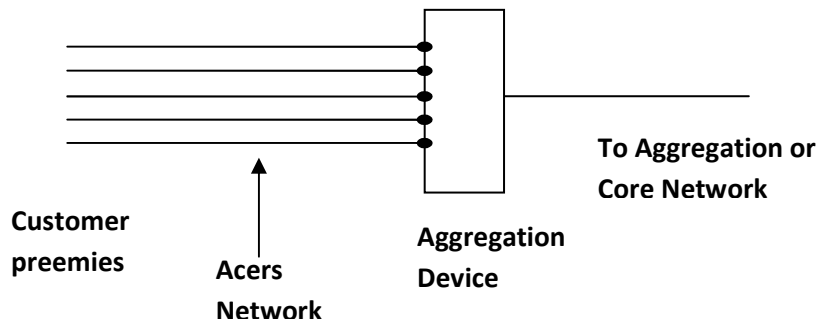


The Access network is connected to the Aggregation devices such as DSLAM or MSAN



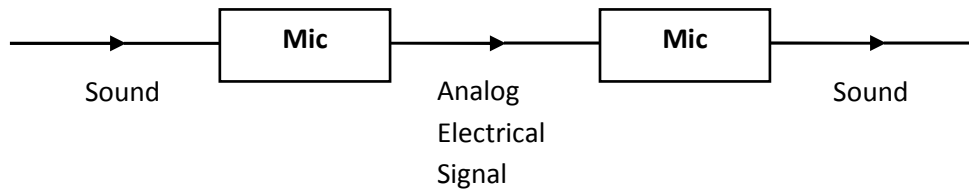
DSLAM

MSAN

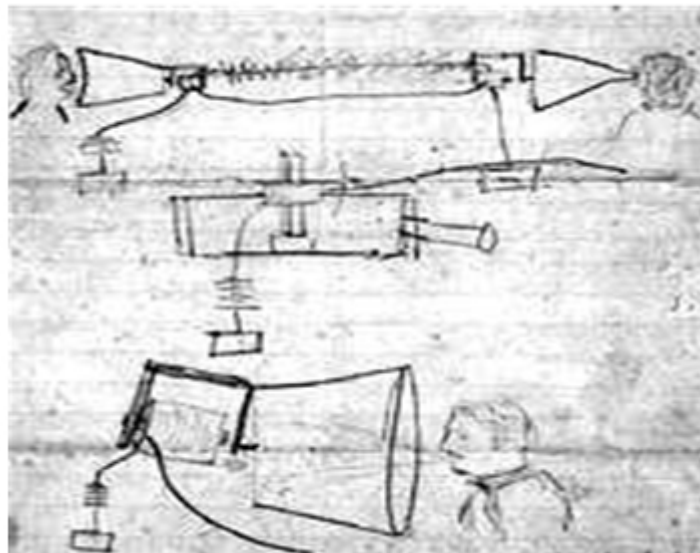
6. Public Switched Telephone Network

6.1 Invention of Telephone

Sir Alexander Graham Bell invented the telephone in 1876. His Concept is gives below.

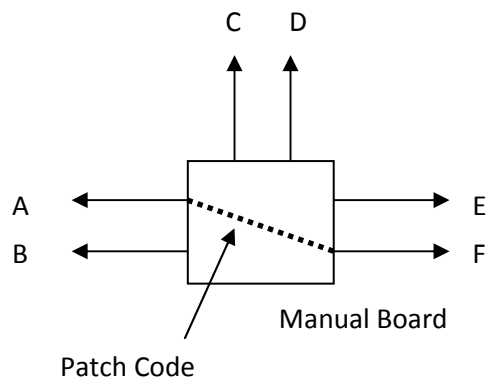


Bell Sketch of Telephone



6.2 Manual Board

Initially the telephone was commercially used by the Manual Board



The Manual board concept is shown in the figure..... . All telephones are physically connected to manual board by a pair of copper cables. If A wants to call F, they are connected by the operator by using a patch code.

Switch board or manual board was developed where upon lifting the telephone receiver by a subscriber, the operator was alerted by using a lighting bulb and subscriber tell her who you wished to speak to. Then operator would take a wire cored (Patch cored) and plug to the subscriber A socket and the other end to subscriber F socket and send a ringing tone to him. When they completed the call, either party is hang up receiver and operator can detected it by lighting off the bulb.

The operator takes down the following information

- Calling number
- Called number

- Starting time
- Ending time

A telephone bill is prepared for each month based on these information.

The following are the important points to note on above process.

- a. Maintain subscriber information
- b. Identity when subscriber needs to get a call
- c. Connect the two subscribers need to communicate
- d. Send the ringing tone to called subscriber
- e. Identify when the conversation is over
- f. Terminate the connection when the conversation is over
- g. Take down the billing information

The above seven Functions can be categorized

- Subscriber & billing information - a, g
- Signaling - b, d, e
- Switching - c, f

Switching and Signaling plays a vital role in PSTN networks.

6.3 Switching

The PSTN Switching can be categorized and follows,

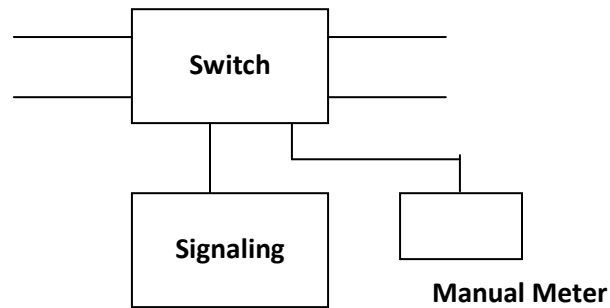
- a) Manual Switching
- b) Automatic Switching

The Automatic Switching can be categorized as,

- a) Electomechanical Switching
- b) Electronic Switching

The first automatic switch was developed by strowger and there was an electromechanical exchange (switch)

An automatic exchange should have the switching, signaling and billing.



- Signaling
 - Dial tone
 - Ringing Tone
 - Ring Back Tone
 - Busy Tone
 - Dialed Numbers
- Manual Meter - Rotary meter increments the units when call is started and in progress

6.4 Strowger Exchange

Human operators intelligent & flexible

- But expensive and not always discreet

Strowger invented automated switch in 1888

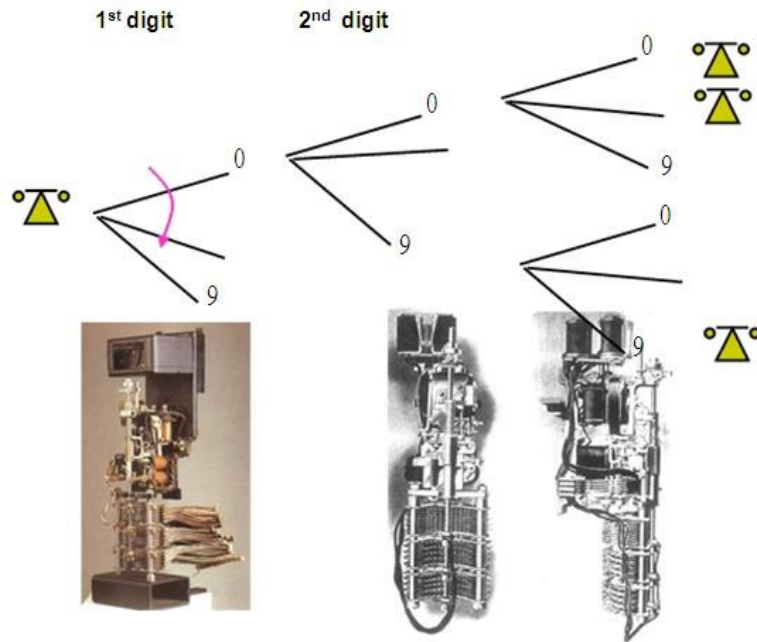
- Each current pulse advances wiper by 1 position

- User dialing controls connection setup

Decimal telephone numbering system

Hierarchical network structure simplifies routing

- Area code, exchange (CO), station number



Almon B. Strowger was an undertaker in Kansas City, USA. The story goes that there was a competing undertaker locally whose wife was an operator at the local (manual) telephone exchange. Whenever a caller asked to be put through to Strowger, calls were deliberately put through to his competitor. This obviously frustrated Strowger greatly and he set about devising a system for doing away with the human part of the equation !

Strowger developed a system of automatic switching using an electromechanical switch based around around electromagnets and pawls. With the help of his nephew (Walter S. Strowger) he produced a working model in 1888 (US Patent No. 447918 10/6/1891). In this selector, a moving wiper (with contacts on the end) moved up to and around a bank of many other contacts, making a connection with any one of them.

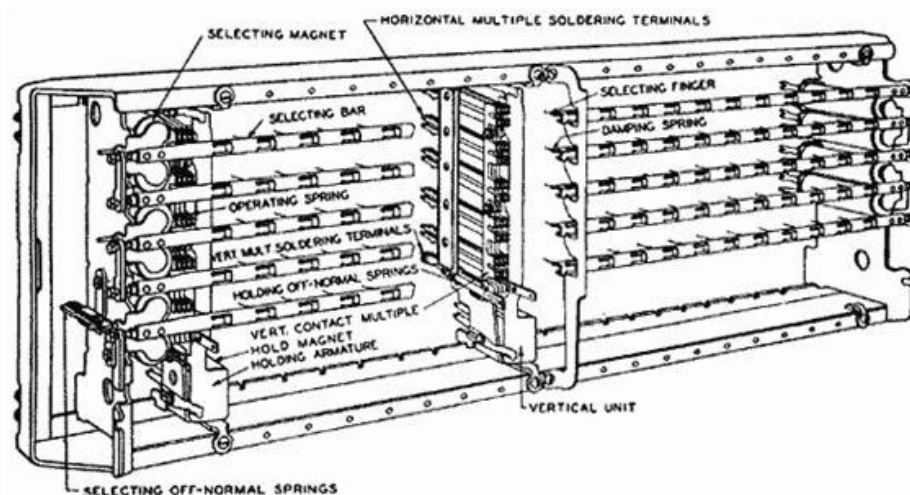
Strowger did not invent the idea of automatic switching; it was first invented in 1879 by Connolly & McTighe but Strowger was the first to put it to effective use. Together with Joseph

Strowger Automatic Telephone

Exchange©in October 1891.

In the late 1890 Almon B. Strowger retired and eventually died in 1902. In 1901, Joseph Harris licenced the Strowger selectors to the Automatic Electric Co. (AE); the two companies merged in 1908. The company still exists today as AG Communications Systems (www.agcs.com), having undergone various corporate changes and buyouts along the way.

6.5 Crossbar Exchange



crossbar switch is one of the principal architectures used to construct switches of many types. Originally the term was used literally, for a matrix switch controlled by a grid of crossing metal bars, and later was broadened to matrix switches in general. Crossbar switches are sometimes referred to as "cross-point switches," "crosspoint switches," or "matrix switches." The other principal switch architectures are that of a memory switch or a crossover switch.

Historically, a Crossbar switch consisted of metal bars allocated with each input and output, controlling movable contacts at each cross point.

6.6 Electronic Switching

Research on electronic Switching started soon after the Second World War II, but commercial fully electronic exchanges began to emerge only about 30 years later.

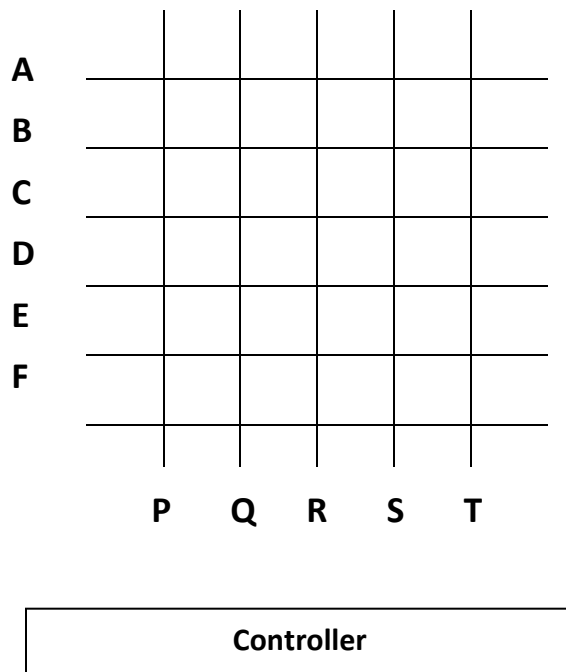
Advances made in Computer technology were incorporated and led to the development of stored-Program, control (SPC). This enables a digital computer to be used as a centre control and perform different functions with the same hardware by executing different programs.

SPC exchanges were introduced on small scale in the 1960's and on a large scale in 1970's and SPC completely took over the industry in 1980's.

Electronic Switching can be done in two different methods.

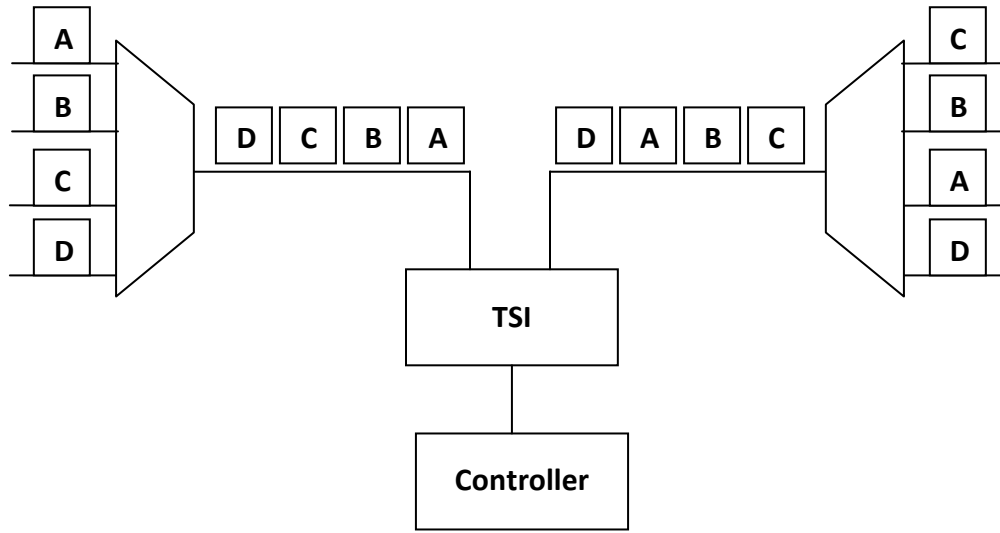
- 1) By using hardware – this is called Space Switching.
- 2) By using multiplexing – this is called Time Switching.

6.6.1 Space Switching

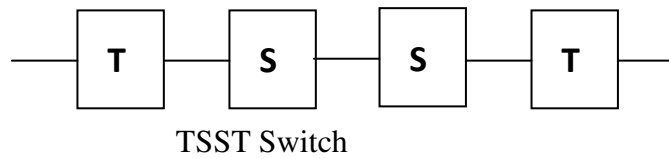
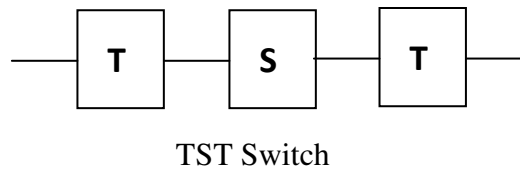


If 'A' needs to get a call to 'P' the AND gate connecting A and P is activated (enabled) by giving C '1' from controller. The signal comes from A is going to P. This type of Switching is called "Space Switching".

6.6.2 Time Switching

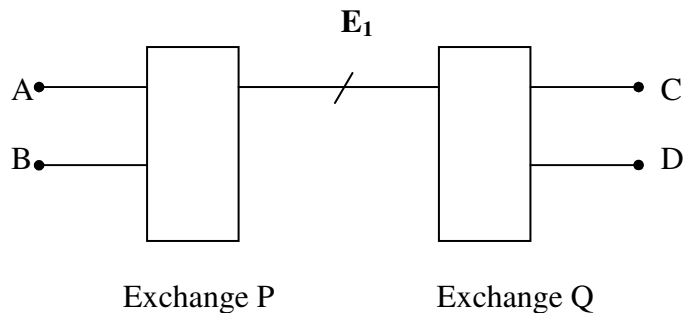


6.6.3 Time & Space Switching



An electronic exchange has a combination of Time Switches and Space switches as shown in Fig..... In general this is called “Circuit Switching”.

In digital (electronic) exchanges the analog signals coming from a telephone is converted to a digital signal by using “PCM”



A and B are subscribers connected to the same exchange. If A needs to call B, the exchange P, switch A to B.

Normally the primary multiplexing is done in the exchange and the output of the exchange is E1. The exchange P is connected to exchange Q. Each channel is allocated a one Time Slot. One Channel is called a trunk.

If A needs to call C one TS is allocated from the E1 connected to exchange P and Q. If A sends any voice to C it is immediately comes to C via exchanges P and Q. This type of connection is called a real time connection.

One Time Slot is equivalent to 64kb/s. This is a fixed bit rate or bandwidth. Normally, for a telephone conversation 40% of the time of the channel (one direction) is utilized. That is, when A talks, C is silent and vice versa. Sometimes both are silent. Therefore the occupancy of the channel for one direction is about 40%. However in circuit switching, 100% of the time , a 64kb/s of bandwidth is allocated for one direction. This is some kind of wastage of bandwidth. In circuit Switching, the trunk bandwidth (Core network bandwidth) is not effectively utilized.

The circuit switching has a real time, dedicated bandwidth connection.

6.7 Signaling

In automatic exchanges, there should be a communication method between subscriber and exchange to setup a call and terminate a call.

When a subscriber needs to get a call, he off hook the receiver. Then he should know whether he has a live connection with exchange. If the dial tone gest it is a live connection.

Then he needs to inform the exchange that the telephone number of the subscriber he wants to call. This information is sent to the exchange by dialing the telephone.

Then the exchange find out a free trunk to other exchange and seize (reserve) it and send the dialed number to other exchange. The ringing tone is sent to called subscriber and ring back tone is sent to calling subscriber.

When the called subscriber off hook the receiver and billing should be started.

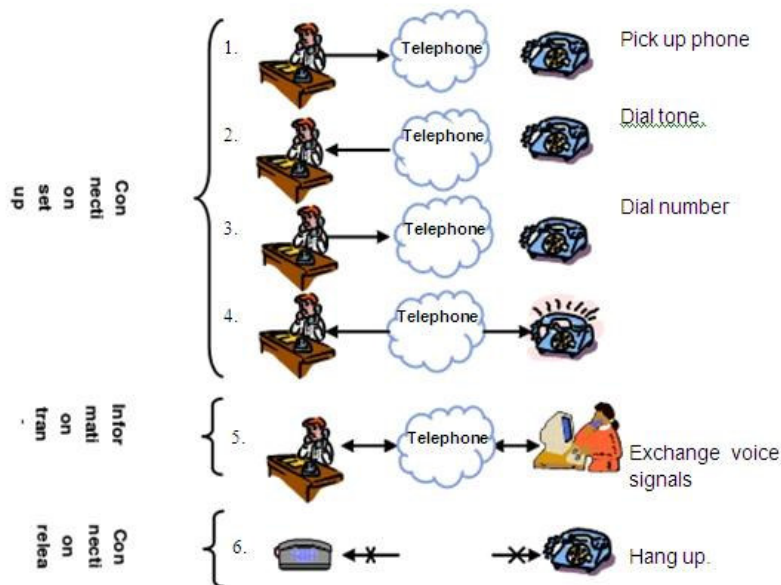
If is clear that before establishing a call some information is exchanged between subscriber and exchange or between the two exchanges. They are called “Control Signals” or normally called “Signals”. The process is called “Signaling”.

The Signaling uses for different purposes.

- Call establishment and call termination.
- Reservation of trunks (resources) – resource management.
- Routing managements.
- Network managements.

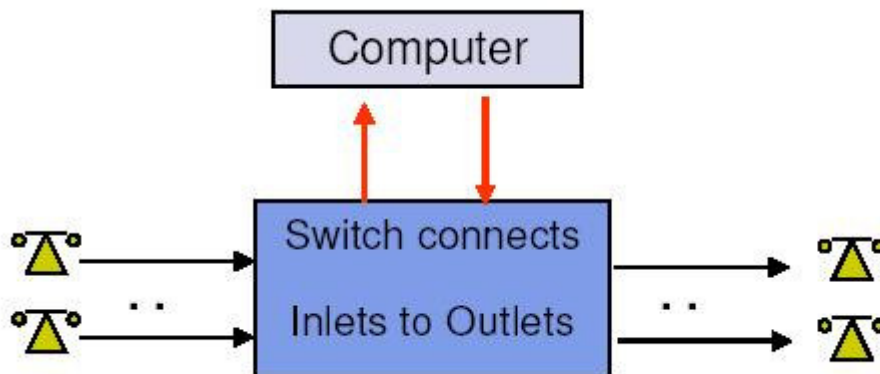
The signaling System developed along with exchange evolution and transmission evolution. The telecommunication signaling systems developed by ITU-T (former CCITT). The development of signaling system along with exchanges is given below.

Signaling system	Exchange Type
CCITT No.1	Manual switchboard
CCITT No.3	Electromechanical
CCITT No.5	Electronic exchange
CCITT No.7	Fully electronic exchanges (ISDN)

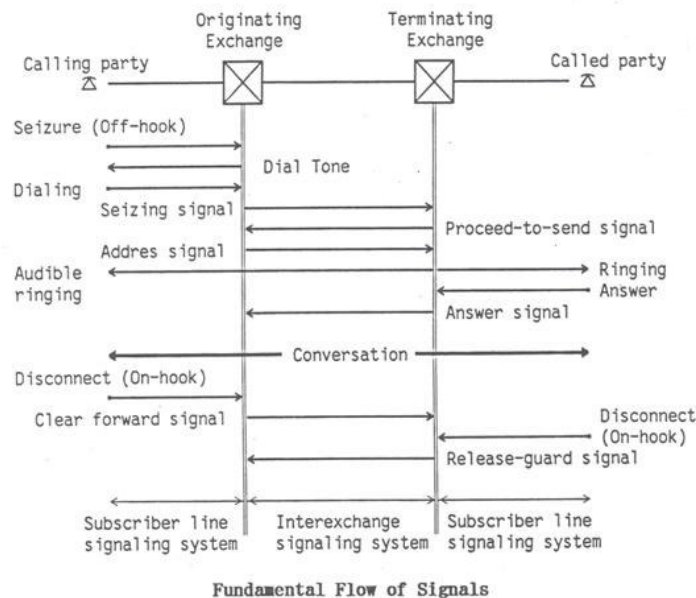


Computer Connection Control

- A computer controls connection in telephone switch
- Computers exchange *signaling messages* to:
 - Coordinate set up of telephone connections
 - To implement new services such as caller ID, voice mail, etc.
 - To enable *mobility and roaming in cellular networks*
- “Intelligence” inside the network
- A separate *signaling network* is required



6.7.1 Signaling flow to establish a call



The signaling between subscriber and exchange is called subscriber line signaling. Signaling among exchanges are called interexchange signaling.

Also the signals can be mainly categorize as supervisory signals and Address Signals.

Categories of Signals and Signaling Systems

Category	Subscriber line signaling	Interexchange signaling
Supervisory signal	Seizure signal, Clear-forward signal, Answer signal, Clear-back signal	Seizing signal, Answer signal Proceed-to-send signal, Clear-forward signal, Release-guard signal, Clear-back signal
Address signal	DP signal, PB signal	DP signal, MF signal
Audible signal	Dial tone, busy tone, Audible ringing tone	—
Ringing signal	Ringing signal	—
Metering signal	Coin collect signal (for payphone)	Metering pulse signal

6.8 Supervisory Signaling

Supervisory Signals supervise the process of connection establishment and termination. The forward Signals (From calling party to called party direction) are also called Control Signals. The backward Signals are called Pilot signals.

6.9 Address Signals

Address Signals are used to send the telephone number.

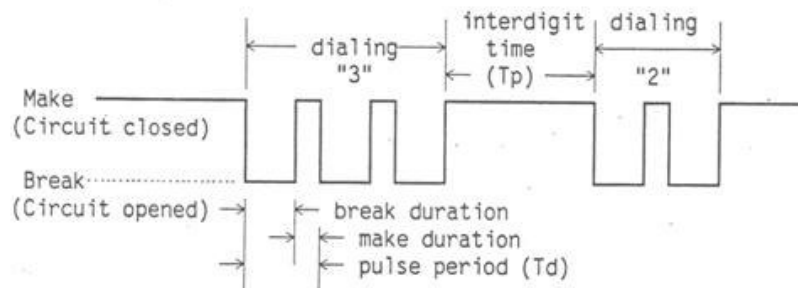
2.2 Address signal

Address signals are intended to identify where to connect the originating call, and to provide the necessary information for an exchange to select the routing and the called party. Consequently, the form of address signal affects both the connection time and the reliability of an exchange. Major categories and functions of address signals are as follow.

(1) DP (Dial Pulse) signal

A DP signal transmits the dialed number in the form of the number of the interruption of a direct loop current. A DP is used in the subscriber line signaling and the interexchange signaling. A DP signal has two transmission speeds--10 pulses per second (PPS) and 20 pps as shown in Fig. 2.2.

A DP signal has the advantage that it requires only a relatively simply constructed pulse generator and pulse receiver. A DP has a disadvantage in that it takes longer to send/receive the signal.



	Td	Tp
10PPS	1/10 sec	600ms ~ 2 sec
20PPS	1/20 sec	450ms ~ 2 sec

DP Signal

(2) PB (Push-Button) Signal

As shown in Table 2.1, a PB signal uses four higher frequencies and four lower frequencies of the speech frequency band. The signal indicates the dialed number by a combination of one frequency each of the higher and lower groups. This signal is used in the subscriber line signaling. A PB signal has the advantage that it only requires simple push-button operation and a short time to transmit the signal. It is, however, transmitted through the voice channel; and thus requires some measure to prevent voice malfunction.

(3) MF (Multifrequency) signal

An MF signal uses six frequencies of the speech frequency band and transmits a dialed number by a combination of two of the six frequencies as shown in Table 2.2. This signal is used in interexchange signaling. An MF signal is characterized by a high transmission speed of 7.5 to 10 numeric characters per second.

Codes KP and ST as shown in this Table are used as control information in transmitting numeric information.

PB Signal

Frequency		Higher group (Hz)		
		1209	1336	1477
Lower group (Hz)	697	1	2	3
	770	4	5	6
	852	7	8	9
	941	*	0	#

MF Signal

Code		0	1	2	4	7	K
Frequency (Hz)		700	900	1100	1300	1500	1700
Numeric information	1	o	o				
	2	o		o			
	3		o	o			
	4	o			o		
	5		o		o		
	6				o		
	7	o				o	
	8		o			o	
	9			o		o	
	0				o	o	
K P				o			o
S T			o				o

An MF Signal uses six frequencies of the speech frequency band and transmits a dialed number by a combination of two of six frequencies as shown in figure.....

ST is used as last destination and KP is used as Transit

6.10 Channel Associated Signaling.

Except CCITT No.7 signaling all others send the signals along with speech channel. This is called Channel Associated signaling.

CCITT No.5 uses the Time Slot 16 of PCM frame to transmit the supervising signals.

In the channel associated signaling address signals are transmitted in the form of DP signal or MF signal.

6.11 Common Channel Signaling

CCITT No.7 Signaling is a common channel signaling system. This was mainly designed to cater to ISDN networks.

C7 signaling has a separate network similar to a data network to transmit signals. This is a packet switching network and it is separated from the speech network (circuit switched network).

It has the following advantages,

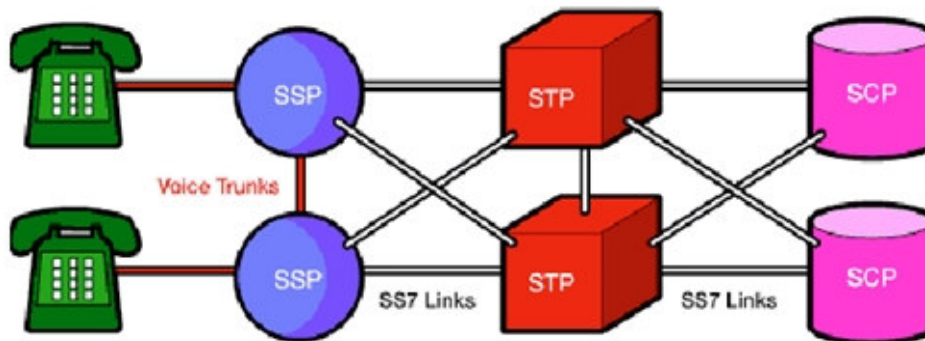
- High speed
- Signal Transmission during conversation
- A wide variety of signals and a large signaling capacity.
- Support for Intelligent Network (IN) Services.
- Support for data transmission
-

6.11.1 Signaling Points

Each element in the C7 signaling network is called a signaling point. Each signaling point is uniquely identified by a numeric point code.

There are three kinds of signaling points.

- Service Switching Point (SSP)
- Signal Transfer Point (STP)
- Service Control Point (SCP)



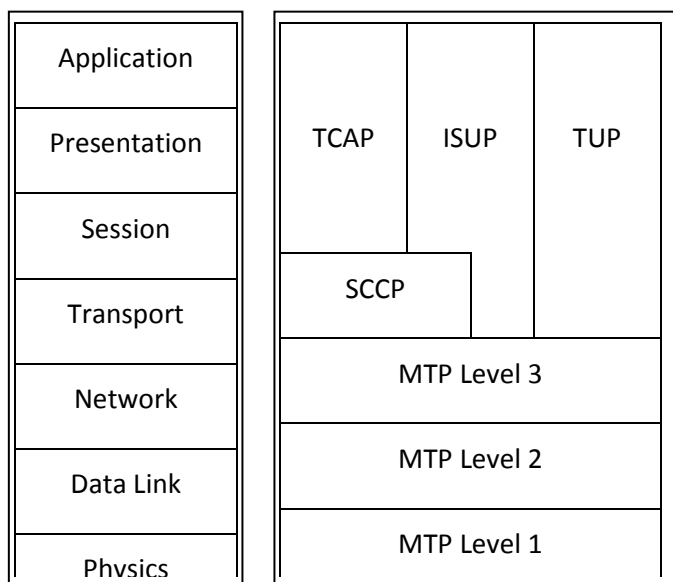
SSPs are switches that establish, terminate or transit calls. An SSP sends signaling messages to other SSPs to setup manage and release voice circuits required to complete a call.

STP is a packet switch. Network traffic between two signaling points may be routed via STP. An STP route each incoming message to an outgoing link based on routing information contained in the message.

The SCP is a centralized database which has the routing information on special numbers such as 800 series toll free numbers. An SSP may send a query message to SCP to determine how to route a special call. The SCP sends a response to the originating SSP containing the routing number (s) associated with the dialed number.

C7 Protocol Stack

The C7 protocol stack can be mapped to the query 7 layers.



Message Transfer Part

Message Transfer Part (MTP) is divided into three levels.

MTP Level 1 is equivalent to the OSI Physical Layer. MTP Level 1 defines the physical, electrical and functional characteristics of the digital signaling link. Physical interfaces defined include E-1 (2048 kb/s; 32 64 kb/s channels); DS-1 (1544 kb/s; 24 64 kb/s channels), DS-O (64 kb/s) and DS-OA (56kb/s).

MTP Level 2 ensures accurate end-to-end transmission of a message across a signaling link. Level 2 implements flow control, message sequence validation and error checking. When an error occurs on a signaling link, the message (or set of messages) is retransmitted. MTP Level 2 is equivalent to the OSI Data Link Layer.

MTP Level 3 provides message routing between signaling points in the SS7 network. MTP Level 3 re-routes traffic away from failed links and signaling points and controls traffic when congestion occurs. MTP Level 3 is equivalent to the OSI Network Layer.

ISDN User Part (ISUP)

The ISDN User Part (ISUP) defines the protocol used to set-up, manage and release trunk circuits that carry voice and data between terminating line exchanges (e.g., between a calling party and a called party). ISUP is used for both ISDN and non-ISDN calls. However, calls that originate and terminate at the same switch do not use ISUP signaling.

Telephone User Part (TUP)

Telephone User Part (TUP) is used to support basic call setup and tear-down. TUP handles analog circuits only.

Signaling Connection Control Part (SCCP)

SCCP provides connectionless and connection-oriented network services and global title translation (GTT) capabilities above MTP Level 3. A global title is an address (e.g., a dialed 800 number, calling card number or mobile subscriber identification number) that is translated by SCCP into a destination point code and subsystem number. A subsystem number uniquely identifies an application at the destination signaling point. SCCP is used as the transport layer for TCAP-based services.

Transaction Capabilities Applications Part (TCAP)

TCAP supports the exchange of non-circuit related data between applications across the SS7 network using the SCCP connectionless service. Queries and responses sent between SSPs and SCPs are carried in TCAP messages. For example, an SSP sends a TCAP query to determine the routing number associated with a dialed 800/888 number and to check the personal identification number (PIN) of a calling card user. In mobile networks (IS-41 and

GSM), TCAP carries Mobile Application Part (MAP) messages sent between mobile switches and databases to support user authentication, equipment identification