MODULE-4

TIME DIVISION SWITCHING: Introduction, space and time switching, Time switching networks, Synchronization. **SWITCHING SYSTEM SOFTWARE**: Introduction, Basic software architecture, Software architecture for level 1 to 3 control, Digital switching system software classification, Call models, and Software linkages during call, Feature flow diagram, and Feature interaction. [Text-1 and 2]

8 Hours

CHAPTER 1: TIME DIVISION SWITCHING

4.1 Introduction

The first application of digital time-division switching was to provide tandem switching of PCM (Pulse Code Modulation) junctions and trunk circuits. Examples of these systems are Bell ESS(Electronics Switching System) No.4 system and the French E 12 system.

Since a tandem exchange is similar to the route switch in a local exchange, local systems were developed by adding reed-relay space division concentrators .examples of such system include the initial version of System X and the AXE 10 and E 10 systems.

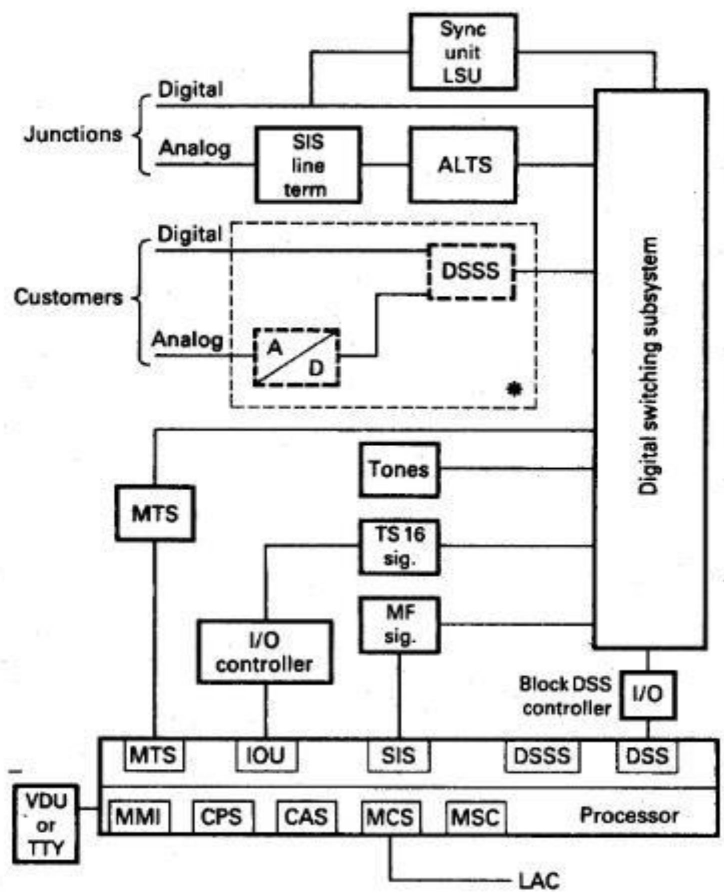

Figure 4.1 system X local exchange

The developments in the technology of solid-state integrated circuits eventually solved the BORSCHT problem and enabled TDM concentrators to replace space division concentrators. This is evolution of integrated digital network

Finally extension of digital transmission over customers' lines has enabled integrated-services digital network (ISDN). It provides the customer with a wide variety of services, based on 64 Kbits/sec digital transmissions, over a single line from a local exchange.

The architecture of a system X local exchange is shown in figure 5.1 the digital switching subsystem (DSS) corresponds to the route switch of Digital switch. The line terminating units of PCM junctions are connected to it directly. Voice-frequency junctions are connected to it directly. Voice-frequency junctions are connected via a signaling internetworking subsystem (SIS) and an analog line terminating subsystem (ALTS) that provides analog/digital and digital/analog conversions.

Analog and Digital customers' line are connected to the DSS via a concentrators, known as the digital subscribers; switching subsystem (DSSS). These concentrators may be in the main exchange or located remotely.

The processor utility subsystem uses software built largely from modules corresponding to the hardware subsystems that they control as shown in figure 4.1

The system has a capacity for 60,000 lines and 10,000 E of traffic. A tandem or trunk exchange uses a similar DSS, but it has no concentrators.

4.2 Space and time switching

4.2.1 General

A tandem switching centre, or the route switch of a local exchange, must be able to connect any channels on one of its incoming PCM highways to any channels of an outgoing PCM highway. A connection will occupy different time slots on the incoming and outgoing highways.

4.2.2 Space switches

Connections can be made between incoming and outgoing PCM highways by means of a cross point. However different channels of an incoming PCM frame may need to be switched by different cross points in order to reach different destinations. The cross point is therefore a two input AND gate. Thus the switching network must be able to receive PCM samples from one time slot and retransmit them in a different time slot. This is known as time switching.

Simple time division switching network make connections between channels on highways carrying a primary multiplex group, i.e. they operate at 1.5 M bits/sec or 2Mbits/sec. A2Mbits/sec line system has 32 timeslots. It uses 30 speech channels, time slot 0 is used for frame alignment and 16 for signaling. One input is connected to the incoming PCM highways and other to a connection store that produces a pulse at the required instants.

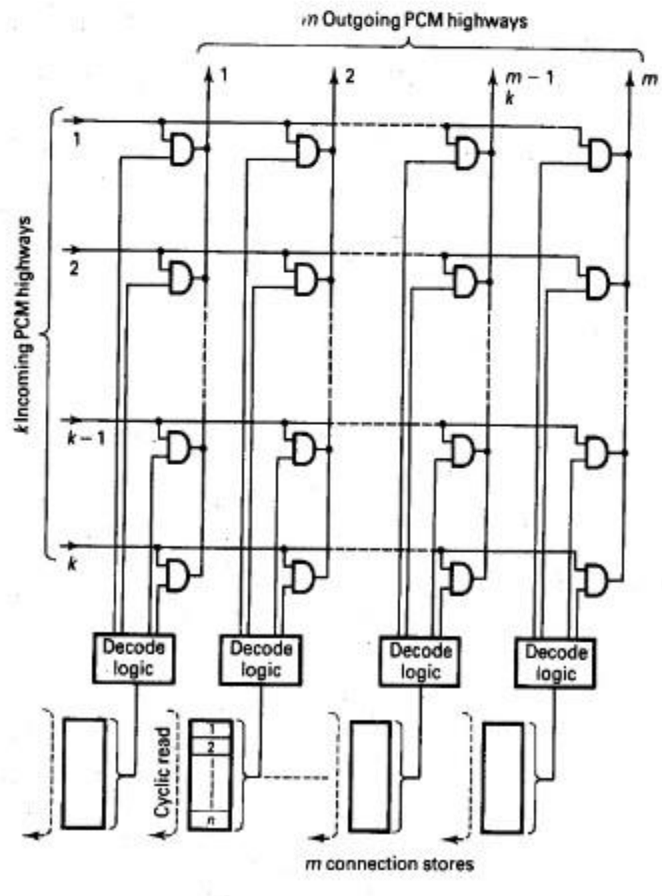

Figure 4.2 space switch

A group of cross point gates can be implemented as an integrated circuit, for example by using a multiplexer chip figure 4.2 shows a space switch with 'k' incoming and 'm' outgoing PCM highways, each carrying 'n' channels. The connection store for each column of cross points is a memory with address location for each time slot, which stores the number of cross point to be operated in that time slot.

4.2.3 Time switches

The principle of Time switch is as shown in figure 4.3(a). It connects incoming n-channel PCM highways to outgoing n-channels PCM highways. Since any incoming channels can be connected to any outgoing channels.

It is equivalent to a space division cross point matrix with "n" incoming and "n" outgoing trunks as shown in figure 4.3 (b).time slot interchange is carried out by means of two stores, each having a storage address for every channels of PCM frame. The speech store contains the data of each incoming time slots at a corresponding address.

Each address of the connection store corresponds to a time slot on the outgoing highways. Information is read into the speech store cyclically in synchronism with the incoming PCM systems; however, random access read out is used. The connection store has cyclic read-out, but writing is non cyclic.

To establish connection, the number (X) of time slot of an incoming channels is written into the connection store at the address corresponding to selected outgoing channel(Y).During the cyclic scan of speech store, the incoming PCM sample from channel X written into address X.

During each cyclic scan of connection store, the number X read out at the beginning of the time slot Y. This is decoded to select address X of speech store, whose contents are read out and sent over the outgoing highways.

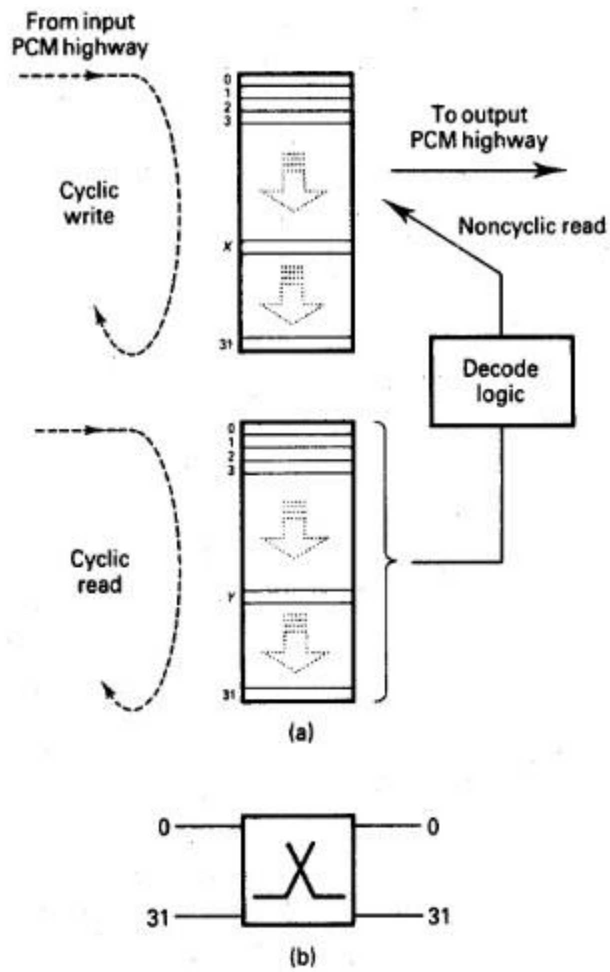

Figure 4.3 Time switching a) Time switch b) Space-division equivalent

4.3 Time switching networks

4.3.1 Basic network

Figure 4.4 shows the space-time-space (STS) switching network. Each of m incoming PCM highways can be connected to “k” links by cross points in the A switch and the other ends of the links are connected to “m” outgoing PCM highways by cross points in the C switch. Each link contains a time switch.

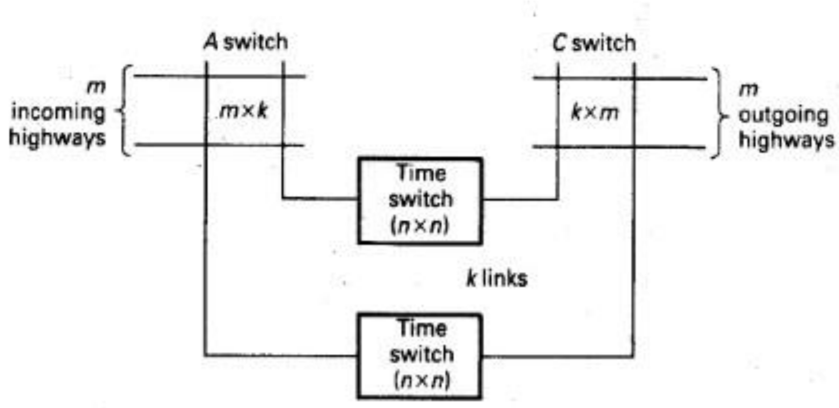

Figure 4.4 space-time-space (STS) switching network m=number of PCM highways, n=number of time slots.

To make the connection between time slots X of an incoming highways and time-slot Y of an outgoing highways, it is necessary to select a link having a address X free in its speech store and address Y free in its connection store. The time switch is then set to produce a shift from X to Y. the connection is completed by operating the appropriate A switch cross point at time X and appropriate C-switch cross point at time Y in each frame.

Time-space- time switch (T-S-T):

Figure 4.5 shows T-S-T switching network. Each of the m incoming and m outgoing PCM highways is connected to a time switch. The incoming and outgoing time switches are connected by space switch.

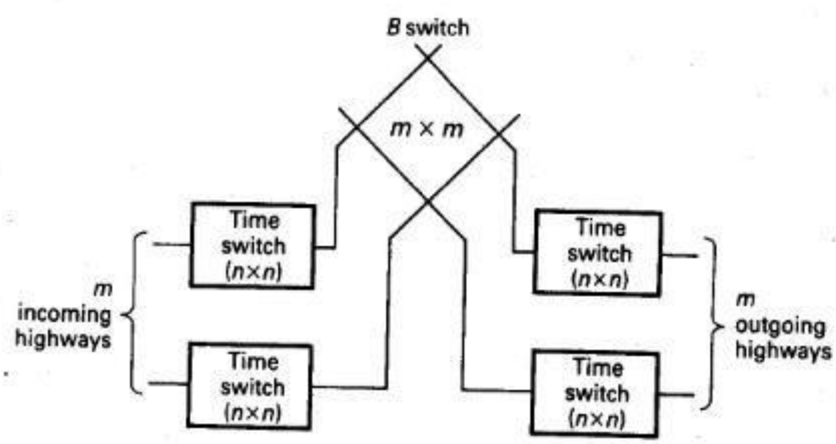

Figure 4.5 Time-Space-Time (T-S-T) switching network m=no. of PCM highways, n=no. of time-slots

To make connection between time slot X of an incoming highways and time slot Y of an outgoing highway, it is necessary to choose a time slot Z which is free, n the connection store of the incoming highway and the speech store of the outgoing highway. The connection is established by setting timer switch to shift from X to Z, setting outgoing time switch to shift from Z to Y and operating appropriate cross point at time Z in each frame.

4.3.2 Bidirectional paths

The switching network S-T-S and T-S-T are unidirectional transmission. Since PCM transmission systems use four wire circuits, it is necessary to provide separate paths for the 'send' and 'receive' channels. One way is provide separate switching network for each direction of transmission. However, this may be avoided by connecting 'send' highways of both incoming and outgoing circuits to one side of the switch and 'receive' highways to other side, as shown in figure 4.6.

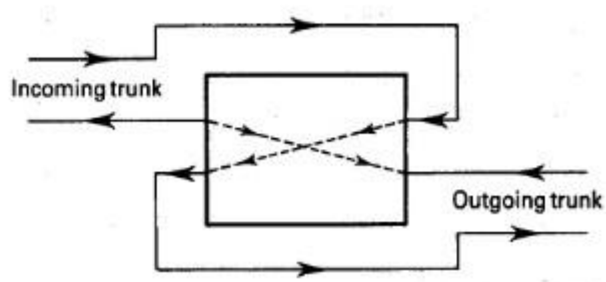

Figure 4.6 Bidirectional transmission through time-division switching network

In an S-T-S network the same speech-store address in the time switch may be used for each direction of transmission. For a connection between time-slot X on one trunk and channel Y on another, for one direction of transmission, the contents at address are written at the end of time slot X and at the beginning of time slot y. For the opposite direction of transmission, they are written at the end of same time-slot Y and read at the beginning of next time-slot X.

In T-S-T network, speech in the two directions must be carried through space switch using different time-slots. In order to simplify through space switch using different time-slot for the two-directions of transmission have a fixed time difference. Usually, the time-slots have phase difference of 180 degrees. In a 32 channels system, if time slot 12 is used for one direction of transmission, then time slot (12+16) =28 is used for reverse direction.

4.3.3 Concentrators

- Concentrators connect to a PCM highway a number of customer's line units greater than number of timeslots on the highway.
- In a simple concentrator, the customer codec are all connected to the common highway and each may use any timeslot.
- A codec is operated in the required time slot by means of a connection store. This method is used in the AXE system. Alternatively, a group of codec's equal to the number of available time-slots (e.g. 24 or 30) uses fixed channels times on a highway.
- The control function of concentrator may be enhanced to enable it to connect calls between its own customers if the PCM link fails.
- Facilities must be added to receive and analyze address signals, generate tones and make cross-switch connections between customer's lines. This unit is then known as a remote switching unit.
- Mark 1 Digital Switching Subsystem DSSS of system X is Shown in figure 4.7

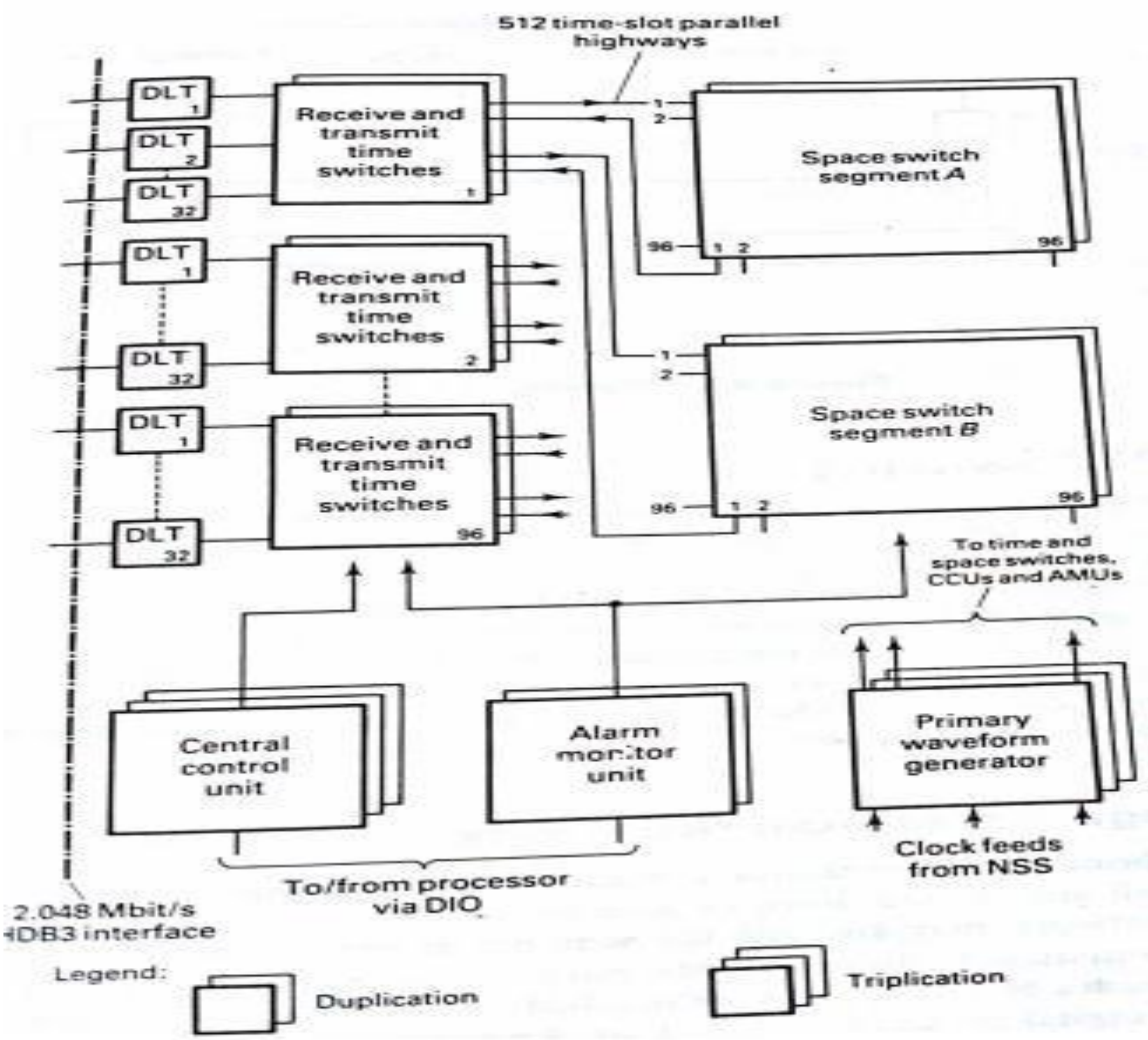

Figure 4.7 Mark 1 digital Switching System of System X. DLT= Digital Line Terminating unit.

4.3.4 PBX switches

A large PBX may use a switching network similar to public exchange. A small PBX may only generate sufficient traffic for all its connection to be made over a single highway. All its ports i.e. those for extension lines, exchange lines and the operator's position, have codec's connected to a common highway, as shown in figure 4.8

The codec's' are operated in the required timeslots by a connection store. In order to increase line capacity of PBX, the number of timeslots on the common highways may be increased by using 8-bit parallel transmission instead of serial transmission. Two time slots are used to provide two way communications over same highway.

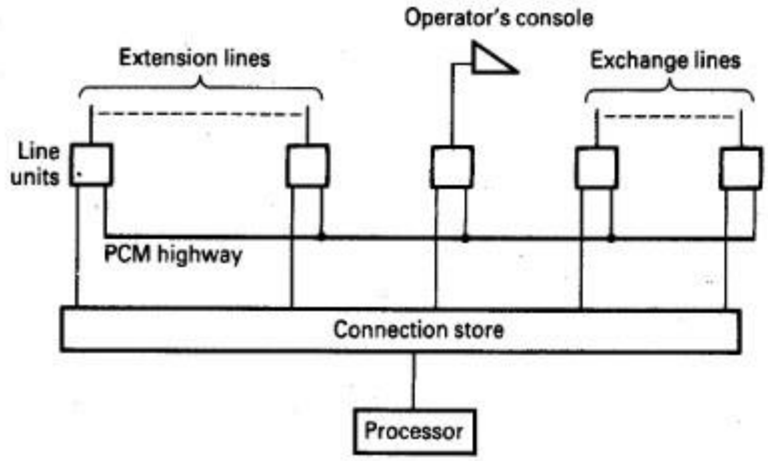

Figure 4.8 Trunking of a digital PBX.

4.3.5 Digital cross connect units

For a telephone call, a connection is made through a digital switching network at the start of a call and cleared down as soon as the call ends. However, a similar digital switching network may be used for semi-permanent connections. It is controlled manually from an operating terminal instead of automatically by processor of exchange. Such digital switching network is called Digital cross connect units. It performs a function for digital circuits similar to that of a distribution frame for analog circuits. It is some time called a 'slow switch', in contrast to a 'fast switch' used to connect telephone calls.

Two functions that can be performed by digital cross connect units are grooming and consolidation. In grooming, 64 k bit/s channels on a common PCM dearer are separated for routing to different destinations. For example a line from a customer's PBX may carry a mixture of PCM channels, some to the public and some to the public exchange and some to other PBXs in the customer's private network. In consolidation, channels onto a smaller number of bearers, thereby improving the utilization of PCM systems.

4.4 Grade of service of time division switching network

4.4.1 : S-T-S network

- In the S-T-S network of figure 4.4 each crosspoints of the space switch is time shared by n channels.
- STS is therefore equivalent to "n" separate crosspoints in a space division switch.
- The "A" switch is equivalent to a "n" space division switches of size m x k and The "C" switch is equivalent to a "n" space division switches of size k x m. Each of k time switches is equivalent to a space division switch of size n x n as shown in figure 4.3b.
- Hence S-T-S network of figure 4.3 can be rewritten as shown below in the figure 4.9

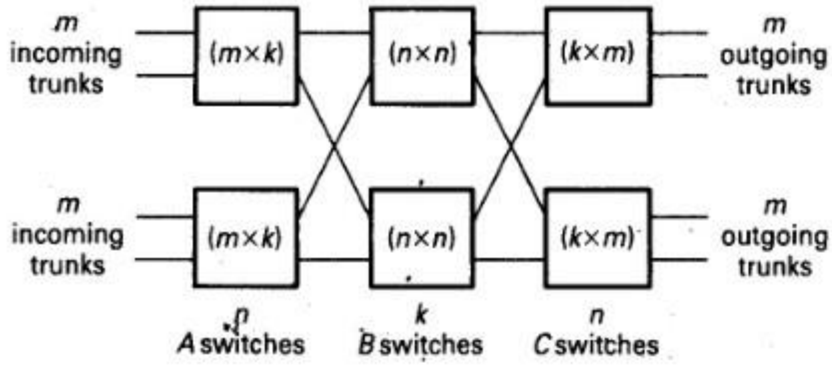

Figure 4.9.Space division equivalent of S-T-S switch: m= number of PCM highways, n=number of Time slots, k= number of time switch links.

Let the Occupancy of A link is a

Occupancy of B link is b

Occupancy of outgoing trunks be c

For mode 1: Connection to a particular Outgoing trunk.

i). Connection is required to a particular free channel on a selected outgoing highway (mode 1)
In this network the choice of secondary switches determines the A and B links
The probability of 1^{st} link being busy =’a’
Probability of 1^{st} link being free is = (1-a)
The probability of $2^{nd\ t}$ link being busy =’b’
Probability of 2^{nd} link being free is = (1-b)
Probability that both the links are free = (1-a) (1-b)
Probability that both the links are busy= blocking probability = [1- (1-a) (1-b)]
However there are g2 (k) secondary switches.
Therefore the probability that all the g2 independent paths are simultaneously blocked is:

$$B_1 = [1 - (1 - a)(1 - b)]^{g2}$$

$$B_1= [1-1+a+b-ab]^{g2}$$

$$B_1= [a + (1-b)a]^{g2}$$

Which gives the grade of service for S-T-S switch block

Since g2=k,

$$B= [a + (1-b)a]^{k}$$

If a=b, then $B = [1 - (1 - b)^2]^k$

The occupancy of a link is $b = \frac{Total\ traffic\ offered\ in\ busy\ hour}{No.of\ PCM\ channel\ x\ number\ of\ links}$

ii) Connection is required to a particular outgoing highway, but any free Channel on it may be used (mode 2)

The probability of an outgoing trunk to be busy is = “c”

The probability of the outgoing trunk to be free is = “(1-c)”

The occupancy of a link is

$$C = \frac{Total\ traffic\ offered\ in\ busy\ hour}{No.of\ PCM\ channel\ x\ m\ incoming\ or\ outgoing\ PCM\ channnel}$$

The probability of blocking of a particular trunk is given by

$B_2 = [1 - (1 - B_1)(1 - c)]$

$= [1 - (1 - B_1)(1 - c)]$ $= [1 - 1 - B1 - c - B1c] = [B1 + (1-B1)\ C]$

The Probability of simultaneous blocking for g3 (n-tertiary trunks) independent paths is given by

$B_2 = [B1 + (1-B1)\ C]^{g3}$

g3= n =number of tertiary trunks

Mode2, $B2 = [B1 + (1-B1)\ C]^n$

Problem 4.1)

1) **A STS network has 16 incoming and 16 outgoing PCM highways, each of which conveying 24 channels.**

Between the incoming and outgoing space switches there are 20 links containing time switches. During the busy hour, the network is offered 300E of traffic and it can be assumed that this is evenly distributed over the outgoing channels. Estimate the required Grade of Services if

i. **Connection is required to a particular free channel on a selected outgoing highway (i.e. mode 1)**
ii. **Connection is required to a particular outgoing highway but any free channel on it may be used (i.e. mode 2)** **10M**

Given Data: m=16, n=24, k=20 A=300E

$B1 = [1 - (1 - a)(1 - b)]^{g2}$

If a=b, then

$B1 = [1 - (1 - b)^2]^k$

The occupancy of a link is $b = \frac{Total\ traffic\ offered\ in\ busy\ hour}{No.of\ PCM\ channel\ x\ number\ of\ links} = \frac{300}{24x20}$

b = 0.625E

$B1 = [1 - (1 - 0.625)^2]^{20}$

$= 0.0482$

Mode 2:

ii) Connection is required to a particular outgoing highway, but any free Channel on it may be used (mode 2)

The probability of an outgoing trunk to be busy is = "c"

The probability of the outgoing trunk to be free is = "(1-c)"

The occupancy of a link is

$$C = \frac{Total\ traffic\ offered\ in\ busy\ hour}{No.of\ PCM\ channel\ x\ m\ incoming\ or\ outgoing\ PCM\ channnel} = \frac{300}{24x16}$$

C = 0.781

The probability of blocking of a particular trunk is given by

$= [1 - (1 - B_1)(1 - c)]$

The Probability of simultaneous blocking for g3 (n-tertiary trunks) independent paths is given by

$= [1 - (1 - B_1)(1 - c)]^{g3}$

$= [1 -1-B1-c-B1c]^n$

Mode2, B2= [B1+(1-B1)C]^n

$B2= [B1 + (1-B1) C]^n$

$= [0.0482+ (1-0.0482) x 0.781]^{24}$ $B_2= 0.0036$

4.2) An S-T-S network has 10 incoming and 10 outgoing highways. Each of which conveys 32 PCM channels between incoming and outgoing space switches; there are 20 lines containing time switches. During the busy hour, the network is offered 200E of traffic and it can be assumed that this is evenly distributed over the outgoing channel. Estimate the grade of service obtained if,

i). Connection is required to a particular free channel on a selected outgoing highway (mode 1)

ii) Connection is required to a particular outgoing highway, but any free Channel on it may be used (mode 2) 10M

Let the Occupancy of A link is a

Occupancy of B link is b

Occupancy of outgoing trunks be c

i). Connection is required to a particular free channel on a selected outgoing highway (mode 1)

In this network the choice of secondary switches determines the A and B links

The probability of 1st link being busy =’a’

Probability of 1st link being free is =(1-a)

The probability of 2nd t link being busy =’b’

Probability of 2nd link being free is =(1-b)

Probability that both the links are free =(1-a) (1-b)

Probability that both the links are busy= blocking probability = (1-a) (1-b)

However there are g2 (k) secondary switches. Therefore the probability that all the g2 independent paths are simultaneously blocked is:

Given Data: m=10, n=32, k=20 A=200E

$$B1 = [1 - (1 - a)(1 - b)]^{g2} \text{ here } a=b$$

If a=b, then $B1= [1 - (1 - b)^2]^k$

The occupancy of a link is $b = \frac{Total\ traffic\ offered\ in\ busy\ hour}{No.of\ PCM\ channel\ x\ number\ of\ links} = \frac{200}{32x20}$

b = 200/(32*20) = 0.3125

$B1 = [1 - (1 - 0.3125)^2]^{20}$

$= (0.52735)^{20}$

= 0.0000027668

ii) Connection is required to a particular outgoing highway, but any free Channel on it may be used (mode 2)

The probability of an outgoing trunk to be busy is = “c”

The probability of the outgoing trunk to be free is = “(1-c)”

The occupancy of a link is

$$C = \frac{Total\ traffic\ offered\ in\ busy\ hour}{No.\ of\ PCM\ channel\ x\ m\ incoming\ or\ outgoing\ PCM\ channnel} = \frac{200}{}$$

3
2
x
1
0

$C = 0.625$

The probability of blocking of a particular trunk is given by

$= [1 - (1 - B_1)(1 - c)]$

The Probability of simultaneous blocking for g3 (n-tertiary trunks) independent paths is given by

$= [1 - (1 - B_1)(1 - c)]^{g3}$

$= [1 -1-B1-c-B1c]^n$

Mode2, $B2= [B1+(1-B1)C]^n$

$B2= [B1 + (1-B1) C]^n$

$= [0.00000276+ (1-0.00000276) \times 0.625]^{32}$ $= [0.625001035]^{32}$ $B_2= 2.93889 \times 10^{-7}$

4.3). An S-T-S network has 10 incoming and 10 outgoing highways and 10 time switch links. The highway conveys 32 PCM channels. The average occupancy of PCM if channel is 0.7E. i). Estimate the blocking probability ii) Estimate the GOS when an incoming will must be connected to selected outgoing highways but may use any d=free channel on it. 10M

Given Data: m=10, n=32, k=10 occupancy=a=b=c=0.7E

Mode 1: $B1 = [1 - (1 - a)(1 - b)]^{g2}$ here a=b

If a=b, then $B1 = [1 - (1 - b)^2]^k$

$B1 = [1 - (1 - 0.7)^2]^{10}$

B1= 0.389.

For Mode2, $B2= [B1+(1-B1)C]^n$

$B2= [0.389 + (1-0.389) 0.7]^{32}$

= 0.0015

$$b = \frac{Total\ traffic\ offered\ in\ busy\ hour}{No.\ of\ PCM\ channel\ x\ No.\ of\ links}$$

Total traffic = b x PCM channels x No. of links

= 0.7 x 32 x 10

Total traffic= A=224E

4.4.2 GOS of T-S-T network

In the T-S- network of figure 4.5 each time switch is equivalent to a space division equivalent of n x n and there are m associated incoming highways and m outgoing PCM highways. space switch is equivalent to n space division switches of size m x m. The TST network of figure 4.5 can be rewritten as shown in figure 4.10.

Let the Occupancy of A link is a

Occupancy of B link is b

Occupancy of outgoing trunks be C

The probability of 1^{st} link being busy ='a'

Probability of 1^{st} link being free is = (1-a)

The probability of $2^{nd\ t}$ link being busy ='b'

Probability of 2^{nd} link being free is = (1-b)

Probability that both the links are free = (1-a) (1-b)

Probability that both the links are busy= blocking probability = [1- (1-a) (1-b)]

However there are g2 (n) secondary switches. Therefore the probability that all the g2 independent paths are simultaneously blocked is:

$$B^1 = [1 - (1 - a)(1 - b)]^{g2}$$

If a=b, g2=n, then $B = [1 - (1 - b)^2]^n$

For mode 2:

All channels on a route are provided by the same outgoing time switch i.e. all the trunks on a route connected to C switch in the equivalent space division equivalent.

The probability of blocking for a connection to this C switch is B

The probability that all trunks outgoing from the C switch are busy is approximated b^n.

The Probability that connections can be made to a free outgoing trunk is = (1-B1)($1-b^n$).

And probability of loss$B_2 = [1- (1-B_1)(1-b^n)]$.

Where b is very small and n is very large $b^n = 0$ $B_2=B_1$

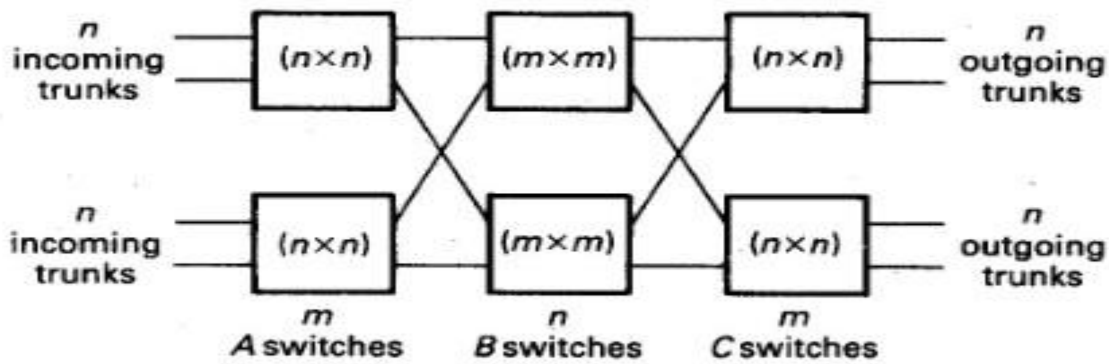

Figure 4.10 Space division equivalent of T-S-T switch. M= number of PCM highways n= number of time slots.

Problem 4.4) A TST network has 20 incoming and 20 outgoing PCM highways, each conveying 30 channels. The required Grade of Services is 0.01. Find traffic capacity of network if

- **i) Connection is required to a particular free channel on a selected outgoing highway (i.e. mode 1)**
- **ii) Connection is required to a particular outgoing highway but any free channel on it may be used (i.e. mode 2)**

Solution:
For the equivalent space division network shown in g=figure 4.10
m=20, n=20
let occupancy of the mn links and trunks be b
Let the Occupancy of A link is a

However there are g2 (n) secondary switches. Therefore the probability that all the g2 independent paths are simultaneously blocked is:

$$B^1 = [1 - (1 - a)(1 - b)]^{g2}$$

If a=b, g2=n, then $B = [1 - (1 - b)^2]^n$

$B = [1 - (1 - b)^2]^{30} = 0.01$

$1 - (1 - b)^2 = 0.01^{0.0333} = 0.858$

$(1 - b)^2 = 0.142$

b=0.623

Total traffic capacity of network is

Total traffic = b x PCM channels x No. of link

= 0.623 x 20 x30 =374 E

For mode 2:

All channels on a route are provided by the same outgoing time switch therefore all the trunks on a route connected to C switch in the equivalent space division equivalent.

The probability of blocking for a connection to this C switch is B 1

The probability that all trunks outgoing from the C switch are busy is approximated b^n.

Therefore The Probability that connections can be made to a free outgoing trunk is = $(1-B1)(1-b^n)$.

And probability of loss $B_2 = [1- (1-B_1)(1-b^n)]$.

Where b is very small and n is very large $b^n = 0$ $B_2=B_1$

If b=0.623, b^{30}=6.8 x 10-7

Therefore $B_2=B_1$

Thus approximately the same loss probability is obtained in either mode and the traffic capacity of the network for B_2=0.01 is again 374E

4.5). A TST network has 10 incoming and 10 outgoing PCM highways, each conveying 32channels. The average occupancy of the incoming cannel is 0.6E.

i. **Design an equivalent space division network**
ii. **Estimate the blocking probability**
iii. **Estimate the GOS when an incoming call must be connected to a selected outgoing highways but may use any free channel on it.**

Given data:

32 channel m=10 b=0.6E

i).

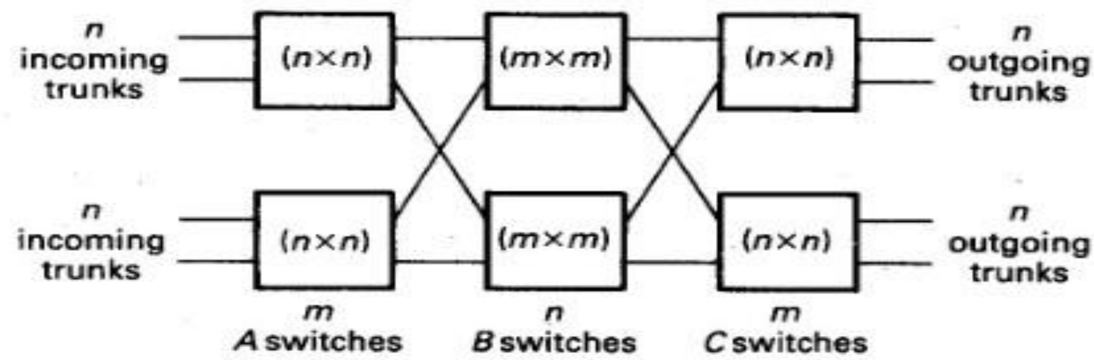

Figure 4.11 space division equivalent of TST

ii).

$B^1 = [1 - (1 - a)(1 - b)]^{g2}$

If a=b, g2=n, then $B = [1 - (1 - b)^2]^n$

$B = [1 - (1 - 0.6)^2]^{32} = 3.77 \times 10^{-3}$

iii) $B2 = 3.77 \times 10^{-3}$

4.6). A TST network has 20 incoming and 20 outgoing PCM highways, each conveying 40 channels. The average occupancy of the incoming cannel is 0.8E.

i. **Design an equivalent space division network**
ii. **Estimate the blocking probability**
iii. **Estimate the GOS when an incoming call must be connected to a selected outgoing highways but may use any free channel on it.**

Given data: m=20, b=0.8E, n=40 PCM channels

i).

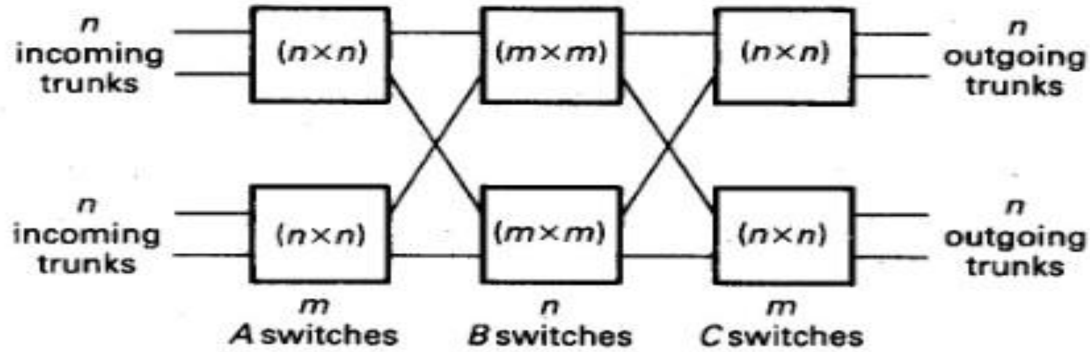

Figure 4.12 space division equivalent of TST

For TST network

B1=B2

ii). 40 channel m=20 b=0.8E

$B^1 = [1 - (1 - a)(1 - b)]^{g2}$

If a=b, g2=n, then $B' = [1 - (1 - b)^2]^n$

$B1 = [1 - (1 - 0.8)^2]^{40}$

= 0.195

iii). B2 = 0.197 because for TST network B1=B2.

Network has 60 incoming and 60 outgoing PCM highways. Each conveying 40 channels. The required grade of service is 0.7. Find the traffic capacity of the network mode1 and mode2.

M=60, n=40 and B'=0.7

$B' = [1 - (1 - b)^2]^n$

$0.7 = [1 - (1 - b)^2]^{40}$

$(0.7)^{1/40} = [1 - (1 - b)^2]$

$(0.7)^{0.025} = [1 - (1 - b)^2]$

$0.9911 = [1 - (1 - b)^2]$

$(1 - b)^2 = [1 - 0.9911]$

$= 0.0089$

1-b= 0.094

B=0.904

The b= $\frac{traffic\ offered}{No.of\ PCM\ highways\ x\ links}$

0.904= $\frac{traffic\ offered}{40\ x\ 60}$

Traffic offered= 2174

Therefore B_1=B_2=2174

4.5 Synchronization.

4.5.1 Frame alignment

For correct operation of a time division switching network the PCM frames on all the incoming highways must be exactly aligned. However, since incoming PCM junctions come from different places, their signals are subjected to different delays. To solve this problem, the line terminating unit of a PCM junctions store the incoming digits in a frame alignment buffer as shown in figure 4.8. Digits are read into this buffer at a rate fa of incoming line, beginning at the start of PCM frame of the exchange. A frame alignment buffer caters perfectly constant misalignment.

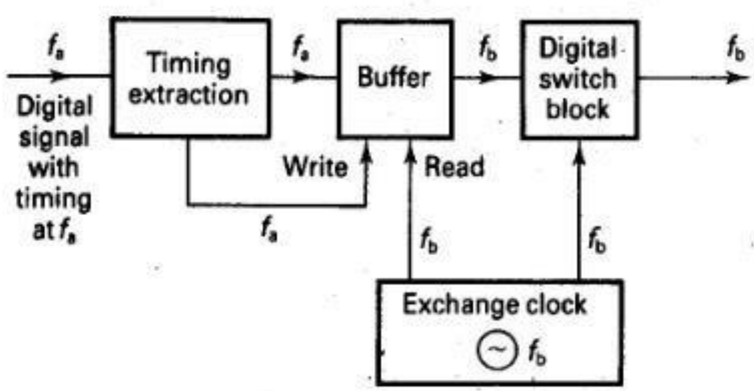

Figure 4.8 Frame alignments of PCM signals entering a digital exchange.

The fill of buffer is constant and its level depends on the phase difference between incoming line system and the exchange. It will also cope with a misalignment that changes slowly between limits (e.g. due to temperature changes in cables).

4.5.2 Synchronization network.

In a Synchronous digital network just one or two atomic reference clocks control the frequencies of clocks, of all exchanges in the network. This is called despotic control.

Synchronizing links may be unilateral or bilateral. In the first case, there is master-slave relationship; the clock frequency of the exchange influences the frequency of the other.

For this purpose, synchronizing network is added to the PSTN in order to link the exchange clocks to the national reference standard.

The local clock in each exchange is provided by a crystal oscillator whose frequency can be adjusted by a control voltage. This control voltage is derived from the incoming digit stream on a synchronizing link, which is used to determine whether the exchange clock rate should be increased, decreased or left unchanged. This ensures that exchanges maintain the same long term average frequency, although short term variation may occur. This is known as mesochronous working.
clock frequency of the exchange influences the frequency of the other. In the second case, there is a mutual relationship; each exchange influences the frequency of the other. The principles of these methods are shown in figure 4.9.

A unilateral sync system is shown in figure 4.9(a) exchange A is the' master ' and exchange B is the 'slave '. Exchange B determines the phase difference between its own clock and that of the exchange A by fill of the aligner buffer on the incoming link. If there is a more than one sync network link into exchange B, its correction is based on a majority decision.

In a single ended bilateral sync link, as shown in figure 4.9(b) the above decision process is made at each end of the link. As a result, both exchange clocks achieve the same average frequency. In a mesh of such synchronous nodes, the exchange would mutually agree on a common frequency without being controlled by an overall master clock. A disadvantage of single ended unilateral and bilateral synchronous system is that phase comparators are unable to distinguish between phase changes due to frequency drift and those due to changes in propagation time. This disadvantage of single ended unilateral and bilateral synchronous system is overcome by double ended system as shown in figure 4.9(c) and (d).

Synchronizing links may be unilateral or bilateral. In the first case, there is master-slave relationship; the

This eliminates the influence of propagation-delay variations by subtracting the change in phase determined at the end of link from that determined at the other end.

Let the phase error detected at exchange A be $\delta(\phi_A-\phi_B) + \delta\phi_T$, where $\delta(\phi_A-\phi_B)$ is the phase change due to discrepancy between the clocks and $\delta\phi_T$ is that due to a change in propagation time. Then the phase change detected at exchange B is $\delta(\phi_B-\phi_A) + \delta\phi_T$. Sinc e $\delta(\phi_B-\phi_A) = -\delta(\phi_A-\phi_B)$, the difference between the two measurements is $2\delta(\phi_A-\phi_B)$and the $\delta\phi_T$ is eliminated. A signaling channel is required to carry the result of phase comparison to the other end of link in order to make subtraction.

For a unilateral network, as shown in figure 4.9(c), this channel is needed in only one direction. For a bilateral link, a signaling channel is needed in each direction as shown in figure 4.9(d).

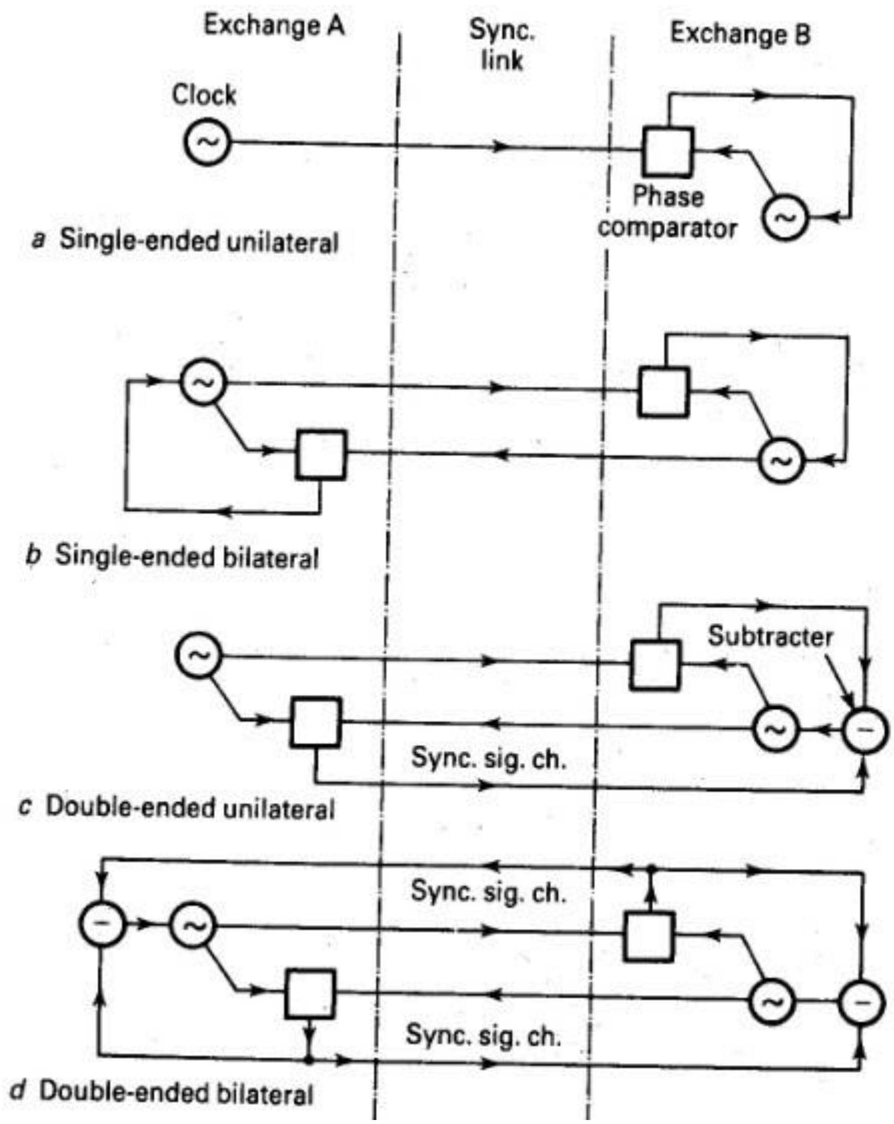

Figure 4.9Exchange synchronization system

A synchronizing network for an integrated Digital Network (IDN) is shown in figure 4.10 since this auxiliary network must link all exchanges in the IDN. The synchronous network has same nodes and the same hierarchical structure as the parent public switch telephone network (PSTN). The synchronous links are provided by PCM systems that carry normal traffic between the exchanges.

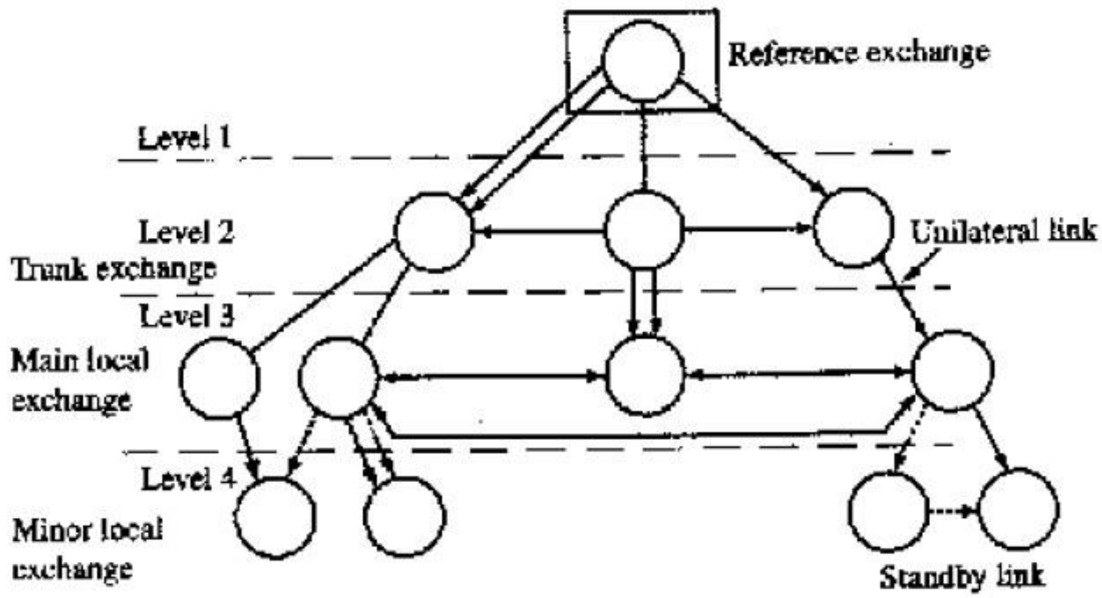

Figure 4.10 synchronization hierarchy of an integrated digital network.

CHAPTER 2: SWITCHING SYSTEM SOFTWARE

Introduction, Scope, Basic software architecture, Call models, and software linkages during a call and call features.

4.6 Introduction

A modern digital switching system is quite complex. The growth in the field of software, the complexity of the DSS also increases. This chapter exposes workings of the software that drives a digital switching system.

4.7 Scope

The scope of this unit is to learn

- basic software architecture of a typical digital switch
- classifies various types of software
- describe the Call model and
- Software linkages that are required during call and Basic call features.

4.8 Basic software architecture

Modern digital switching employs quasi-distributed hardware and software architecture. The software employed in the modern digital switching system at different levels of control. Figure 6.1 shows the basic software architecture of a typical digital switching system. Figure shows the levels of the control and minimum software requirement at each level of control. Here both high-level and low-level details are necessary to design the switching system.

1. Operating systems

Modern digital switching system consists of an operating system as a part of the software architecture, operating systems (OS) may be defined as software that manages the resource of a computer system or controls and tasks other programs.

These programs are also called as control programs, supervisory programs and monitor programs as a part of the software architecture. There are different types of operating systems. They are

- Serial batch systems
- Multiprogramming system
- Time sharing system and
- Real time systems.

The OS employed by the DSS are Real time operating systems because modern DSS demands for the task to execute in the real time. Typically the real time operating system of a DSS interacts with different layers of the application required to support telephony features and functions. Most modern DSS uses quasi-distributed architecture; the processor or the controller for each of the subsystem may use different OS.

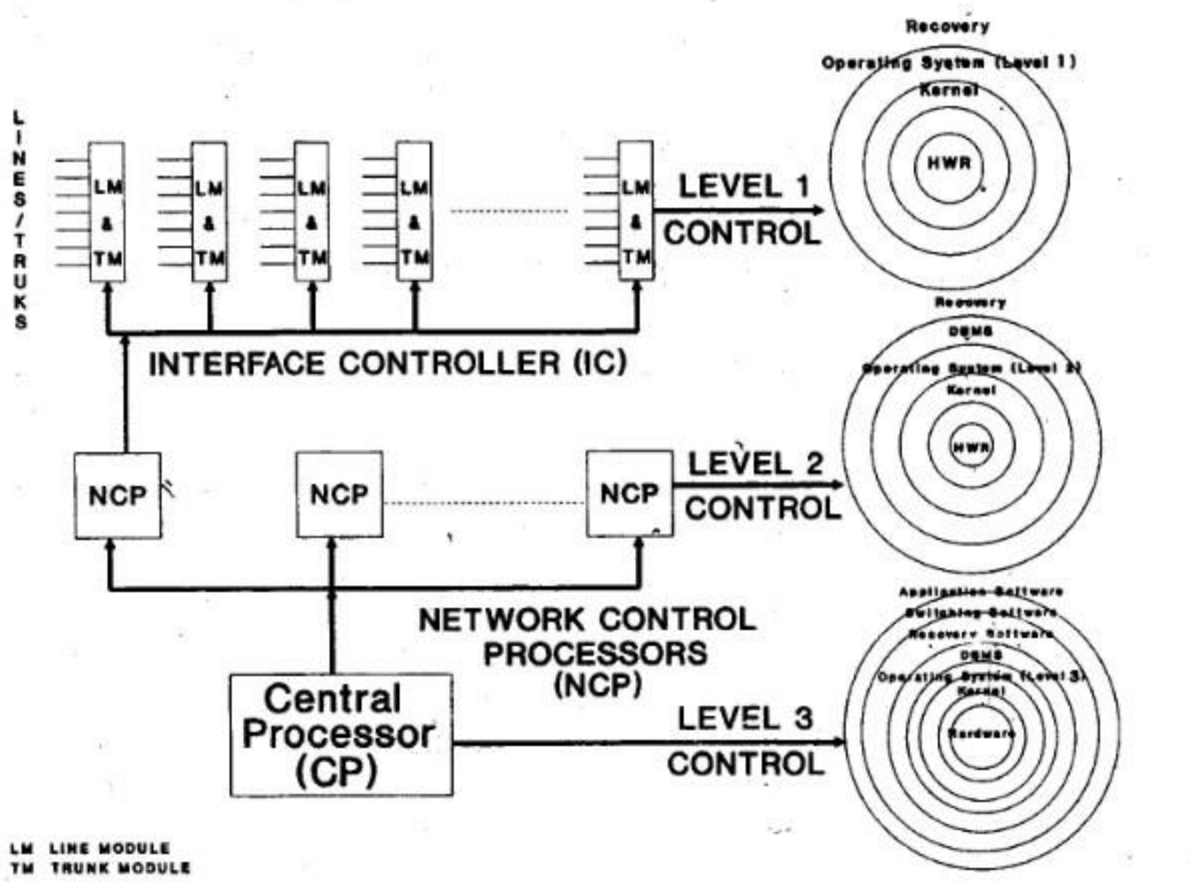

Figure 4.11 shows the basic software architecture of a typical digital switching system.

2. Kernal

The kernel of the operating system consists of those functions of an operating system that are primitive to the system environment. It usually consists of the following functions.

- Process control and process scheduling
- Memory management
- Input and output control i.e. request from the terminal and buffers.
- Domain protection of main memory Read and write operations.

Most of real time operating system that controls the DSS use priority based scheduling mechanism. Most DSS employs Kernels that reside in the main memory. The highest priority given to system maintenance interrupts followed by other types of interrupts required for call processing and other ancillary functions.

3. Database Management

The databases that are employed in the DSS are usually relational and sometimes distributed. Distributed databases imply multiple databases requiring data synchronization. The relational databases system uses the relational data model in which the relationships between files are represented by data values in file *records*.

A record is a relational database is flat, i.e., a simple two dimensional arrangement of data elements. The grouping of related data items is sometimes referred to as a **tuple**. A **tuple** containing two values is called a pair. A **tuple** containing N values is called an **N-tuple**.

An example of relational database in case of DSS is a database, which cross references all the directory names that are assigned to a line equipment of subscriber. When a subscriber goes off-hook, the scanning equipment identifies the line equipment. The database is searched to find the particular directory number that identifies all characteristics of the line.

4. Concept of generic program

The generic program contains all programs necessary for the switching system to functions. It consists of operating system, common switching software, and system maintenance software and configuration management of a central office (CO). The translation of the data between the customer premises and CO side is provided by the telephone companies.

Most of the DSS have modular software structure. Most of the modular switching system employ generic program concept. Due to growth in the software, it is very difficult to define the generic program with respect to particular switching system.

Generally most of the switching system consists of *base* or *core* program that controls the basic functionalities of the system and on the top of these programs reside the basic features and special options required by the switching system. The quality and the performance of the switching system are based in the reliability of the components used and stability of the software programs.

A group of telephone companies are sometime used to identify the generic program. Usually, this set of programs can be labeled as a generic, base or core release for a DSS.

In general, generic program contain operating system, common switching software, system maintenance software and common database(s) software for office data and translation data management.

5. Software architecture for level 1 control

The lowest level of control in switching system architecture is level 1 control. This level consists of lines, trunks and other low level functions and software at the level is a part of the switching software.

As shown in the figure 6.1, the interface controllers (ICs) are controlled by microcontroller and have a small kernel controlling the hardware of the IC. IC will have small OS (level 3) to control and scheduling the tasks.

The IC do diagnostics of lines and trunks and other peripherals associated with the hardware. Diagnostic routines reside in central processor or in the IC itself. Central processor can run the diagnostic routines program itself or request a fault-free IC to run it.

The interfaces will diagnostics and submit the result to the central processor. In any case of failures the IC should have the ability to recovery locally and make the central processor to deliver better performance.

6. Software architecture for level 2 control

The next level of the switching system architecture is named as level 2 control; this level is associated with network controllers that may contain relational database or distributed database, customer database, and service routines.

At this level the central processor (CP) are usually associated with the network control processors (NCP). NCP is independent of the CP as shown in figure 4.11 the NCPs has their own OS has a kernel that control the hardware and software functionalities of the NCP.

At this level of control the database system maintains the translation of the data between the subscriber and parameter required to control the NCP. So at this level, system recovery is very crucial in order to avoid failure of NCP, because that impact on the interfaces such as lines, trunks, and peripherals.

The NCP should have the ability to diagnosis and switch to working backup. The design of NCP depends on the requirement raised by the DSS. The recovery mechanism in case of failure of NCP is dependents on the requirement. Either a central NCP may responsible for recovery of all NCPs or central processor is responsible.

The basic functionality of a NCP: When a subscriber goes off-hook, the interface receives an off-hook notification from the line modules. The interface requests details on the subscriber, such as allowed feature and application restriction for a call to process. The NCP maintains the subscriber database; NCP queries its database for this information and passes it back to Interface Controller. This database is supposed to be managed and kept up to date with the latest information for each subscriber.

7. Software architecture for level 3 control

The top level of switching system architecture is level 3, is usually associated with the central processors of a DSS. These central processor are mainframe type computers, provides the all high-level functions. These functions include the database management such as office data, high level subscriber data, software patch level, feature control, maintenance data and system recovery in case of hardware or software failures.

Modern DSS contains OS at this level 3; the OS is real time operating system and performs multitasking (i.e., it can support more than one call at a time). Operating system is responsible for database management, switching software, recovery software, feature control, traffic control and interface with other components' of the DSS.

Most central processor works as active/standby mode, because if one goes to standby mode other one enters into active mode state, this improves the reliability of the DSS. In active/standby mode one CP is always available to go into active mode if the active CP develops faults.

We have different mode like matched mode, hot standby and cold standby mode. However both should be synchronized in order to carry the functionality in case of failure, then standby processor becomes active.

8. Digital switching system software classification

Typical DSS software is shown in figure 4.12. The functionality of a DSS can be divided into five basic elements and other functions can be derived from these basic elements.

- Switching software
- Maintenance software
- Office data
- Translation data
- Feature software

Switching software

The most important layer of software for a digital system consists of

- Call processing software
- Switching fabric control software
- Network control software
- Peripheral device control software

Switch maintenance software

- The most important role of the maintenance software is to control the DSS software and related hardware such as line test, remote diagnostics, system recovery and trunk tests.
- The recovery software of a modern DSS is distributed among all the subsystem, which controls the switching system. This method allows the system to recovery from faults more efficiently.
- Digital switching system may employ a large number of programs that are external to the system, such as remote programming and diagnostics, operational support systems (OSSs), operator position support, and advanced features (e.g., ISDN,NCP,AIN).The objective of Figure is to provide the analyst with clear picture of the digital switch software.

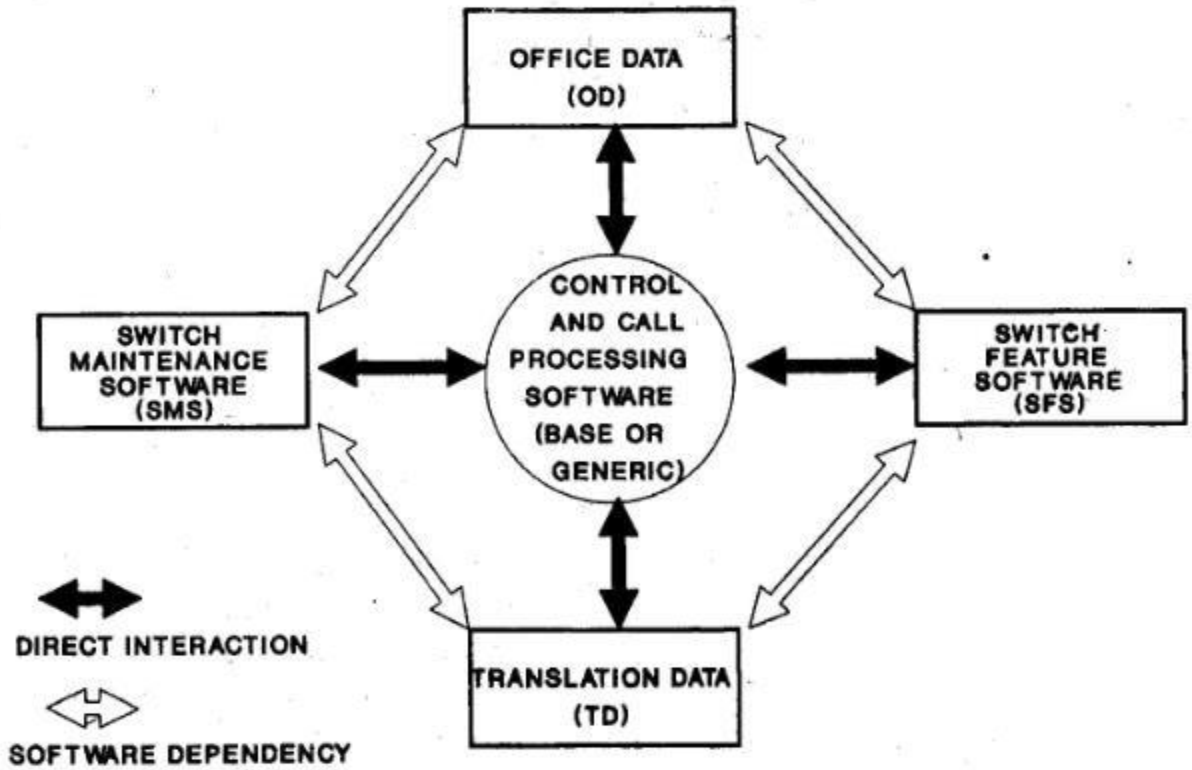

Figure 4.12Theclassification of digital switch software.

Office data

Office data defines the software parameters along with the hardware equipment. Office data of a DSS describe the extent of a central office (CO) to the generic program. Some general hardware parameters are

- Number of NCP pairs in the Central office.
- Number of line controllers in the Central office.
- Number of lines configured in the Central office.
- Total number of line equipment in CO.
- Total number of trunks and types of trunks configured in the Central office
- Total number and types of services circuits in the CO. services such as ringing units, and DTMF and Dial Pulse (DP) receiver and transmitter are provided.

The software parameters are as follows

- Size of the automatic message accounting (AMA) registers.
- Number of AMA registers.
- Number and types of traffic registers
- Size of buffers for various telephony functions
- Names and types of features supported

Translation data

Translation is the data given by the subscriber and is specific to each subscriber. The telephone companies provide translation data. The database and the entry for the translation data is a part of the DSS. Translation data may consist of the following.

- Assignment of directory number to a line equipment number.
- Enabling the feature subscribed by a particular customer, such as call waiting, conference call and call forward.
- Call restriction, such as no outgoing calls, certain call blocked.
- Intercom and call announce.
- Area code translator, identifying the call route calls, STD calls and international calls.

The CO should maintain the database about the routing of specific calls. If a new central office is installed information about the traffic is provide by the telephone companies.

Features software

Most features implemented in modern DSS are offered through feature packages. Some of the feature packages are put in a feature group and are offered to a group telephone companies. These features may be included in the base packages of a generic release. Most of the features are considered to be applications of a digital switch. Some examples of the feature packages are

- Operator services
- Centrex feature
- ISDN basic rate
- STP extensions
- SCP database.

Depending on the DSS, these feature packages can be extensive and large.

Software dependencies

Most telephony feature of DSS requires specific office data and translation data for their operation. They depend on the generation of feature-specific office data and/or translation data. These dependencies are, design specific.

Similarly the maintenance programs also require office data and translation data for testing feature functionality of DSS. It is shown in figure 6.2

4.8. Call models

The call model describes the basic connection between the hardware and software that are necessary for connecting and disconnecting a call. Call model is dependent on the type of call. A basic call model is shown in the figure 4.13.

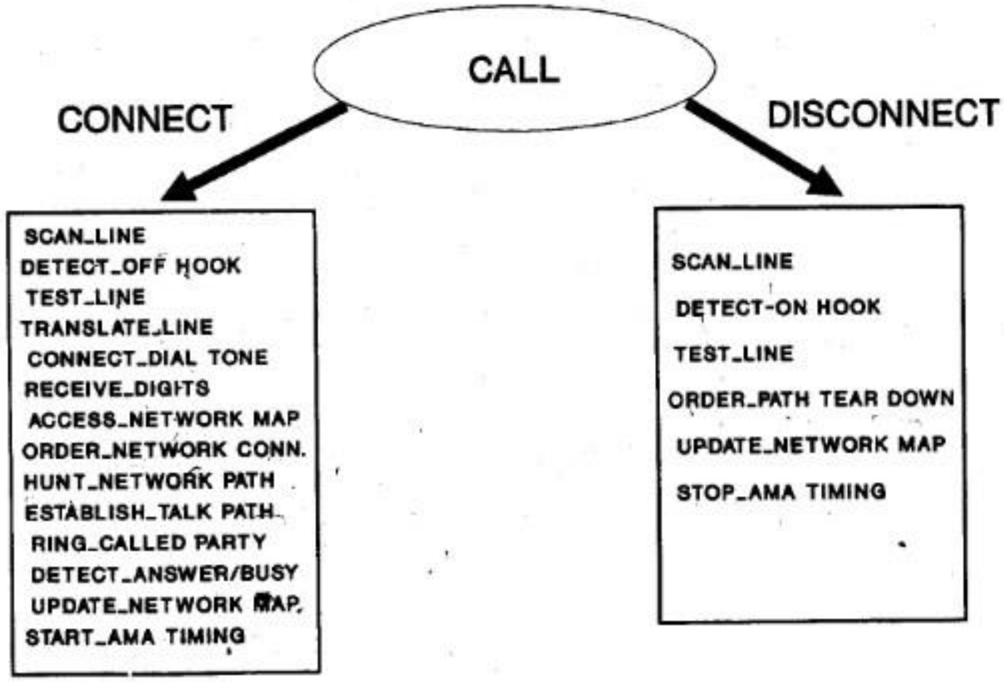

Figure 4.13. A basic call model

Connect sequence:

Connect sequence consists of software routines that scan the line and detect request for originations. Connect sequence of a call has to follow a set of software procedure to be invoked to in order to accept the request. First step of the Connect sequence is to scan line, once the line is detected that indicated line has gone off-hook and it is the legitimate request for the dial tone.

The off-hook program passes on the control to the test line program, these program tests for the presence of false-ground, high-voltage, line cross, and other conditions. After successful completion of these tests a dial tone is returned to subscriber, signaling the user to dial the digits. These steps must be completed in less than 3 seconds.

Once subscribers enter the digits the dial tone is removed and the digits are collected in the buffer. After the correct number of digits received from the subscriber, switching fabric map is consulted. Network control orders are then issued to establish a talking path through the switching fabric.

After completion of the path, the ringing service circuit is connected to the called party, and ringing is initiated. When the called party answers the call, the billing and accounting times are started.

Disconnect sequence:

The disconnect sequence is shown in figure 4.13. The lines are constantly scanned for disconnect from either end users. Once off-hook is detected from either of the party, then switching network issues an order to tear down the call. Once the call is disconnected the billing software timer is stopped.

4.9 Software linkages during Call

In order to processor a call through a DSS requires software linkages, an example of Software linkages required during a typical call is shown in figure 4.14. The line control programs scan the LMs and report the status to the network status program, which intern work with network control programs.

The line control programs also work with the line service circuit programs in providing the dial tone, digit receivers, ringing circuits, etc., to the subscriber lines. The network control program is responsible for notifying the network connection when a subscriber goes off-hook and feed a dial tone, when the subscriber stops entering the digits.

The call processing program is responsible for processing a call, accounting a call, message wait indication and maintenance programs.

The maintenance programs are responsible for system recovery, remote diagnostics, backup of software, and maintenance related programs. All these programs are responsible for processing a call. If the called party is not in the same digital switch, then an outgoing trunk is used to establish a call between the two parties through the switching network. While here line and outgoing trunk is constantly scanned to disconnect from either of the party.

If the called party and calling party reside in the same Digital switch then it is called as intra-office call. If the called party and calling party reside on the different Digital switch, then it is called as inter-office call.

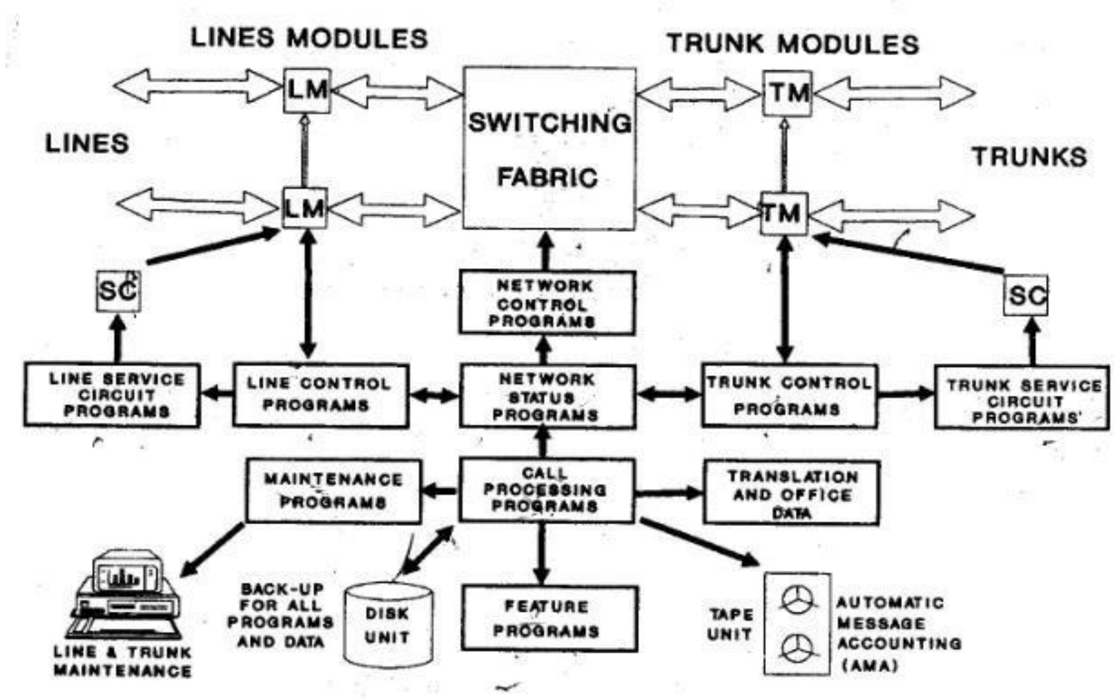

Figure 4.14 Software linkages required during a typical call

4.10 Call features

The basic functions of an end office digital switching system are to provide telephony services to its customers. The modern DSS contain several features. The features supported by DSS depend on the customer requirement. These requirements are divided into the following categories:

- Residence and business customer features
- Private facility access and services
- Attendant features
- Customer switching system features
- Customer interfaces
- Coin and charge-a-call features
- Public safety features
- Miscellaneous local system features
- Interoffice features
- Call processing features
- Database services
- Data services
- System maintenance features
- Trunk, line, and special service circuit test features
- Administrative features
- Cut-over and growth features
- Billing and comptrollers features

a. Feature flow diagrams

The features employed in the DSS are usually very complex. The functionality of features can be understood with the help of Flow diagrams.

The simplified flow diagram for one of the most commonly used subscriber features; call forwarding is shown in figure 4.15. This feature has three modes of operation. They are

- Feature Activation
- Feature Operation
- Feature De-activation

Feature Activation

The Feature is activated when the customer goes off-hook and dials an activation code.

The software checks for the correct validation code. If the activation code is wrong, the subscriber does not get the second dial tone.

If the activation code is correct, the subscriber gets a second dial tone and is allowed to dial the call forwarding telephone number.

The call-forwarded subscriber line is rung once, and the number is recorded in the system memory for future use.

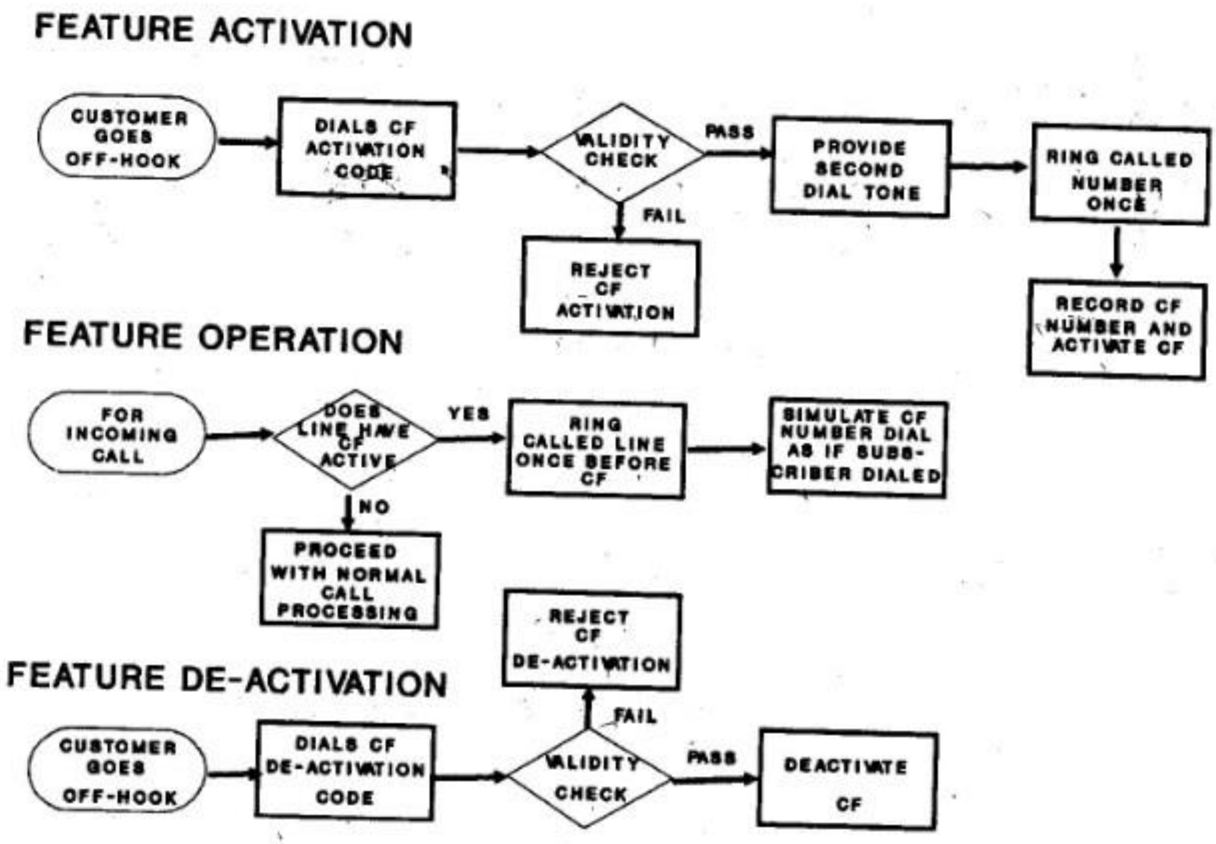

Figure 4.15a Feature Activation Figure 4.15b Feature Operation Figure 4.15c Feature De-activation

Feature Operation

Here the subscriber receives a call on the line that has the CF features activated. The system rings the called subscriber once and then forwards the call to a number previously recorded by the subscriber during feature activation.

Feature De-activation

This feature can be deactivated when the subscriber goes off-hook and dials the deactivation code. If the code is valid, the CF number is removed; otherwise, the deactivation request is ignored.

b. Feature interaction.

Due to hundreds of features supported by the modern DSS, feature interaction is necessary. One way to overcome this is to conduct regression test on the software and the related hardware.

TEXT BOOKS:

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2. Digital Switching Systems, Syed R. Ali, TMH Ed 2002.