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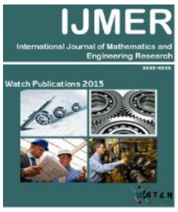

PDH (Plesiochronous Digital Hierarchy)/SDH-SONET (Synchronous Digital Hierarchy / Synchronous Optical Networking)

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Abstract

The rapid increase in development of digital communication networks in the mid-1970s started with the introduction of light-wave systems for transmission. Since that time, services have evolved from voice and fax at 64 Kbit/s to Ethernet and to the next Generation of SDH/SONET which offer more such as resiliency, reliability, scalability, built-in protection, management and rerouting which are sometime called Multiservice Provisioning Platforms (MSPP), can offer a combination of data interfaces such as Ethernet, 8B/10B, MPLS or RPR, without removing those for SDH/PDH from its legacy system. This paper overview the evolution PDH/SDH-SONET networks, services, frame formats, difference between PDH/SDH-SONET and next generation SDH-SONET.

Keywords: *SDH-SONET, PDH/SDH-SONET, communication networks*

INTRODUCTION

Rapid development of digital communication has helped to change from use of direct transfer of point to point to the use of adapter. In order to meet the demand of users, SDH transmission system is now emerged has the new backbone technology that is used to synchronized transmission optical network for integrated information, in which multiplexing, circuit transmission and switching are integrated and operated by the unified network management system.

The mainstream SDH system is standard and common intelligent network management; however, the complexity of this technology and high cost has an excessive burden on customers as the end of access network compare with the traditional telecom PDH networks. PDH (Plesiochronous Digital Hierarchy) technology has continued to meet and fit for the application requirements of end access networks because of its ability to meet customer needs, mature technology, low cost, easy installation, and do not take only 155M port, so PDH technologies are continually and widely used in the end access network market. But, network management cannot take to unified network management of PDH network technology in the end access network. This appear to the major problems that the existence between PDH and SDH technology in same network. This paper analyzed and researched on PDH and SDH-SONET network.

PLESIOCHRONOUS DIGITAL HIERARCHY (PDH)

The integration of traditional time-division multiplexing technology and Ethernet fiber transceiver is an important reason for promoting PDH devices development. Gastone et al. 2008. PDH device provides abundant interfaces, in addition to the standard E1 interfaces; 100M Ethernet interface, voice data interface, and low-speed data interface are provided in order to meet the various needs of users. The simplest transmission signal of PDH network using a multiplexer is E1 signal, the rate of its line is 2.048M, and using PCM encoding. 30 analog phones can be multiplexed into a 2M of base group E1; four E1 can be multiplexed into a 8M of 2 groups, also called as E2; four E2 can be multiplexed into a 34M of 3 groups, also called as E3; four E3 can be multiplexed into a 140M of 4 groups, also called as E4; such a system is PDH, called quasi-synchronous system. Xingyu et al. 2012.

Because Plesiochronous is not quite Synchronous, each of the multiplexers need a small bit of overhead on their high speed trunks to supplement for the slight differences in data rates of the streams on the low speed ports Figure 1. Some of the data from low speed ports (that are running too fast) can be carried in the trunk overhead, and this can happen at all multiplexing levels which can be called Justification or Bit Stuffing.

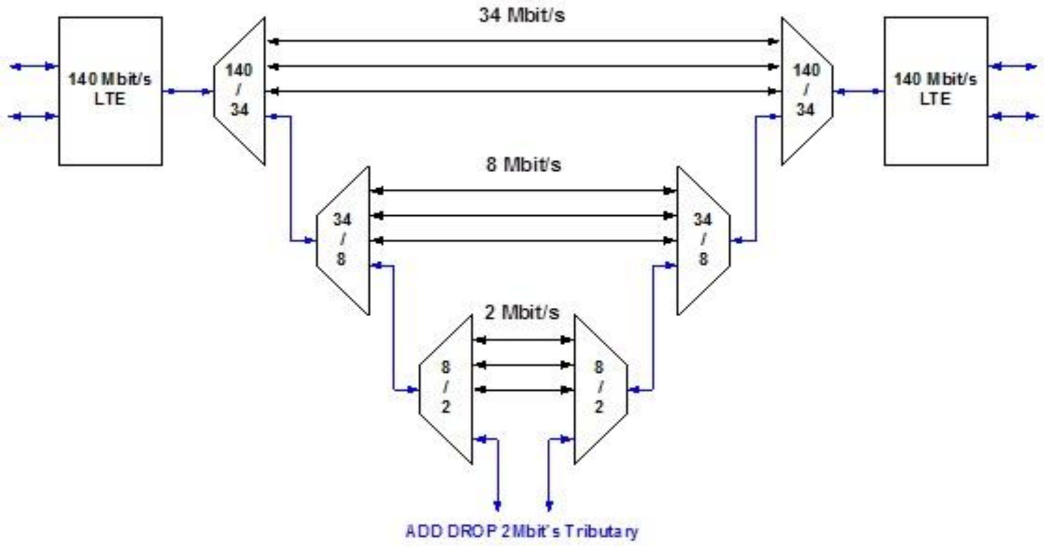

Figure 1: Showing the Plesiochronous Digital Hierarchy (PDH***)***

Table 1: PDH Multiplexing Levels

Level	US (T-)	Europe (E-)	Japan
0	0.064 Mb/s	0.064 Mb/s	0.064 Mb/s
1	1.544 Mb/s	2.048 Mb/s	1.544 Mb/s
2	6.312 Mb/s	8.488 Mb/s	6.312 Mb/s
3	44.736 Mb/s	34.368 Mb/s	32.064 Mb/s
4	274.176 Mb/s	139.264 Mb/s	97.928 Mb/s

PDH Multiplexing Hierarchy

Table 1 shows three different hierarchies. They are US, Europe and Japan and each level are not multiple of each other.

For example Europe and Australia support 120 Calls but it requires more than 4 times the bandwidth of US (T-) to achieve this. This is because PDH is not exactly synchronous and each multiplexing level requires extra bandwidth to perform Bit Stuffing as shown in Figure 2. So Plesiochronous Hierarchy requires “Bit Stuffing”, at all levels, to cater for the differences in clocks. This makes it particularly difficult to locate a particular 2Mbit/s stream in the 140Mbit/s trunk unless you fully de-multiplex the 140Mbit/s stream all the way down to 2Mbit/s.

Drop & Insert a 2Mbit/s stream

To drop & insert a 2Mbit/s stream from a 140Mbit/s trunk you need to break the 140Mbit/s trunk and insert a couple of “34Mbit/s to 140Mbit/s” multiplexers. You can then isolate the appropriate 34Mbit/s stream and multiplex the other 34Mbit/s streams back into the 140Mbit/s trunk. Then you de-multiplex the 34Mbit/s stream, isolate the appropriate 8Mbit/s Stream and multiplex the other 8Mbit/s streams through the higher layer multiplexer, into the 140Mbit/s trunk. Then you de-multiplex the 8Mbit/s stream, isolate the 2Mbit/s Stream that you have been looking for and multiplex the other 2Mbit/s streams up through the higher layer multiplexers into the 140Mbit/s trunk Figure 3.

THE LIMITATIONS OF PDH:-

- ***PDH is not very flexible***

It is difficult to identify individual channels in a higher order bit stream. You must multiplex the high rate channel down through all multiplexing levels to find a particular lower speed channel which very expensive and causes complex “multiplexer mountain”.

- ***Lack of Performance***

It is not easy to provide good performance if you can’t monitor the performance in the first place. For PDH there is no international standard for performance monitoring and no agreed management channels. There are some spare overhead bits that are being used for management but they have limited bandwidth.

- ***Lack of standards***

Not only does PDH have three different multiplexing hierarchies but it is quite weak on standards. For example there are no standards for data rates above 140Mbit/s

From PDH to SDH-SONET

In the early 80's digital systems became more complex, yet there was huge demand for some features that were

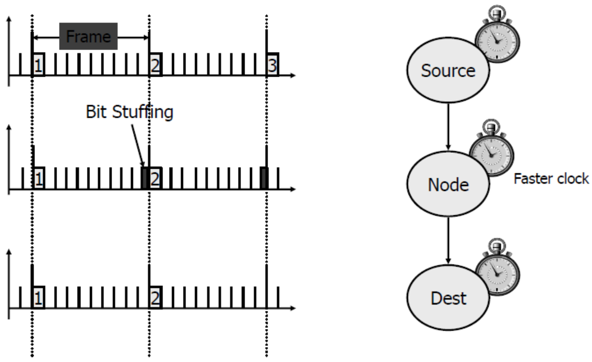

Figure 2: Bit Stuffing

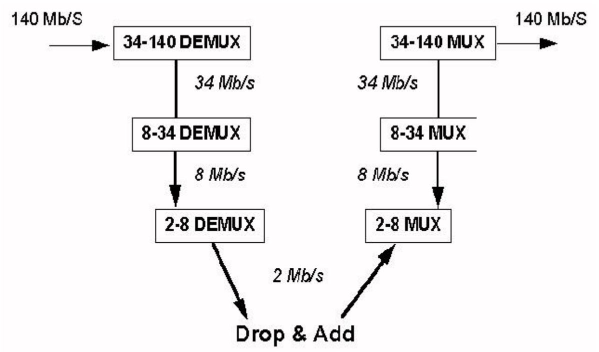

Figure 3: "multiplexer mountain" required to drop & insert the 2Mbit/s stream.

not supported by the existing systems. The demand was mainly to high order multiplexing through a hierarchy of increasing bit rates up to 140 Mbps or 565 Mbps in Europe. The solution that was created then was a multiplexing technique, allowed for the combining of slightly non synchronous rates.

SONET/SDH defines the low level framing protocol used on the optical links. By "framing", we mean a block of bits (or octets) which have a structure, and which utilize some technique which allows us to find the boundaries of that frame structure Table 2. Parts of the block may be devoted to overhead for the network provider to use to manage the network.

Communication between various localized networks is costly because of differences in digital signal hierarchies, encoding techniques and multiplexing strategies. For example, the DS1 signals consist of 24 voice signals and one framing bit per frame. It has a rate of 1.544 Mbps. DS1 uses the AMI encoding scheme, it robs a bit from an eight-bit byte for signaling. Therefore, it has a rate of 56 kbps per channel. But with the B8ZS bipolar violation-encoding scheme, every bit is used for transmission. Therefore, it has a rate of 64 Kbps per channel. The CEPT-1(E1) signal consist of 30 voice signals and 2 channels for framing and signaling, its rate is 2.048 Mbps. Therefore communication between different networks requires complicated multiplexing / de-multiplexing, coding/decoding process to convert a signal from one format to another format. 3ITU-T Rec. 2001. To solve this problem SONET standardize the rates and formats. The Synchronous Transport Signal (STS) is the basic building block of SONET optical interfaces with a rate of 51.84 Mbps. The STS consists of two parts, the STS payload (data, carries the information) and the STS overhead (carries the signaling and protocol information).

SDH/SONET network requires some basic components. Firstly, 3 add/drop multiplexers that function as path termination equipment and line termination equipment and 2 regenerators Figure 4.

- *Path Termination Equipment*: PTE is a network element that multiplex / de-multiplex the STS payload. The STS path terminating equipment assembles 28 1.544Mbps DS1signals and inserts path overhead to from a 51.84 Mbps STS-1 signal. It can detect mismatched Signal labels, also considered provisioned if it has been configured for a mapping and has been assigned signals to and from which the mapping takes place.

- *Section Terminating Equipment:* STE can be a terminating network element or a regenerator and can access, modify, terminate the overhead, or originate them. It regenerates signals for long distance transport.

- *Line Terminating Equipment:* LTE provides the function that originates and terminates line signals. SONET line terminating equipment can originate, access, modify, or terminate line overhead in any combination

a) SDH/SONET FRAME STRUCTURE

The SONET/SDH works on the physical layer of the OSI model. It function is to solve the operation and maintenance problems often found when dealing with networks that have component streams lacking a common clock.

Each SONET STS-1 (Synchronous Transport Signal) Frame is represented by 9 rows of 90 bytes. Each SONET frame is transmitted row by row in 125µsec (microseconds). The math for achieving this transmission rate is as follows:

9 rows x 90Bytes = 810 bytes or 6480 bits. Each frame is sampled once every 125µsec or 8000 frames/sec, 8000 frames/sec x 6480 bits/frame = 51.84 Mbits/sec (Speed of STS-1 SONET payload envelope). SDH [Online].

As illustrated in Figure 5, the STS-1 contains the Synchronous Payload Envelope (SPE) with the data payload(s). Its value is 87 octets. An actual packet or cell within an SPE can span multiple SONET Frames. In the SONET Frames, the first 3 columns make up the SONET Transport Overhead, which consists of 27

Table 2: SDH/SONET data rates

SONET name	SDH name	Line rate (Mbps)	SPE rate (Mbps)	Overhead rate (Mbps)
OC-1	STM-0	51.84	50.112	1.728
OC-3	STM-1	155.52.	150.336	5.184
OC-12	STM-4	622.08	601.344	20.736
OC-48	STM-16	2,488.28	2,406.376	81.944
OC-192	STM-64	9,953.28	9,621.504	331.776
OC-768	STM-256	39,819.12	38,486.016	1,327.104

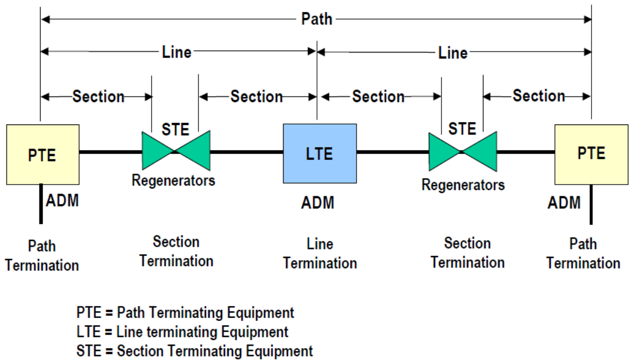

Figure 4: Typical End-to-End SONET connection.

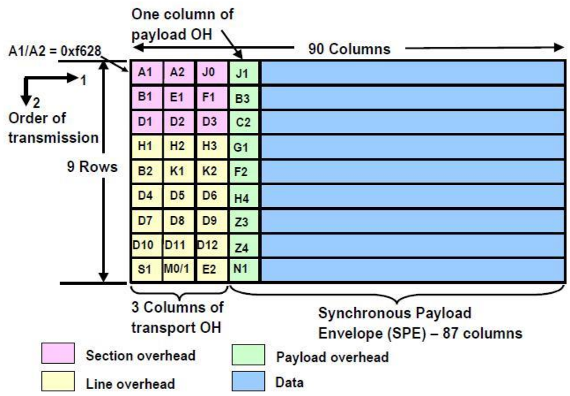

Figure 5: Basic SONET Frame

octets. The SONET Transport Over head is divided up such that the STS Section Overhead (SOH) consumes 9 octets, while the STS Line Overhead (LOH) consumes 18 Octets for a combined SONET Transport Overhead of 27 octets. Both the SOH and LOH are used by the SONET Operations, Administration and Maintenance (OA&M) function to support network management facilities. The SOH fields are used by a receiving SONET multiplexer to synchronize onto the SONET signal. The LOH fields are used Figure 6:

- ***The Photonic Layer***: This is the electrical and optical interface for transporting information over fiber optic cabling. It converts STS electrical signals into optical light pulses. This layer is commonly compared with the Data-Link layer of the OSI model, which also handles framing and physical transfer.

- ***The Section Layer:*** This layer deals with the transport of an STS-N frame across the physical medium. It main functions are framing, scrambling, error monitoring and section maintenance.

- ***The Line Layer***: This takes care of a number of functions, including synchronization and multiplexing for the path layer above it. It also provides automatic protection switching, which uses provisioned spare capacity in the event of a failure on the primary circuit.

- ***The Path Layer:*** This takes services such as DS-3, T1, or ISDN and maps them into the SONET/SDH format. This layer, which can be accessed only by equipment like an add/drop multiplexer (a device that breaks down a SONET/SDH line into its component parts), takes care of all end-to-end communications, maintenance, and control.

b) TOPOLOGY

SONET/SDH supports several topologies, including point to point, a hub and spoke star configuration, and the ring topology. The ring topology, which is by far the most popular, has been used for years by such network technologies as FDDI and Token Ring and has proven quite robust and fault-tolerant. A SONET/SDH ring can contain two pairs of transmit and receive fibers. One pair can be designated as active with the other one functioning as a secondary in case of failure. SONET/SDH rings have a "self-healing" feature that makes them even more appealing for long distance connections from one end of the country to another.

One of SONET/SDH's most interesting characteristics is its support for a ring topology. Normally, one piece of fiber - the working ring - handles all data traffic, but a second piece of fiber, the protection ring remains on standby. Should the working ring fail, SONET/SDH includes the capability to automatically detect the failure and transfer control to the protection ring in a very short period of time, often in a fraction of a second. Cavendish et al. 2002 For this reason, SONET/SDH can be described as a self-healing network technology.

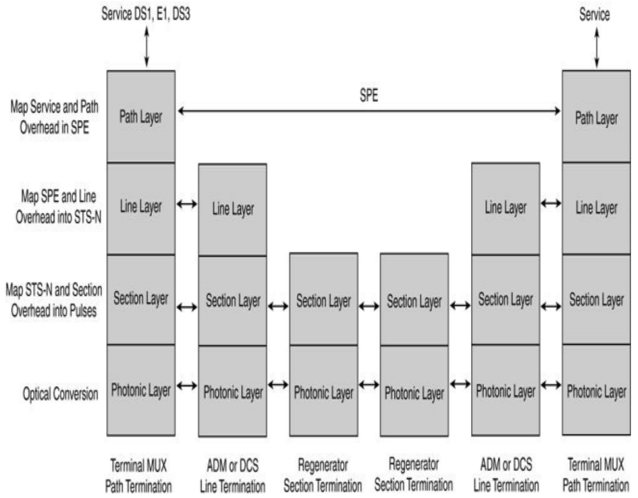

Figure 6: The SONET Layers

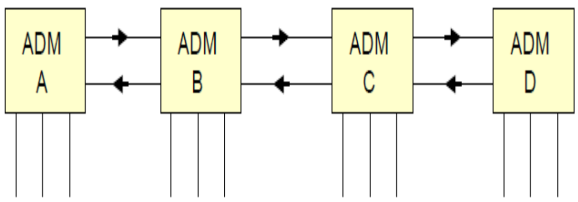

Figure 7: Linear Topology

The usefulness of rings also depends on their physical location. If the rings are located next to each other, then if a back-hoe from a construction company takes out one of your fibers, it is quite likely that the second one will go as well. Thus, your rings should be physically separated from each other as much as possible in order to achieve high uptime Figures 7 and 8.

c) CURRENT DEPLOYMENTS IN THE WORLD

A few years back, the SDH/SONET networks were mostly used for the transport of voice signals, frame-relay and ATM services. But due to the growth of a new generation of services that offer large income to network services operators, there has been a great deployment of SDH/SONET networks in metropolitan and long-distance environments.

Due to this fact, deployment of SDH/SONET has significantly increased in some parts of the world including North America, Europe and some parts of Asia. SONET is widely deployed in the United States and Canada, while SDH is widely deployed in most European and Asian countries, including England, Germany, Russia, China, Japan, and India, just to mention a few. ITU-T (2000)

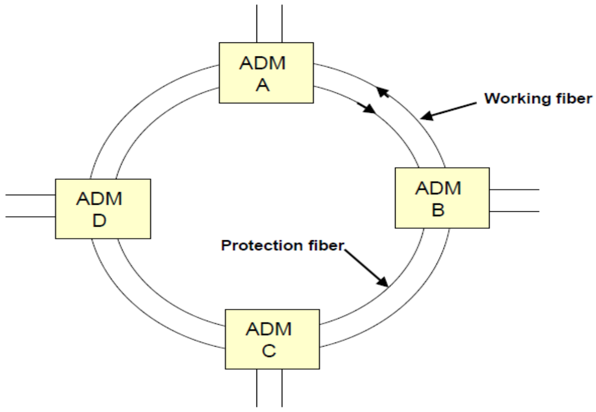

Figure 8: Ring Topology

INTERNET PROTOCOL OVER SONET

The explosive growth in Internet traffic has created the need to transport IP on high-speed links. In the days of low traffic volume between IP routers, bandwidth partitions over a common interface made it attractive to carry IP over a frame relay and/or an ATM backbone. As the traffic grows, it is becoming more desirable to carry IP traffic directly over the synchronous optical network (SONET), at least in the core backbone with very high pairwise demand. However, significant trends in the industry, with the emergent demand for the support of real-time IP services (e.g., IP telephony), is the development of routers with sophisticated quality of service (QoS) mechanisms. IP backbone providers are seeking expedient, cost-effective solutions for providing high-capacity interconnection between gigarouters. Clauberget al. (2000). IP-over-SONET technology is a leading solution to this need. Apart from some flaws with the early IP-over-SONET specification which have subsequently been fixed, IP directly over SONET using HDLC provides a robust, reliable, bandwidth-efficient solution for the transport of IP from 155 Mb/s to 2.4 GB/s rates. Extensions to the specification will be necessary to extend the transmission range to 9.8 GB/s. Based on architectural motivations, optical wavelength-division multiplexing is considered the most cost-effective transport solution in the long-term evolution of IP backbone networks.

OVERVIEW OF PDH AND SDH/SONET

But if we compare the PDH system with that of the SDH system, the latter one has a large number of advantages. Some of the most common advantages enjoyed by the usage of SDH include:

- optical interfaces
- capability of powerful management
- world standard digital format

- synchronous structure is flexible
- cost effective and easy traffic cross connection capacity and add and drop facility
- reduced networking cost due to the transversal compatibility
- forward and backward compatibility

CONCLUSION

Apart from all the advantages mentioned above, the SDH also has various management capabilities such as performance management, security and access management, configuration management and the event or the alarm management. So, we can clearly make a distinction between the PDH and SDH systems so that as per the needs of the telecommunication, the appropriate transmission system can be used.

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