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Analyzing Bandwidth spectrum in SONET & SDH

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ABSTRACT

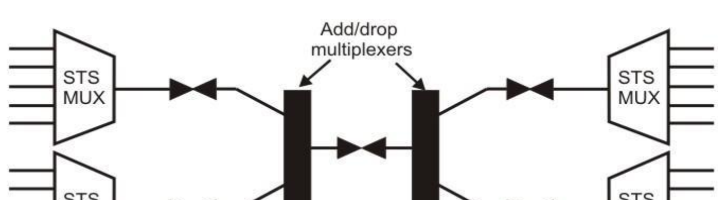
Synchronous Optical Networking & **Synchronous Digital Hierarchy** are standardized protocols that transfer multiple digital bit streams synchronously over optical fiber using lasers or highly coherent light from light-emitting diodes. At low transmission rates data could also be transferred via an electrical interface. method was developed to replace plesiochronous digital hierarchy (PDH) system for transporting large amounts of telephone calls & data traffic over same fiber without synchronization problems. SONET generic criteria are detailed in Telcordia Technologies Generic Requirements document GR-253-CORE. Generic criteria applicable to SONET & other transmission systems (e.g., asynchronous fiber optic systems or digital radio systems) are found in Telcordia GR-499-CORE.

[1] INTRODUCTION

To satisfy requirements of ever increasing data rate for diverse applications; ANSI developed standard known as Synchronous Optical Network (SO-NET) by utilizing enormous bandwidth of optical fiber. Another similar standard developed by ITU-T would be known as Synchronous Digital Hierarchy (SDH). SO-NET would be American National Standards Institute standard for synchronous data transmission on optical media. international equivalent of SO-NET would be synchronous digital hierarchy (SDH). Together; they ensure standards so that digital networks could interconnect internationally and that existing conventional transmission systems could take advantage of optical media through tributary attachments. Short for **S***ynchronous* **O***ptical* **Net***work;* standard for connectingfiber-optic transmission systems. SO-NET had been proposed by Bellcore in middle 1980s and would be now ANSI standard. SO-NET defines interface standards at physical layer of OSIseven-layer model. standard defines hierarchy of interface rates that allow data streams at different rates to be multiplexed. SO-NET establishes Optical Carrier (OC) levels from 51.8 Mb ps(OC-1) to 9.95 Gbps (OC-192). Prior rate standards used by different countries specified rates that had been not compatible for multiplexing. With implementation of SO-NET; communication carriers throughout world could interconnect their existing digital carrier and fiber optic systems.

STS	OC	Raw (Mbps)	SPE (Mbps)	User (Mbps)
STS-1	OC-1	51.84	50.12	49.536
STS-3	OC-3	155.52	150.336	148.608
STS-9	OC-9	466.56	451.008	445.824
STS-12	OC-12	622.08	601.344	594.432
STS-18	OC-18	933.12	902.016	891.648
STS-24	OC-24	1244.16	1202..688	1188.864
STS-36	OC-36	1866.23	1804.032	1783.296
STS-48	OC-48	2488.32	2405.376	2377.728
STS-192	OC-192	9953.28	9621.604	9510.912

Table 1 Synchronous transport signals and optical carriers



Physical Configuration and Network Elements

Three basic devices used in SO-NET system are shown in Fig. 1. Functions of three devices are mentioned below: Synchronous Transport Signal (STS) multiplexer/demultiplexer: It either multiplexes signal from multiple sources into STS signal or demultiplexes STS signal into different destination signals. Regenerator: It would be repeater that takes received optical signal and regenerates it. It functions in data link layer.

Figure 1 Devices used in SO-NET system

[2] LITERATURE REVIEW

1.A research conducted by Mr. Sanjay Kumar in 2010 titled "Study and Simulation of Next Generation SONET/SDH Netwoks" states that according to them the Internet has growing from a small research network to a global network that we use in every day. Network traffic desires have grown quickly over the last few years. Traffic is believed to have grown 100 times between 2000 and 2002 and at 100% every year. The limits of our current computer and telecommunication networks are testes by the rapid expansion of the Internet and the ever increasing demand for multimedia information. The need for the development of new high-capacity networks is required for supporting growing bandwidth requests. Optical networks is a possible answer to put up this rapid growth. In all optical network, data packets were reserved in optical format from door to door. According to the optical buffering technology in electronic networks are challenging to apply in all - optical network. The Internet Protocol (IP) to place information in packets are used for the nearest router is when a host wants to communicate with other hosts.

2 .SONET/SDH Optical Transmission System

This paper describes Fujitsu's SONET/SDH transmission system. Fujitsu produces the Fujitsu Lightwave Add/Drop Shuttle (FLASH) series, which conform to the SONET/SDH standard. The FLASH series was well received in the North America market. Also, this paper describes Fujitsu's plans for future equipment and the key technologies used in some of Fujitsu's new optical transmission systems.

3. In another research by Mr. Bhupesh Bhatia, Mr. Vijay Raj Shokeen & Dr. Narendra Kumar Verma in their research titled "DIFFERENCE BETWEEN SONET AND OBS ON THE BASIS OF BLOCK DIAGRAM" introduced to SONET and OPTICAL BURST SWITCHING (OBS) and compare them on the basis of various parameters. Firstly, Sufficient amount of information is provided so that beginner can understand the underlying technology. After that a light is thrown on the early work on burst transmission incorporated by the characterize of a new emerging protocol for SONET i.e. (NGSONET) and then OBS networks called Just-Enough-Time (JET) and WB-OBS are considered.

4 Research titled "**Analysis, Review and Optimization of SONET/SDH Technology for today and future aspects**" by Gourav Verma & Deepika Ramaiyais dedicated to analysis and review of literature for today's technology and future aspects of optical networks. This in depth analysis of today's SONET/SDH Architecture and Reconfigurable structures for SONET rings has been discussed so that one can formulate the next generation SONET/SDH networks. Network layers are analyzed for their design and issues of

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researches, while dense wavelength division multiplexing equipment has been deployed in networks of major telecommunications carriers for a long time, the efficiency of networking and relation with network control and management have not caught up to those of digital cross-connect systems and packet-switched counterparts in higher layer networks. In this paper, focus on issues by understanding the current structure of the SONET/SDH Layers, its connection to other network technology layers. It will be useful for current OPMA.

[3] Fundamentals of SONET/SDH

When data is transmitted over a communications medium, a number of things must be provided on the link, including framing of the data, error checking, and the ability to manage the link (to name a few). For optical communications these functions have been standardized by the ANSI T1X1.5 committee as Synchronous Optical Networking (SONET) and by the ITU as Synchronous Digital Hierarchy (SDH). Although there are a lot of similarities between SONET and SDH, there are some significant differences, especially in terminology. In an attempt to avoid the confusion, we have focused primarily on SONET and SONET terminology because **SONET is a subset of SDH**. Once we understand SONET, it's easier to understand SDH. There are a number of things in SDH which don't make sense until you realize that SDH had to do it that way to maintain compatibility with SONET. Currently, SONET is more widely used in North America, while SDH is more widely deployed in Europe. So lets first understand the difference between SONET and SDH.

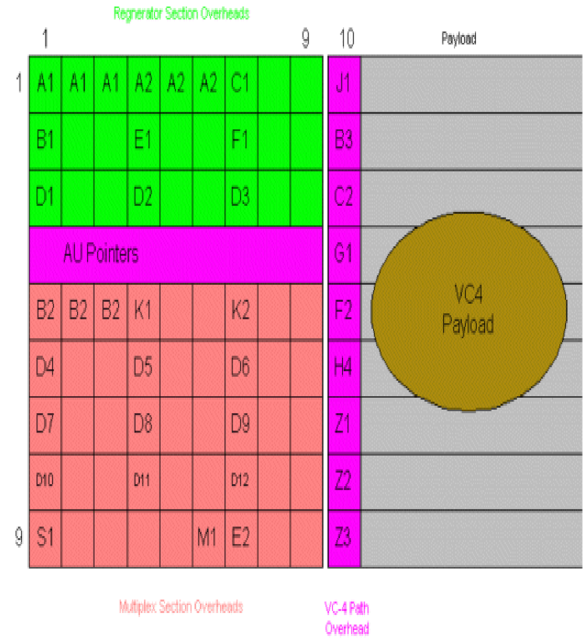

Figure 2 Section and VC-4 Path Overheads

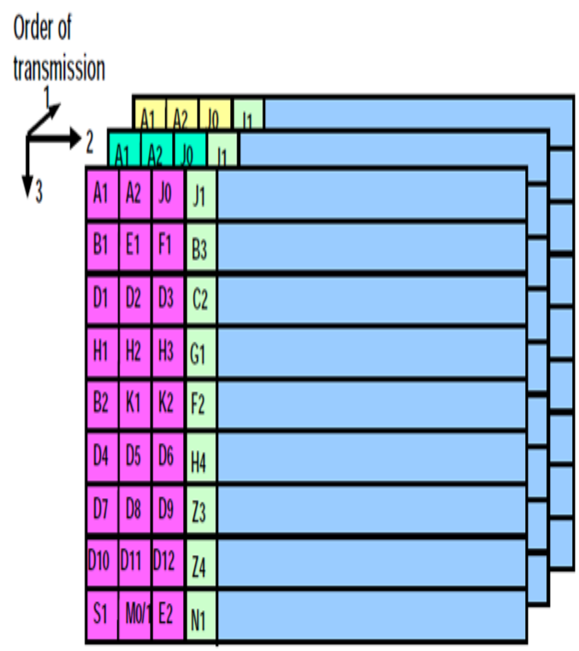

Figure 3. Interleaving of three SONET STS-frames into an STS-3 frame

SONET/SDH Interleaving

An STS- 3 can be thought of as three STS-1 bit streams

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transmitted in the same channel so that the resulting channel rate is three times the rate of an STS-1. And when multiple streams of STS-1 are transmitted in the same channel, the data is octet multiplexed. For example, an STS-3 signal will transmit octet A1 of stream 1, then octet A1 of stream 2, and then octet A1 of stream 3, then octet A2 of stream 1, octet A2 of stream 2, etc. This multiplexing is carried out for all levels of SONET and SDH, including STS-192 and STS-768. Because of this, SONET/SDH maintains a frame time of 125s.

[4] Proposed Work

BIT Interval Parity (BIP)

Networks Compared to PDH/T-Carrier systems, SDH/SONET systems provide advanced network management features. One of the most important is that any bit errors can be assigned to a particular portion of the network, meaning that it is easier to isolate the source of the error. This feature is made possible thanks to a special technique known as “Bit Interleaved Parity” (BIP). Bit Interleaved Parity (BIP-X) code is defined as a method of error monitoring. With “even” parity (as opposed to “odd” parity) an X-bit code is generated by the transmitting equipment over a specified portion (also called “block”) of the frame. The BIP-X calculation principle is the following: The monitored portion is divided in words of X-bit length. “X” can take the values: 1, 2, 8, 24, 96, etc.The first bit of the BIP code provides even parity over the first bit of all the X-bit words in the portion of the frame in question, the second bit provides even parity over the second bit of all the X-bit words within the specified portion, etc.

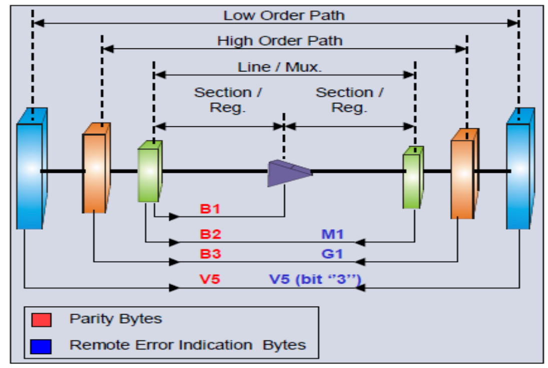

Figure 4 The BIP calculation method introduces some limitations. The limitations regarding the maximum error rates for B1, B2, B3, V5 bytes in SDH/SONET transmission system can be confusing.

As mentioned previously, all the BIPs are calculated over their respective portion and the results are placed in the following frame (except for V5 which is inserted every 4 frames). All the BIPs are calculated prior to scrambling except B1 which is calculated after the frame has been scrambled.The following example illustrates this specific process with the B1 byte:

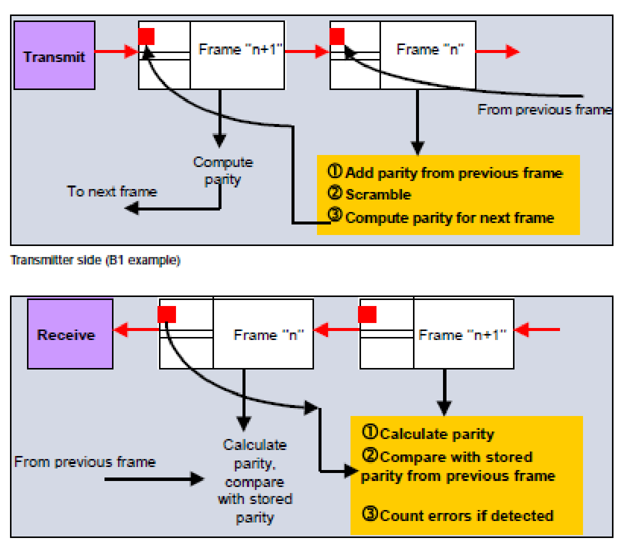

Figure 5 Receiver side (B1 example)

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[5] Result and Discussion

Information is sent over an optical fiber by turning the light off and on in the fiber. For example, suppose that the presence of light indicates a "1" while the absence of light indicates a "0". Just knowing this much we can send and receive bits across an optical link.But how do we extract the information from those bits? This is where SONET/SDH comes in. SONET/SDH defines the low level framing protocol used on these 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. Parts of the block may be devoted to overhead for the network provider to use to manage the network. Other parts will be dedicated to carrying payload, or information we want to communicate. For example, since we assumed the reader knows communications principles, I'm going to assume you already know something about high level data link control protocol (HDLC). HDLC is the protocol used on lower speed links, perhaps over a POTS modem link. HDLC has a framing character at the beginning and end of the frame, some control information, the payload, and a cyclic redundancy check (CRC) field which is used to check if any errors occurred in the transmission. See Figure 5.1. SONET/SDH is simply the HDLC for optical links.

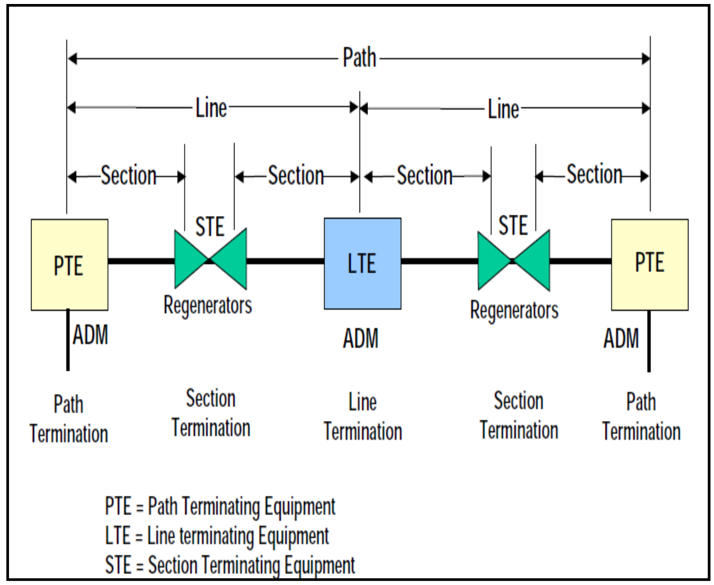

Figure 6 Terminology used in SONET/SDH.

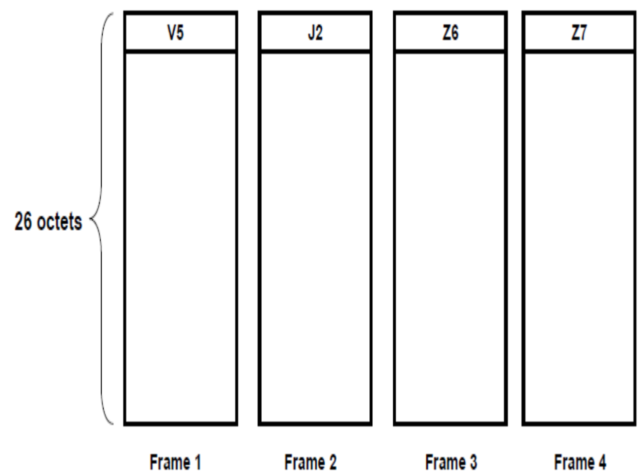

Figure 7 The four VT payload frames of a super frame.

The SONET equipment keeps track of where the V1, V2, V3, and V4 octets are so we can think of the VT payload as existing in isolation without the V1, V2, V3, V4 octets. And since we have a four-frame multiframe, the VT payload is

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divided into four sections, or frames, of 26 octets each. See Figure 7.

Type of digital circuit	Bit rate (Mbps)
DS-1 (T1)	1.544
E1	2.048
DS-1C	3.152
DS-2	6.312
DS-3 (T3)	44.736

Table 2 : Plesiochronous traffic mapped into a SONET STS-1 frame.

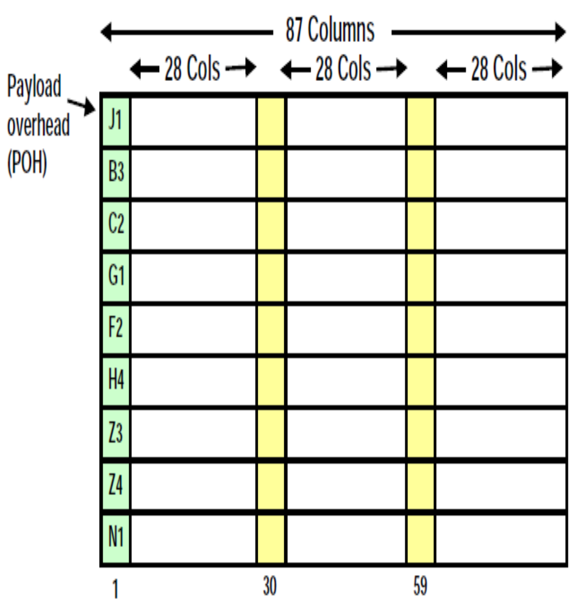

Figure 8 The payload (SPE) of an STS-1 SONET frame

One column is taken by the payload overhead (POH) leaving 86 columns. Next, we break the 86 columns into seven groups of 12 columns. Now seven groups of 12 columns are only 84 columns, leaving two extra columns. These two columns are columns 30 and 59, where the POH is counted as column 1. All mappings of payloads into an STS -1 frame have these two columns "blocked out" meaning that the real payload of an STS-1 SPE is really only 84 columns by 9 rows, by 8 bits, eight thousand times per second or 48.384 Mbps. Each of these seven groups is called a Virtual Tributary Group (VTG). The seven VTGs are interleaved into the 84 columns in the same manner as was discussed earlier for interleaving STS -1s into higher levels of SONET, e.g., into an STS-3. That is, the first column of the first VTG goes into the column after the POH. Then is the turn of the first column of the second VTG and after then the first column of the third VTG, and so on.

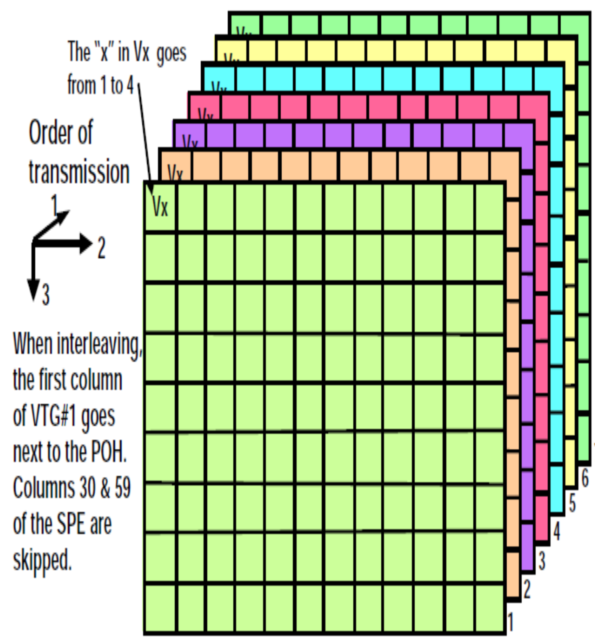

Figure 9 : The 84 usable columns of the STS-1 SPE are divided into seven groups of 12 columns. Each group of twelve columns is known as a virtual tributary group (VTG). The VTGs are interleaved into the SPE in the same fashion as STS-1 are interleaved into an STS-N.

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