Synchronous Digital Hierarchy — An Overview and Network Architecture

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1. Introduction

The rapid development of telecommunication technologies, particularly in the area of data transport in broadband telecommunications services such as video conferencing, remote detabase access etc requiring flexible high quality networks with a high level of protection and demand for minimisation of manual control by automatic software controlled network management led to the design of a new family of equipments and new network topologies based on Synchronous Digital Hierarchy (SDH). The SDH frame has been developed with advanced drop and insert cross-connect capabilities to give greater operating flexibility and more transmission network management facilities.

In this article, we will mainly discuss the advantages of this newly adopted SDH networking principle over the former Plesynchronous Digital Hierarchy (PDH) network mainly based on the well-known Pulse Code Modulation (PCM) System.

Before going to the main topics of discussion, let us go through a brief recapitulation on PCM system as applied on PDH network.

2. Pulse Code Modulation and Plesynchronous Digital Hierarchy

Pluse Code Modulation is a well-known digital modulation technique. In India, for PCM hierarchy, the European model is basically followed which implements 32 channels to form a single 'frame' (of which 30 are baseband data-transport channels and 2 for supervisory purpose) - each channel consists of 8 bit data with a bit rate of 8000 samples per sec (or same duration of 125 Msec). So, the bit rate for a primary PCM multiplexer (otherwise called a frame) is = (32 channels) x (8 bits/channel) x (8000 samples / sec) = 2048kb/s ≈ 2 Mb /s

In PDH architecture, higher order PCM multiplexing are applied as shown in the following shematic diagram :

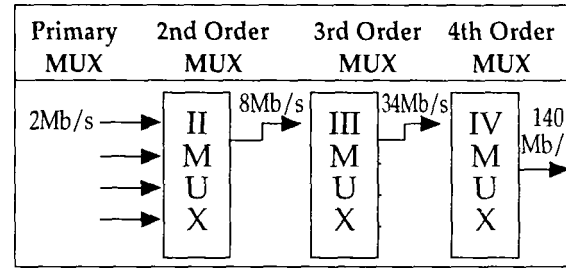

Fig. 1 : PDH Hierarchy

There are two distinct models of PDH hierarchy - one is adopted in Europe and India and the other is implemented in Japan and North America. So, there is a low degree of international standardisation regarding the PDH system. The other limitations of this system are —

- no flexible software support (the whole system is controlled manually)
- large amount of equipment
- mainly based on telephony demand (lacking other modern telecommunication services

like video conferencing, remote database access etc as stated earlier)

- bandwidth limitation

In this context, we will come to know the main advantages of Synchronous Digital Hierarchy (SDH) system.

3. Advantages of SDH System over the former PDH System

i) standardisation of line optical interface (only one model adopted throughout the world)

ii) standardisation of frame format

iii) adoption of standardised auxiliary channels and control bit

iv) implementation of systems with flexible structure that can become part of new networks (LAN, WAN, B-ISDN)

v) reduction of costs allowed by the synchronous frame structure due to the following reasons —

a) automatic and centralised management of the transmission network

b) new network topologies

c) integration of terminals and multiplexers

d) new generation of multiplexers - ADMs (Add/Drop Multiplexers)

e) introduction of DXCs (Digital Cross Connects)

f) greater flexibilities for transporting non-standard tributeries

4. Comparison between the basic mode of action of PDH and SDH

The distinction between the basic mode of action of PDH and SDH system will be understood easily if we cite an example from our daily life –

Suppose five residents of the same appartment go to a shopping complex for marketing purposes and after buying goods of their own choice they bring baggages individually to home or they bring their own goods together to their appartment using a single carriage and then separate their individual goods and reach home.

The first approach is nothing but the PDH system whereas the second approach is SDH system. To be more precise, in the PDH system, different long distance calls from callers of nearly same region to the receivers again of closely related regions go through distinct roots thereby increasing the revenue as well as network failures. But, in the new SDH system, there are some major centres distributed throughout the country which serves the purpose of multiplexing in a large scale and transmitting to another major center related through a closed 'ring'. Some of the ring members are connected to more than one ring to transmit the long distance calls from one ring to another ring. One example, considering the ring status of Calcutta Centre will make it very clear to us.

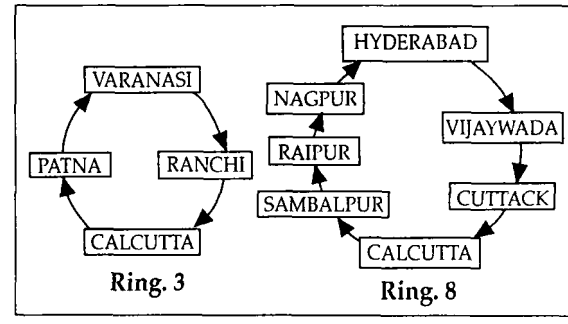

Fig. 2 : Ring Status of Calcutta Centre

There are 10 such rings distributed nationwide and the above ring 8 is the largest. The blocks in

these drawings are ADMS (Add/Drop Multiplexers) which means they have 63 PCM frames (one frame contains 32 Channels, as stated earlier). Now, suppose a caller from Delhi wants to call a subscriber at Cuttack. His call first comes to the junction at Varanasi, then transmitted to Calcutta through ring 3 and finally to Cuttack through ring 8. Besides the national rings, local rings have also been developed. The ring status for West Bengal is shown below :—

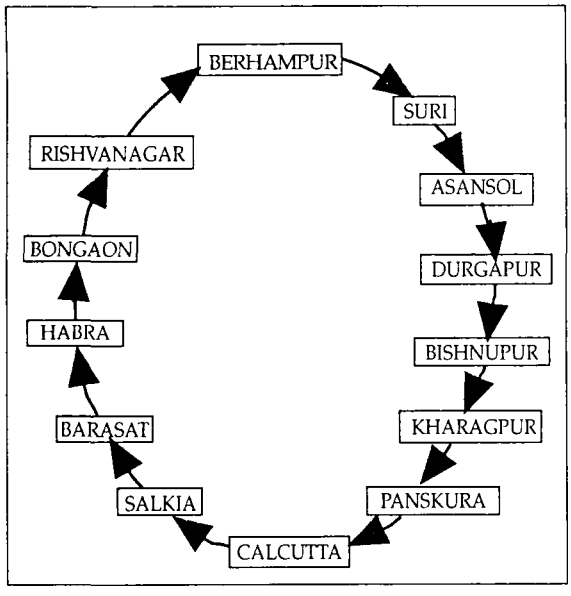

Fig. 3 : Inter District Ring -2 for West Bengal

When a signal reaches the nearby ADM centre, it distributes the nearby calls to the individual receiving subscribers.

It should also be noted that every ring is considered unidirectional in their natural mode of action.

5. SDH Network Architecture

Which were called frames in the PDH system, have their successor called STM in the today's SDH system. In STM-1, there are 9 rows and 270 columns. The reason for 9 rows arranged in every 125 M sec is as follows :

For 1.544 Mb/s PDH signal (used in North America and Japan) there are 25 bytes in 125 M sec and with 2 additional supervisory signals, there are in total 27 bytes in a single frame which can be alternately expressed as 9 rows x 3 columns.

Correspondingly, in 2.048 Mb/s signal (implemented in Europe and India) has 30 speech channels and 4 supervisory signals to make the frame a 36 channel frame that means 9 rows x 4 columns.

So, in the process of standardisation, we first find the equity in the number of rows for both the conversions. That is why, 9 rows is accepted as

$$\frac{9 \text{ rows x } 270 \text{ columns x } 8 \text{ bits}}{125 \text{ M sec}} = 155.52 \text{ Mb/s}$$

the standard in the STM system.

For STM-1, the bit rate can be calculated as follows :—

The other STM levels are —

- STM-1 : 1,55,520 kbps.
- STM-4 : 6,22,080 kbps
- STM-16 : 24,88,320 kbps

Typically, the core (or backbone) of a network will have point-to-point links at the highest available rates (i. e. STM-16). At the regional level, either point-to-point lines or SDH rings will provide distribution of the SDH signal within a region. At the lowest level (the local level), ring structure may be implemented. In the local ring network, ADMs will supply subscribers with the required transmission facilities.

However, SDH and PDH systems will be used side by side for a long period in the network (which is also the present status of the countrywide telephony system).

6. Network Topologies

Network topologies can be divided into four main types as under:

6.1 String Network

In a string network (Fig. 4) the traffic is transported by a succession of interconnection rodes. The services can be added or dropped at any rode in the chain. The two end rodes are called terminal rodes and can be formed either terminal multiplexers or line terminals. The intermediate rodes can be either add and drop rodes, containing ADMs, or regenerating rodes containing regenerators. String networks are often called linear network of applications such as railway, highway and pipeline network.

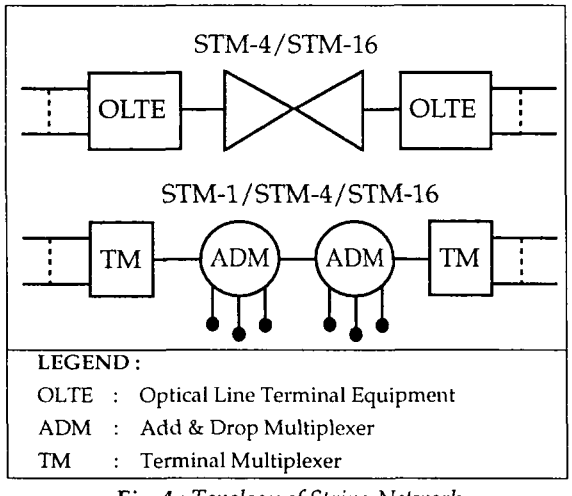

Fig. 4 : Topology of String Network

6.2 Ring Network

A Ring network (Fig. 5) is a String looped back on itself, formed only of ADM nodes, with no terminal node. This type of network plays an important role because of the network's self healing mechanisms that operate at very high speed (< 50 milliseconds) when the network fails due to faults like cable breakage, power failure, fire in a rode etc. Ring network have a wide range of applications from access network onto LAN, WAN and national network.

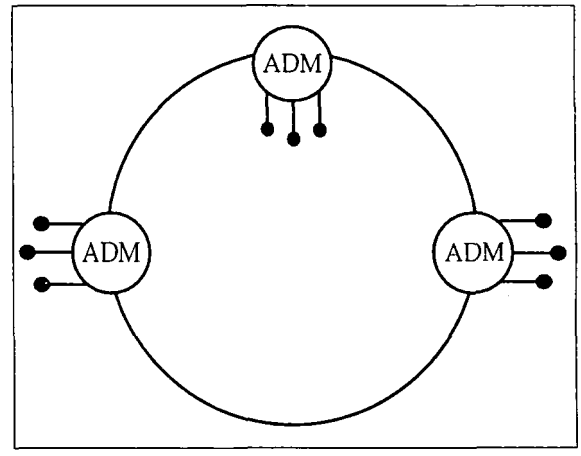

Fig. 5 : Topology of Ring Network

6.3 Star Network

In a Star network (Fig. 6) all the traffic passes through a central node, called the hub, which is generally a cross-connect equipment. The main disadvantage of the Star topology is the weakness of the network. If the hub fails, no traffic can be transported among the various branches (or links) of the Star. This type of topology is commonly used in subscriber access networks.

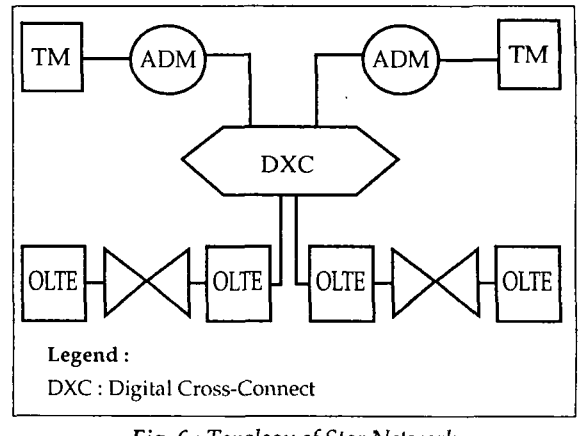

Fig. 6 : Topology of Star Network

6.4 Mesh Network

In a Meshed network (Fig. 7), each hode is interconnected to atleast two others by one or

more links. The modes of meshed networks mainly contain cross-connect equipment. Meshed networks are very useful in SDH, because of their reflex type self-healing mechanism (< 200 milliseconds) with the cross-connect equipments or network restoration through re-rooting (assisted by network manager). Meshed networks are mainly used for national networks.

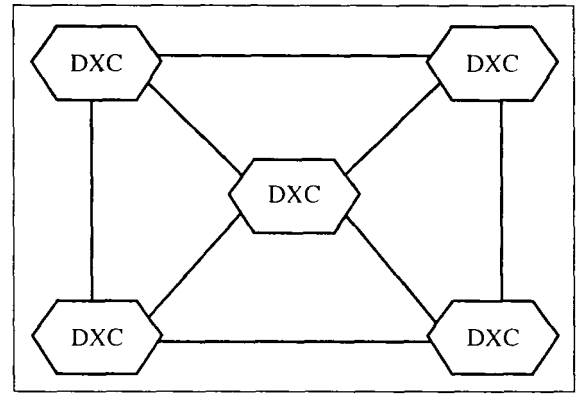

Fig. 7 : Topology of Mesh Network

What greater solace can there be than the feeling that one has lived and died for a principle? What higher satisfaction can a man possess than the knowledge that his spirit will beget kindred spirits to carry on his unfinished task? What better reward can a soul desire than the certainty that his message will be wafted over hills and dales and over the broad plains to every corner of his land and across the seas to distant lands? What higher consummation can life attain than peaceful self-immolation at the altar of one's cause?

— Netaji Subhas Chandra Bose