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Review on Data transmission 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.

SONET & SDH, which are essentially same, were originally designed to transport circuit mode communications (e.g., DS1, DS3) from a variety of different sources, but they were primarily designed to support real-time, uncompressed, circuit-switched voice encoded in PCM format.[3] primary difficulty in doing this prior to SONET/SDH was that synchronization sources of these various circuits were different. This meant that each circuit was actually operating at a slightly different rate & with different phase. SONET/SDH allowed for simultaneous transport of many different circuits of differing origin within a single framing protocol. SONET/SDH is not a communications protocol in itself, but a transport protocol.

1. INTRODUCTION

SONET & SDH often use different terms to describe identical features or functions. This could cause confusion & exaggerate their differences. With a few exceptions, SDH could be thought of as a superset of SONET. SONET is a set of transport containers that allow for delivery of a variety of protocols, including traditional telephony, ATM, Ethernet, & TCP/IP traffic. SONET therefore is not in itself a native communications protocol & should not be confused as being necessarily connection-oriented in way that term is usually used. The protocol is a heavily multiplexed structure, with header interleaved between data in a complex way. This permits encapsulated data to have its own frame rate & be able to "float around" relative to SDH/SONET frame structure & rate. This interleaving permits a very low latency for encapsulated data. Data passing through equipment could be delayed by at most 32 microseconds (μs), compared to a frame rate of 125 μs; many competing protocols buffer data during such transits for at least one frame or packet before sending This on. Extra padding is allowed for multiplexed data to move within overall framing, as data is clocked at a different rate than frame rate. protocol is made more complex by decision to permit this padding at most levels of multiplexing structure, but This improves all-around performance. Both SDH & SONET are widely used today: SONET in United States & Canada, & SDH in rest of world. Although SONET standards were developed before SDH, this is considered a variation of SDH because of SDH's greater worldwide market penetration. SONET is subdivided into four sublayer with some factor such as path, line, section & physical layer. The SDH standard was originally defined by European Telecommunications Standards Institute (ETSI), & is formalized as International Telecommunication Union (ITU) standards G.707,

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G.783,G.784, & G.803. SONET standard was defined by Telcordia & American National Standards Institute (ANSI) standard T1.105. which define set of transmission formats & transmission rates in range above 51.840 Mbit/s. Advantages of HDT A single fiber link could be used to send different kinds of traffic to full capacity of link. There is no need to set up VT or sub-VT channels in advance. ATM cells, IP (and other protocols) packets, PPP, frame relay, NxDS0, T1/T3, & others could be mixed inside SPE on a packet-by-packet basis. PDH channels such as T1/E1 could be dynamically allocated anywhere inside SONET payload in 64kbps bandwidth increments. Bandwidth is reusable in fine granularity in 64kbps increments, with any type of data. For instance, an IP packet could be dropped at node B & node B could reuse packet area for inserting ATM cells, frame relay, PDH traffic, or any other data type. HDT could take many packets of one or different data types & put them inside a single SONET or data-over-fiber frame while preserving time dependency of data packets such as PDH. It is not necessary to terminate whole payload capacity at each node. Direct data-over-fiber configurations (without SONET framing) could be easily supported without frame structure changes, with full link monitoring & management. Support for variable-size packet SONET add/drop multiplexer (SONET ADM) devices. Variable-size packets could be put inside a SONET SPE & nodes could cross-connect & add/drop packets on different ports. The SDL framing protocol prefixes a payload with a 32-bit word, 16 bits of which hold length of packet. other 16 bits contain CRC (Cyclic Redundancy Check) for length field. SDL provides a robust CRC-16 based framed boundary delineation mechanism (compared with traditional 0x7E delimiter) that solves all current POS issues like robustness in bad BER conditions, variable packet size expansion, & malicious long-packet scrambler manipulation.

A null packet inside a frame is a 32-bit length/CRC construct with length field equal to zero. Packets are located by hunting for a length/CRC match, same way that ATM cells are located by HEC synchronization. next packet within a SONET payload is located by jumping length bytes in frame & again looking for a length/CRC match. In case of data corruption at location of a length CRC field, hardware begins a byte-by-byte hunt for length/CRC construct until a match is found.

2. PACKET FRAMES

In packet-oriented data transmission, such as Ethernet, a packet frame usually consists of a header & a payload. header is transmitted first, followed by payload (and possibly a trailer, such as a CRC). In synchronous optical networking, this is modified slightly. header is termed *overhead*, & instead of being transmitted before payload, is interleaved with this during transmission. Part of overhead is transmitted, then part of payload, then next part of overhead, then next part of payload, until entire frame has been transmitted. In case of an STS-1, frame is 810 octets in size, while STM-1/STS-3c frame is 2,430 octets within size. For STS-1, frame is transmitted as three octets of overhead, followed by 87 octets of payload. This is repeated nine times, until 810 octets have been transmitted, taking 125 μs. In case of an STS-3c/STM-1, which operates three times faster than an STS-1, nine octets of overhead are transmitted, followed by 261 octets of payload. This is also repeated nine times until 2,430 octets have been transmitted, also taking 125 μs. For both SONET & SDH, this is often represented by displaying frame graphically: as a block of 90 columns & nine rows for STS-1, & 270 columns & nine rows for STM1/STS-3c. This representation aligns all overhead columns, so overhead appears as a contiguous block, as does payload. The internal structure of overhead & payload within frame differs slightly between SONET & SDH, & different terms are used within standards to describe these structures. Their standards are extremely similar within implementation, making this easy to interoperate between SDH & SONET at any given bandwidth. In practice, terms STS-1 & OC-1 are sometimes used interchangeably, though OC designation refers to signal within its optical form. This is therefore incorrect to say that an OC-3 contains 3 OC-1s: an OC-3 could be said to contain 3 STS-1s. SDH FRAME The STM-1 (Synchronous

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Transport Module, level 1) frame is basic transmission format for SDH—the first level of synchronous digital hierarchy. STM-1 frame is transmitted within exactly 125 µs, therefore, there are 8,000 frames per second on a 155.52 Mbit/s OC-3 fiber-optic circuit. STM-1 frame consists of overhead & pointers plus information payload. first nine columns of each frame make up Section Overhead & Administrative Unit Pointers, & last 261 columns make up Information Payload. pointers (H1, H2, H3 bytes) identify administrative units (AU) within information payload. Thus, an OC-3 circuit could carry 150.336 Mbit/s of payload, after accounting for overhead. Carried within information payload, which has its own frame structure of nine rows & 261 columns, are administrative units identified by pointers. Also within administrative unit are one or more virtual containers (VCs). VCs contain path overhead & VC payload. first column is for path overhead; this is followed by payload container, which could itself carry other containers. Administrative units could have any phase alignment within STM frame, & this alignment is indicated by pointer within row four. The section overhead (SOH) of a STM-1 signal is divided into two parts: *regenerator section overhead* (RSOH) & *multiplex section overhead* (MSOH). overheads contain information from transmission system itself, which is used for a wide range of management functions, such as monitoring transmission quality, detecting failures, managing alarms, data communication channels, service channels, etc. The STM frame is continuous & is transmitted within a serial fashion: byte-by-byte, row-by-row. Transport overhead The transport overhead is used for signaling & measuring transmission error rates, & is composed as follows: Section overhead Called RSOH (regenerator section overhead) within SDH terminology: 27 octets containing information about frame structure required by terminal equipment. Line overhead Called MSOH (multiplex section overhead) within SDH: 45 octets containing information about error correction & Automatic Protection Switching messages (e.g., alarms & maintenance messages) as may be required within network. error correction is included for STM-16 & above. AU Pointer Points to location of J1 byte within payload (the first byte within virtual container) Path virtual envelope Data transmitted from end to end is referred to as path data. This is composed of two components: Payload overhead (POH) Nine octets used for end-to-end signaling & error measurement Payload User data (774 bytes for STM-0/STS-1, or 2,340 octets for STM-1/STS-3c) For STS-1, payload is referred to as synchronous payload envelope (SPE), which within turn has 18 stuffing bytes, leading to STS-1 payload capacity of 756 bytes. The STS-1 payload is designed to carry a full PDH DS3 frame. When DS3 enters a SONET network, path overhead is added, & that SONET network element (NE) is said to be a *path generator & terminator*. SONET NE is *line terminating* if this processes line overhead. Note that wherever line or path is terminated, section is terminated also. SONET regenerators terminate section, but not paths or line. An STS-1 payload could also be subdivided into seven *virtual tributary groups* (VTGs). Each VTG could then be subdivided into four VT1.5 signals, each of which could carry a PDH DS1 signal. A VTG may instead be subdivided into three VT2 signals, each of which could carry a PDH E1 signal. SDH equivalent of a VTG is a TUG-2; VT1.5 is equivalent to VC-11, & VT2 is equivalent to VC-12.

Three STS-1 signals may be multiplexed by time-division multiplexing to form next level of SONET hierarchy, OC-3 (STS-3), running at 155.52 Mbit/s. signal is multiplexed by interleaving bytes of three STS-1 frames to form STS-3 frame, containing 2,430 bytes & transmitted within 125 µs.

Higher-speed circuits are formed by successively aggregating multiples of slower circuits, their speed always being immediately apparent from their designation. For example, four STS-3 or AU4 signals could be aggregated to form a 622.08 Mbit/s signal designated OC-12 or STM-4.

The highest rate commonly deployed is OC-768 or STM-256 circuit, which operates at rate of just under 38.5 Gbit/s.[13] Where fiber exhaustion is a concern, multiple SONET signals could be transported over multiple wavelengths on a single fiber pair by means of wavelength-division multiplexing,

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including dense wavelength-division multiplexing (DWDM) & coarse wavelength-division multiplexing (CWDM). DWDM circuits are basis for all modern submarine communications cable systems & other long-haul circuits.

3. SONET/SDH DATA RATES

SONET/SDH Designations & bandwidths				
SONET Optical Carrier level	**SONET frame format**	**SDH level & frame format**	**Payload bandwidth[nb 3] (kbit/s)**	**Line rate (kbit/s)**
OC-1	STS-1	STM-0	50,112	51,840
OC-3	STS-3	STM-1	150,336	155,520
OC-12	STS-12	STM-4	601,344	622,080
OC-24	STS-24	–	1,202,688	1,244,160
OC-48	STS-48	STM-16	2,405,376	2,488,320
OC-192	STS-192	STM-64	9,621,504	9,953,280
OC-768	STS-768	STM-256	38,486,016	39,813,120

4. OBJECTIVE OF RESEARCH

a. Study of Frame format within case of SDH & SONET at different Carrier levels

b. Analysis of payload bandwidth within SDH & SONET at different Carrier levels

c. Analysis of line rate within case of SDH & SONET at different Carrier levels

d. Comparative analysis of data transmission within Case of SDH, SONET & other technologies.

e. To make analysis of challenges faced during implementation of SDH & SONET

5. TOOLS & TECHNOLOGY

Hardware Requirement:

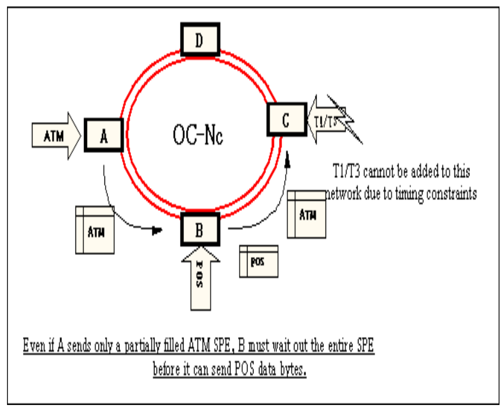
- PROCESSOR: Intel(R) Core(TM) i3-2310M CPU@2.27Ghz
- INSTALLED MEMORY (RAM): 2.00 GB
- SYSTEM TYPE: 32/64 bit operating system

Software Requirement:

- MATLAB
- Window 7

6. CHALLENGES

Lack of support for data mix within SONET



Lack of data mix within a SONET payload results within poor bandwidth use

In a SONET payload, only one type of data (such as ATM cells, POS, or PDH traffic), identified by a unique PSL (Path Signal Label) C2 byte value within POH, could be carried at one time.This lowers bandwidth usage even for networks carrying only delay-tolerant data traffic. In figure [xx], for instance, nodes at different points within SONET ring have different types of data to send on network. Assume, for instance, that node A has ATM cells to transmit on SONET ring. This creates a SONET SPE, sets PSL value (in POH) for ATM cells & sends SONET frame down link. Even if SPE is only partially full, an entire SPE frame must be transmitted. If node B has IP packets to send, This cannot use partially filled

SONET frame received from A to add POS packets because PSL value identifies only ATM cells.

7. SCOPE OF RESEARCH

SONET was designed to efficiently carry Plesiochronous Digital Hierarchy (PDH) telephony channels such as T1/T3. This was easily achieved by dividing its payload area within fixed slots called virtual tributaries (VT). Nowadays, wide-area & metropolitan-area network (MAN) communications rely on short- & long-haul fiber optic networks to transport data & telephony traffic. As volume of packet data on optical networks has gone up, many methods have been developed to force-fit packet data onto SONET framework, which is better suited for PDH transport. Using current protocols for simultaneous support of packet network & PDH traffic on SONET results within inefficient use of precious optical fiber bandwidth. This research refers to SONET for all of its discussions, with similar implications for Synchronous Digital Hierarchy. With growing volume within data traffic, SONET/SDH networks must now carry a significantly large number of data packets within addition to traditional T1/T3 channels. Current protocols on these networks, however, do not allow transmission of different data types on a single fiber (or wavelength) without seriously compromising timing relationships and/or wasting available bandwidth. This paper describes a Hybrid Data Transport (HDT) protocol that allows transmission of Fractional T1 (in increments of DS0, starting at DS0 bandwidth), T1/T3, ATM, IP & any other protocol data within a single SONET frame, allowing maximum bandwidth usage on a fiber. With a unified packet framing across a mix of SONET & non-SONET networks, dynamic bandwidth provisioning on a packet-by-packet basis, & hybrid data mixing capability, this protocol maximizes bandwidth usage & yields major cost savings within fiber infrastructure, equipment, & operation.

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