



SONET

Synchronous Optical Networking

Technical Overview

WHITE PAPER

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1.0 INTRODUCTION

In today's business world, each industry is looking for different ways to create competitive advantages to deliver information, products and services in a more timely and cost effective manner. End-to-end SONET (Synchronous Optical Networking) network solutions are one important ingredient in creating a competitive edge. As a convergence technology, SONET provides for the unification of voice, data and video over the same transport service.

This guide is intended to offer an operational overview of SONET (Synchronous Optical Networking) for those who are not familiar with the standard, or those who want to refresh their knowledge. At the beginning of this document, an important point to remember is this: SONET is a powerful, highly scalable technology. Although it may appear to be complex, most of what goes on in a SONET network is transparent to the user. Another note of importance: This guide briefly discusses Wave Division Multiplexing (WDM) for awareness purposes only, since WDM is another high-performance transport technology that also leverages fiber optics.

SONET is a *transport* technology, designed to provide enterprise and government users – as well as service providers – a network infrastructure with survivability characteristics, so that business operations continue uninterrupted. SONET's self-healing fiber optic ring functionality enables automatic network recovery due to failures that can be caused by a fiber optic cable cut, lost signal, or degraded signal (e.g. due to aging laser) or node/system failure. SONET is also a technology that is designed to ensure network traffic is restored within 60 milliseconds in the event of a failure.

SONET is the North American standard for telecommunications transmission using fiber-optic cables. SONET provides a set of protocols for the management and control of high bandwidth optical networking transmission. The SONET standard includes definitions for a multiplexing structure, optical parameters, service mappings, and network management (operations) support for existing and future services. SONET uses standardized interfaces, which allows multivendor interconnection of terminal (SONET Multiplexers) and subsystems.

This document will discuss: a brief history of SONET's inception, SONET deployment, the differences between SONET and ATM, the advantages of deploying ATM over SONET, Wave Division Multiplexing (WDM), and SONET technology.

The SONET technology section of this document makes up the body of this document. SONET is discussed from the viewpoint of the User Device into the SONET Multiplexer into a SONET ring and its operational aspects (see figure 1).

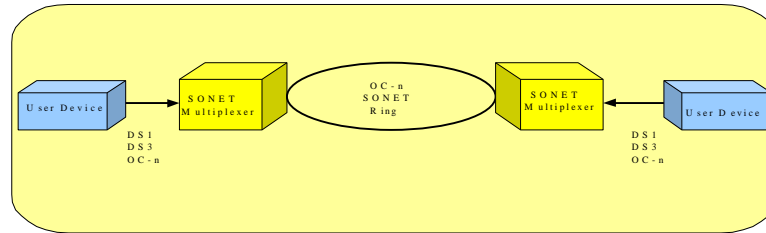


Figure 1

2.0 INCEPTION OF SONET

SONET was conceived of and written about back in the early 1980's, when submitted to the members of American National Standard Institute (ANSI) T1 Committee as a universal transport system. In the mid-1980's the T1 Committee further enhanced the standard to arrive at the Synchronous Transport Signal One (STS-1) as the base-signaling rate. Around this time, the ITU-T (International Telecommunication Union-Telecommunications standard) (formerly CCITT) adopted SONET as the basis for its international standard referred to as SDH (Synchronous Digital Hierarchy) transport system, where the STS-1 rate (51.84Mbps) was to be a factor of 3 in terms of the European base rate of 155.52Mbps.

3.0 SONET DEPLOYMENT

SONET equipment is being deployed in significant numbers into the field by most of the major Service Providers (e.g. SPRINT-SONET Sphere, U.S. West Network 21, and MCI). Many utility, civil government and large enterprise customers have also elected to deploy SONET on their enterprise backbones to take advantage of its scalability, high performance, and inherent reliability and survivability characteristics. These government and enterprise customers either bypass their local carriers and self-manage the entire SONET infrastructure, or they tie into a Central Office (CO) to allow their local service provider to offer WAN connectivity or network management services.

In North America, SONET equipment is being deployed and configured to transport DS-1, DS-3, ATM, FDDI, Frame Relay and IP traffic among other services, using ring-based, hub-based and point-to-point based configurations. The ring-based configuration is the most popular SONET topology, where mission-critical applications demand network survivability. For additional survivability, dual-ring configurations are also being implemented (discussed later in this document).

4.0 DIFFERENCE BETWEEN SONET AND ATM

In terms of the 7 layer OSI model, SONET is a layer 1 (physical layer) technology, where ATM (Asynchronous Transfer Mode) is a layer 2 (data link) and above technology. ATM must use a physical layer technology to transport its services. SONET is one of the physical

layers used by ATM. Other physical layer examples include WAN interfaces such as DS1/E1, DS3/E3. The operations of ATM are essentially independent from and transparent to the physical layer. ATM is based on a fixed cell length technology, where SONET is frame based. Also, ATM specifies the insertion of cells into SONET frames, such that ATM cells can be transported over a SONET infrastructure.

5.0 ADVANTAGES OF ATM RUNNING OVER SONET

Given that SONET is a physical layer technology, government agencies and enterprises that deploy ATM are able to leverage the benefits of SONET as a transport technology. By interconnecting campus-based ATM devices to high-speed SONET devices, users are able to leverage the inherent advantages of SONET, which include the following:

- Multivendor interoperability through standardized interfaces
- Fault-tolerance and survivability
- High-performance, scalable transport capabilities

6.0 What Is Wave Division Multiplexing (WDM)?

Wave Division Multiplexing (WDM) is a technology that leverages fiber optic cable to more than double its available bandwidth. WDM is a technology based on photonics. Photonics provide a method to send bits of information using pulses of light through fiber cables. WDM uses a technology set that can generate many shades of light (channels) through a single fiber span, allowing each shade to carry different bits of network traffic.

By increasing the bandwidth available on existing fiber optic cable, users are able to achieve higher bandwidths while foregoing the high costs of laying additional fiber optic cable throughout their enterprise.

Waveband Division Multiplexing technology uses a Waveband Coupling System to combine 2 (e.g. Narrowband WDM) or more optical signals of different wavelengths on an existing fiber optic cable (span). WDM technology is implemented in three variations:

- Narrowband
- Wideband
- Dense

6.1 Narrowband WDM (NWDW) is a technology that doubles the fiber span's capacity. NWDW implements two wavelengths, typically 1533 and 1577 nanometers (nm) wavelengths.

6.2 Wideband WDM (WWDM) is technology that increases a fiber span by twofold. WWDM is implemented by combining a 1310nm wavelength with another wavelength into the low-loss window of a fiber optic cable between 1528nm and 1560nm in wavelength.

6.3 Dense WDM (DWDM) is a technology that can increase a fiber span's capacity by eightfold. DWDM implements 8 wavelengths, which fall into two different bands, a red band and a blue band. Each band is used in opposing directions. The wavelengths for each are as follows:

- Red Band – 1529nm and 1541nm wavelengths
- Blue Band - 1549nm and 1577nm wavelengths

6.4 Lucent WDM Systems

Lucent Technologies leads the WDM systems industry with such systems as the 80-channel (Ultra-Dense Wave Division) WaveStar™ OLS 400G Global Optical Networking System that can deliver *up to 400Gbps* of capacity over a single fiber span. Lucent has *more than 1,600 patents* in optical networking, including the invention of the laser.

7.0 SONET TOPOLOGIES

SONET technology enables a number of different network topologies to solve networking requirements, including survivability, cost, and bandwidth efficiencies. The following provides a description of 3 different SONET configurations, which are deployed in a variety of enterprise situations. The SONET configurations include:

- Point-to-point configuration
- Hubbed configuration
- Linear Add/Drop configuration
- Ring configuration

7.1 Point-to-Point Configuration

SONET point-to-point configurations (see figure 2) create a simple topology that terminates a SONET payload at each point of a fiber optic cable span. Point-to-point configurations are typically deployed in transport applications, which require a single SONET multiplexer in a single route. Point-to-point configurations can be enhanced to increase survivability by to deploying a protection path (second fiber span) over a different path between two or more SONET multiplexers.

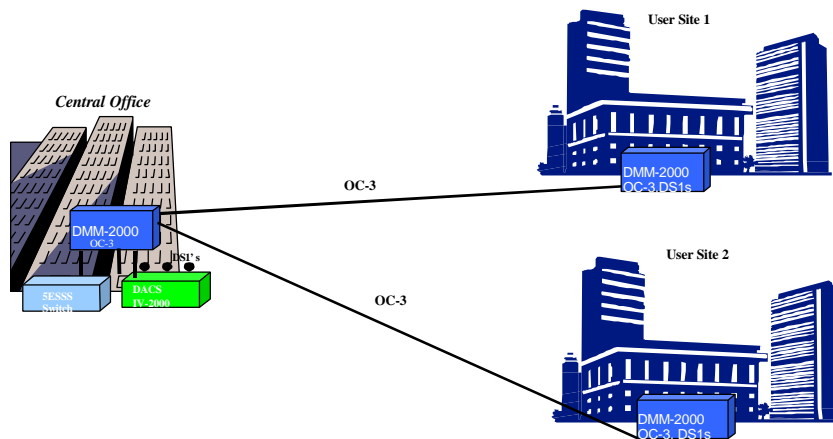


Figure 2
Point-to-Point Configuration

7.2 Hubbed Configuration

Hubbed configurations (see figure 3) consolidate traffic from multiple sites onto a single optical channel, which then can be forwarded to another site. This topology is often used in applications where the user wants to consolidate traffic from multiple satellite sites to a single site such as corporate headquarters, before extending it, in some cases to a central office. This topology helps to reduce the number of hops as well as the equipment required to create a multisite topology.

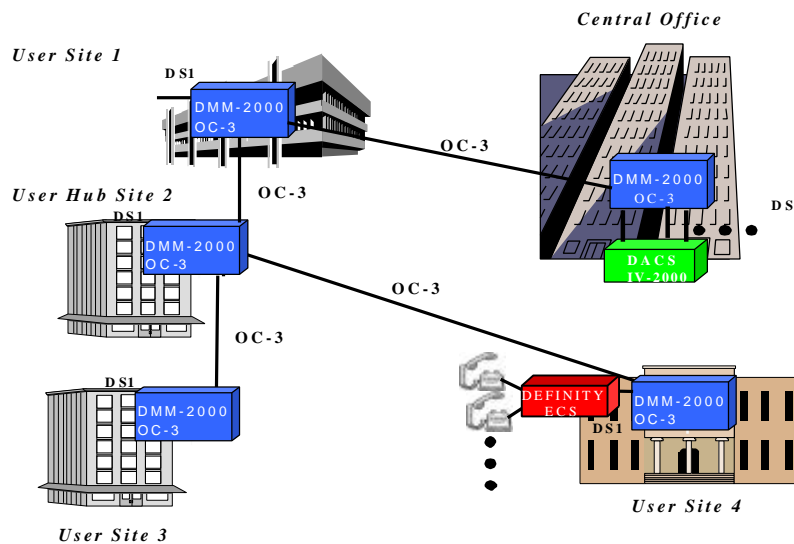


Figure 3
Hubbed Configuration

7.3 Linear Add/Drop Configuration

In the asynchronous digital signal hierarchy environment, every time a digital signal is accessed the entire signal needs to be multiplexed/demultiplexed, costing time and money at each site along a given path. However, a Linear Add/Drop configuration (see figure 4) enables direct access to VTS/STS channels at each intermediate site along a fiber optic path. Therefore the Linear Add/Drop configuration eliminates the need to process (multiplex/demultiplex) the entire optical signal for pass-through traffic.

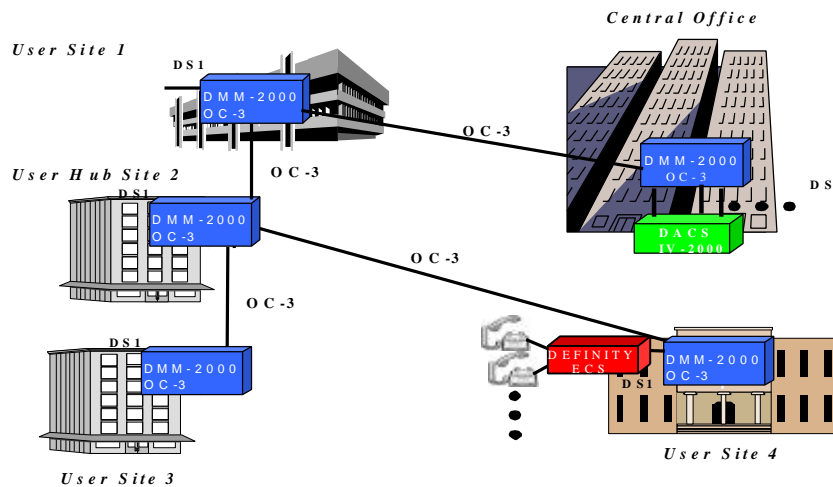


Figure 4
Add/Drop Linear Configuration

7.4 Self-Healing Ring Configuration

In a Self-Healing Ring configuration, a mechanism referred to as Automatic Protection Switching is employed. There are two types of protection ring topologies. The first is UPSR (unidirectional Path Switched Ring), the other is BLSR (Bi-directional Line Switched Ring). Each of these ring topologies is discussed later in this section of this document. The Self-Healing Ring configuration is the most commonly deployed SONET topology in mission critical government and enterprise backbones, due to its survivability characteristics.

Automatic Protection Switching is a mechanism provided within the SONET specification that is designed to provide duplicate finer span paths. In this configuration, a backup fiber span (protection ring) is enabled when and if there is a failure within the fiber span currently carrying traffic on a SONET network. It should be noted that during normal operating conditions, both fiber spans are always active, and a SONET multiplexer selects which fiber span to receive traffic, based on an internal algorithm (e.g. based on which fiber module was installed in the multiplexer first). The SONET standard specifies that the protection ring should automatically become the fiber span (ring) the SONET multiplexer receives traffic from within 60 milliseconds (unnoticeable to the user) in the event of a failure on the other fiber span (see figure 5).

There are three main types of operational problems that can occur where the protection ring will take over and become the fiber span (ring):

- A break in the fiber cable
- Signal failure (e.g. laser problem)
- Signal degrade (which can happen when an old laser fail due to age)
- Node failure

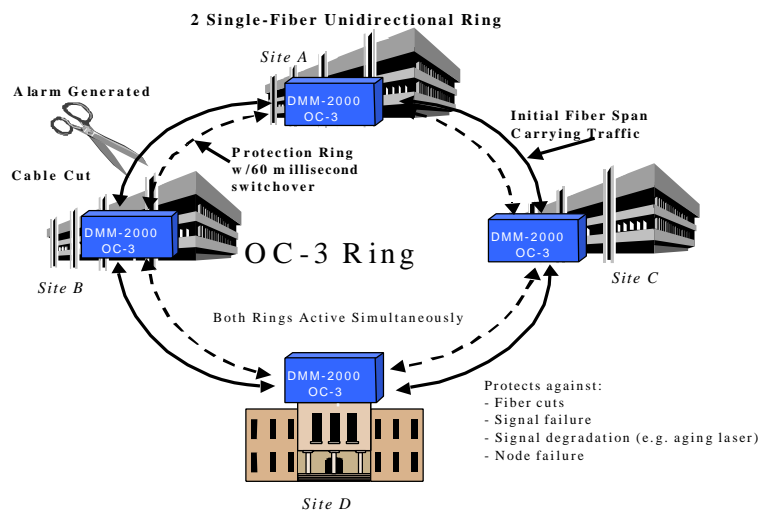


Figure 5
Automatic Protection Switching Ring

7.4.1 Bi-directional Line Switched Self-Healing Ring (BLSR)

A network configuration known as a Bi-Directional Line Switched Self-Healing Ring (BLSR) is another means of creating a survivable SONET network. This type of configuration uses a closed-loop transport design that implements duplicate, geographically diverse paths for each SONET service. The closed-loop design implements bi-directional fiber spans, where each dual fiber span handles one direction of SONET traffic. Each direction of SONET traffic carries a duplicate copy of the traffic, one on the working ring and the other on the protection ring. The integrity the SONET signal is compared at each multiplexer along its path. When cable cuts, signal failures or signal degrades are detected, a BLSR configuration automatically switches traffic to the surviving fiber span. BLSR configurations are typically deployed in interoffice applications where distributed meshed or linear node-to-node configurations are implemented. Figure 6 shows a BLSR configuration.

Enterprise Application With Bidirection Line Switched Self-Healing Ring (BLSR)

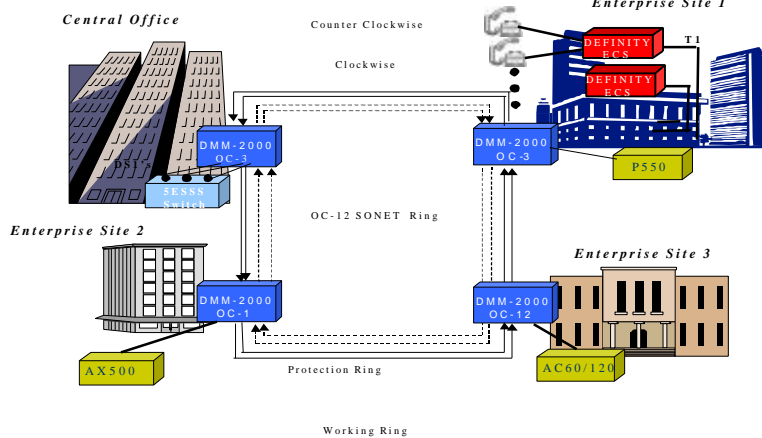


Figure 6

7.4.2 Unidirectional Path-Switched Ring (UPSR)

Some SONET multiplexers (e.g. DDM-2000) support the Unidirectional Path Switched Ring (UPSR) configuration to support critical ring applications. UPSR ensures network survivability by using a closed-loop transport that automatically protects against cable cuts, signal failure, or signal degrades by implementing duplicate, geographically diverse paths for each SONET service. A UPSR configuration is made up of a single fiber optic pair that interconnects neighboring SONET multiplexers. Traffic flows in one direction for the working path, while traffic on the protection path flows in the opposite direction. Traffic on each path is continuously monitored by a SONET multiplexer. When there is a fiber failure – or signal degradation is detected on the working fiber path – traffic is automatically diverted to the backup fiber protection path. UPSR configurations are typically implemented in SONET access networks where traffic is terminated at a central office. Figure 7 depicts an enterprise network where UPSR is enabled.

Enterprise Application With Unidirection Switched Path Ring (USPR)

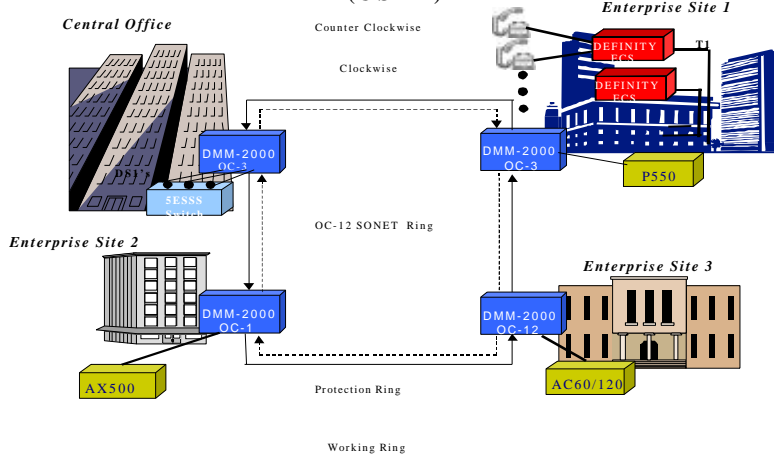


Figure 7

7.5 Dual Ring Interconnection (DRI)

The Dual Ring Interworking configuration allows multiple rings sharing traffic to be resilient from a SONET multiplexer node failure. If a catastrophe takes out a SONET multiplexer system, traffic will be routed through the operational SONET multiplexer. The benefit to the user is that continuous network operation is maintained, and business continues as usual even though a failure has occurred. This is all transparent to the user. This type of configuration is typically deployed in central office topologies. Figure 8 see illustrates a DRI configuration.

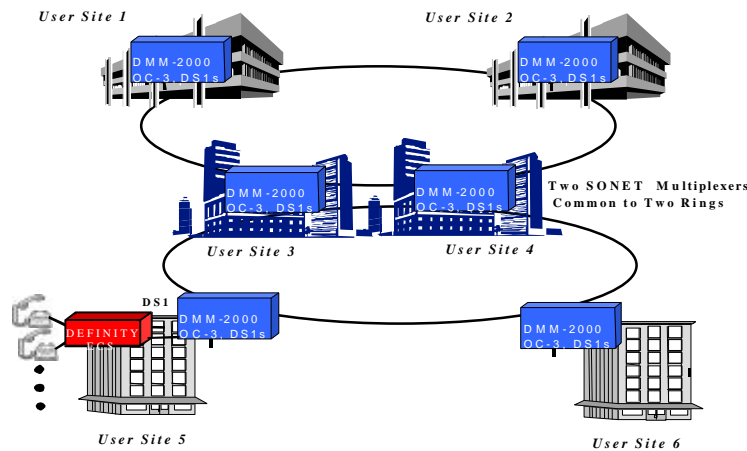


Figure 8

7.6 Folded Rings

When route diversity is not available, a two-fiber span path switched ring can be configured in what is known as a SONET folded ring configuration. A folded ring is a single path ring that provides simplicity and minimizes equipment costs. Figure 9 illustrates a SONET folded ring configuration.

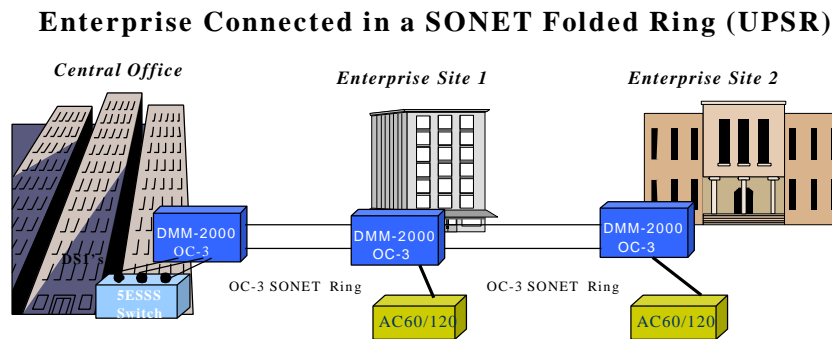


Figure 9

8.0 SONET EQUIPMENT LAYERS

SONET defines the end-to-end connection as being made up of 3 different equipment layers, including Path Terminating Equipment (PTE), Line Terminating Equipment (LTE), and Section Terminating Equipment (STE). Figure 10 illustrates where each terminating equipment function resides within a SONET network.

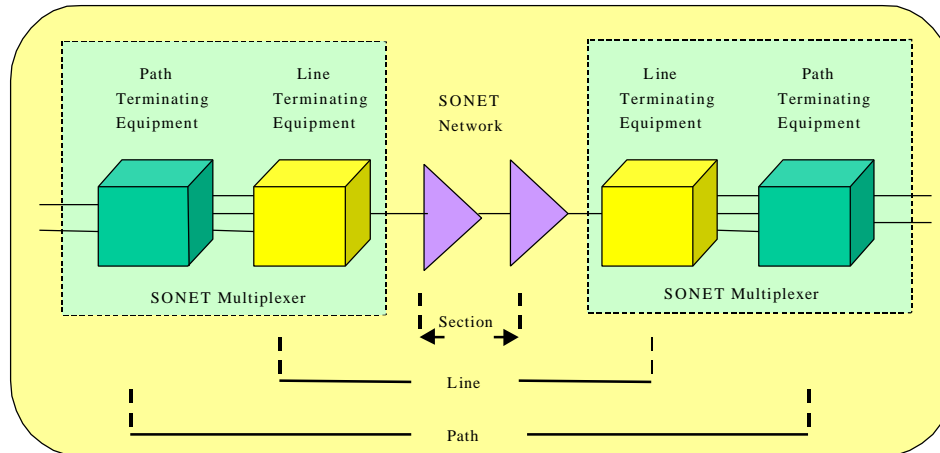


Figure 10

8.1 Path Terminating Equipment (PTE)

STS (Synchronous Transport Signal) path terminating equipment provides the multiplexing and demultiplexing functions within a SONET network. Path terminating equipment can originate, access, modify, or terminate path overhead in any combination.

8.2 Line Terminating Equipment (LTE)

SONET line terminating equipment provides the function that originates and terminates line signals. SONET line terminating equipment can originate, access, modify, or terminate line overhead in any combination

8.3 Section Terminating Equipment (STE)

A SONET “section” is any two neighboring SONET network elements. SONET section terminating equipment can be a network element or a SONET regenerator. SONET section terminating equipment can originate, access, modify, or terminate section overhead in any combination

9.0 SONET FRAME STRUCTURE

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:

- $9 \text{ rows} \times 90 \text{ Bytes} = 810 \text{ bytes}$ or 6480 bits. Each frame is sampled once every 125 µsec or 8000 frames/sec
- $8000 \text{ frames/sec} \times 6480 \text{ bits/frame} = 51.84 \text{ Mbits/sec}$ (Speed of STS-1 SONET payload envelope)

As illustrated in Figure 11, 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 octets. The SONET Transport Overhead 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:

- By pointers to indicate the offset of the first octet (byte) used by the pointer and the first octet used in the SPE
- To provide frequency justification of the SPE
- For performance monitoring of STS-1 frames
- For detection of errors or failures as part of the SONET automatic Protection Switching feature in line terminating equipment, and for alarms and recovery

The Path Overhead function supports STS and VT Path Overhead for performance monitoring of STS-1 SPEs or VTs, and monitoring of path status.

SONET STS-1 Frame Format

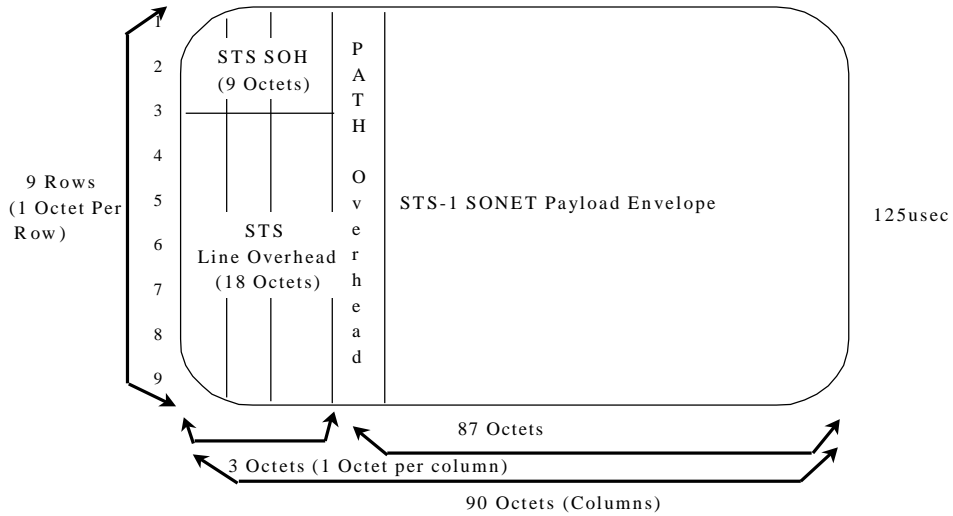


Figure 11

10.0 SONET SIGNALING HIERARCHY

10.1 SONET Multiplexing

SONET multiplexing is a technology designed to take multiple low-speed digital signals (e.g. DS1) and map them into single SONET Payload Envelopes (SPE) of STS-1s (Synchronous Transport Signal). These are then converted into an Optical signal (OC-n - - Optical Carrier) to be transported over a SONET fiber optic network. SONET technology is designed to handle multiplexing asynchronous DS1s (1.5Mbps) and synchronous DS1s, as well as asynchronous DS3s.

There are several phases in multiplexing digital signals (e.g. DS1) into Optical signals. The steps are as follows:

- DS1's are mapped to VT1.5's
- VT1.5's are then mapped to STS-1
- DS3's are mapped directly to STS-1's

Each VT1.5 carries a single DS1 payload, and four (4) VT1.5s are bundled into what is referred to as a VT-G (Virtual Tributary Group). Seven (7) VT-Gs are byte interleaved into a single STS-1 payload envelope. For efficiency purposes, byte interleaving is a method used to combine multiple signals (e.g. DS1s) into a combined signal (STS-1).

Figure 12 shows the phases which multiple digital signals go through to be multiplexed into an Optical Carrier signal (OC-n) for transport over a SONET network.

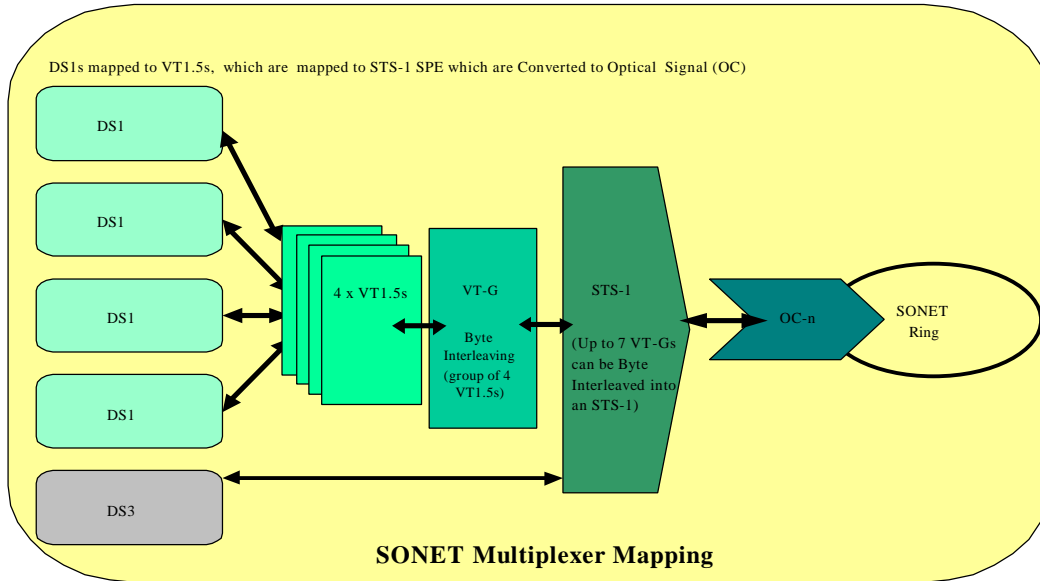


Figure 12

Table 1 below shows the actual mapping of signals, their speeds and mapping equivalents at different speeds.

Electrical	Optical Hierarchy	Transmission Line Rate	DS-3 Equiv.(#)	DS-1 Equiv.(#)	DS-0 Equiv.(#)
STS-1	OC-1	51.840Mbps	1	28	673
STS-3	OC-3	155.520Mbps	3	84	2,016
STS-12	OC-12	622.080Mbps	12	252	6,048
STS-18	OC-18	933.120Mbps	18	504	12,096
STS-24	OC-24	1,244.160Mbps	24	672	16,128
STS-36	OC-36	1,866.240Mbps	36	1,008	24,192
STS-48	OC-48	2,488.320Mbps	48	1,344	32,256
STS-192	OC-192	9,9953.280Mbps	192	5,376	129,024

Table 1

10.2 Virtual Tributaries (VT)

As described in the previous section, STS-1 is the North American standard for the SONET payload envelope (SPE), however, SONET also specifies synchronous formats at sub-STS-1 levels. An STS-1 payload can be subdivided into synchronous signals to handle the transmission of low-speed transmissions (e.g. DS1) known as Virtual Tributaries. Virtual Tributaries enable more efficient use of SONET multiplexing. In this case, the VT rate is multiplexed as a subset, rather than as the full STS-1 payload envelope.

There are four (4) types of Virtual Tributaries VT-1.5, VT-2, VT-3 and VT-6. Each VT type is designed to handle a specific digital signal type.

DS1 and DS3 are signaling frames that are primarily used in North American, whereas CEPT1 is primarily used in Europe, and DS2 is used in Japan.

These Virtual Tributaries map to the following transmission speeds as shown in table 2.

Virtual Tributary	Digital Signal	Transmission Speed	VT Rate
VT-1.5	DS1	1.544Mbps	1.728Mbps
VT-2	CEPT1	2.048Mbps	2.304Mbps
VT-3	DS1C	3.152Mbps	3.456Mbps
VT-6	DS2	6.312Mbps	6.912Mbps

Table 2

10.3 SONET Pointers

SONET implements a function, referred to as pointers, that are used to handle variations in signal phase and frequency caused by sending SONET payload envelopes across different timing boundaries. The benefit of pointers is that they prevent jitter, delay, and loss of data by using slip buffers to maintain synchronization.

11.0 EQUIPMENT THAT INTERFACES TO SONET

11.1 Add/Drop Multiplexer (ADM) Systems

An Add/Drop Multiplexer (ADM) is a form of digital cross-connect system. An ADM system multiplexes STS (Synchronous Transport Signals) input signals (e.g. DS0, DS1 signals) into Optical Carrier channels (signals). Add and Drop refers to the adding and dropping of payloads onto one of two channels. The input signals (traffic) not dropped onto the channel at a given site are passed directly through an Add/Drop Mutliplexer without being processed. An ADM can be used to consolidate or segregate traffic from multiple sites. Figure 13 shows an Add/Drop Multiplexer (ADM) system where certain DS1 & DS3 signals are added and dropped to one site, while other traffic is sent on through the SONET network.

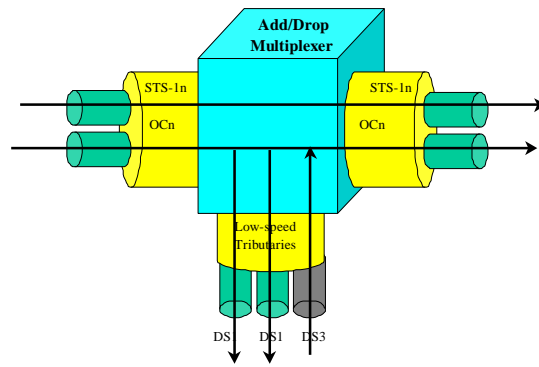


Figure 13

11.2 Wideband Digital Cross-Connect Systems

Wideband digital cross connects switch SONET traffic at Virtual Tributary (VT) signaling rates (e.g. DS1/DS3). Typically, a wideband cross-connect system offers the advantage of less multiplexing and demultiplexing, since traffic is only accessed and switched at the VT level. A wideband digital cross-connect system typically handles transport transmission services with a capacity ranging from 1.5Mbps to 50Mbps. Figure 14 shows a digital cross-connect system where certain DS1 signals are added and dropped to different DS3 channels.

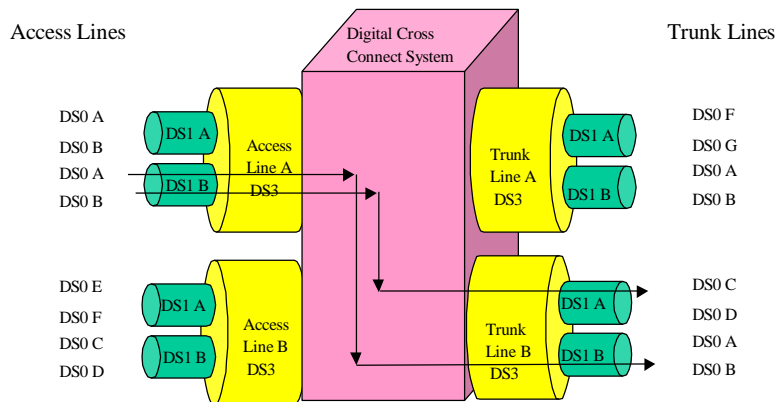


Figure 14

11.3 Broadband Digital Cross-Connect Systems

Broadband digital cross-connect systems deal with optical carrier rates. Broadband systems access Synchronous Transport Signals (STS-1) and switch SONET traffic at carrier-rate levels. A broadband digital cross-connect is designed to interconnect a large number of STS-1s. Broadband digital cross-connect systems typically handle transport transmission services that range in capacity from 50Mbps to 600Mbps. These systems can be used for the consolidation or segregation of bandwidth. As stated earlier, consolidation is a way of combining traffic from multiple sites (which reduces cabling requirements, etc.). Segregation allows traffic from multiple sites to be sent in a multipoint configuration (e.g. hub configuration), thereby reducing the amount of required multiplexing/demultiplexing of SONET traffic. This type of bandwidth consolidation or segregation is sometimes referred to as grooming.

12.0 SONET SYNCHRONIZATION AND TIMING

12.1 Importance of Synchronized Timing

Network timing between SONET devices is an integral part of maintaining accurate information transmitted over a SONET network.

In the earlier days of networking, the method used in timing was Asynchronous. In Asynchronous timing each switch runs its own clock. In Synchronous timing, switches can use a single common clock to maintain timing. This single common clock is referred to as a Primary Reference Source (PRS) or Master Clock. Synchronous timing maintains better accuracy than Asynchronous timing because it uses a single common clocking scheme to maintain timing. This accurate timing often becomes important to government and enterprise applications, particularly when they are running time sensitive applications (e.g. video streaming applications).

There are three methods typically used in obtaining synchronous timing in SONET multiplexers (e.g. Lucent DDM-2000 Multiplexer), they include:

- Timing from an onboard internal oscillator
- Timing from an incoming optical signal from a high-speed interface
- Timing from an external source coming from a DS1 timing reference that can be stratum 3 or higher clocking

SONET defines a timing hierarchy known as the Stratum Clock hierarchy. Table 3 below shows the long-term accuracy requirements within the Stratum Clock hierarchy, which ranges from Stratum 1 through 4.

Stratum Clock	Minimum Free Run Accuracy
1	+ or - 1.0 x 10 ⁻¹¹
2	+ or - 1.6 x 10 ⁻⁸
3	+ or - 4.6 x 10 ⁻⁶
4	+ or - 32 x 10 ⁻⁶

Table 3

Although Synchronous networks display accurate timing, some variations can occur between different network devices or between networks. This difference is known as phase variations. Phase variations are defined as Jitter or Wander. Jitter is defined as short-term phase variations above 10Hz. Wander is defined as long-term phase variations below 10Hz. In digital networks, Jitter and Wander are handled by buffers found in the interfaces within different network devices. One example is a Slip Buffer. The Slip Buffer is used to handle frequency differences between read and write operations. To prevent against write operations happening faster than read operations, read operations are handled at a slightly higher rate. On a periodic basis, read operations are paused, while a bit is stuffed into a stream to account for any timing differences between the read and write operations. This bit-stuffing scheme is referred to as a controlled slip (frame).

In terms of Wander, Bit Slips and Controlled Slips, the Stratum Clocking accuracy timing requirements are defined in table 4. The timing accuracy requirements increase as the Stratum hierarchy increases. As you will see, the Stratum 1 Clock must meet the highest degree of accuracy.

Stratum Hierarchy	Wander (.12 usec Incr.)	Bit Slips	Controlled (Frame Slips)
1	3.3hrs	18 hrs	20.6 weeks
2	7.5 sec	41 sec	2.17 hrs
3	26 ms	140 ms	27 sec
4	4 ms	20 m s	3.9 sec
Stratum Clock Requirements			

Table 4

13.0 SONET REGENERATOR

A SONET Regenerator, sometimes referred to as Section Terminating Equipment (STE) is a technology designed to extend the fiber span reach of a SONET multiplexer. A SONET Regenerator provides signal reception and signal regeneration, and typically performs frame alignment, scrambling, error detection, and monitoring functions. A Regenerator can either be an external device or be an integrated function within a SONET multiplexer (e.g. via circuit pack or module).

14.0 SONET STANDARDS

The base standard for SONET is the T1.105-1991 American National Standard (ANSI) for Telecommunications- Digital Hierarchy-Optical Interface Rates and Formats Specification (SONET). SONET standards define rates and formats as well as optical interfaces. The following American National Standards Institute (ANSI) specifications provide the primary standards, which define SONET:

- ANSI T1.106-1998 Specification for Optical Parameters
- ANSI T1.102-1993 Specification for Electrical Parameters
- ANSI T1.105-1991 Specification for Multiplexing Methods to Map Existing Digital Signals (e.g. DS1) into SONET Payload Signals
- ANSI T1.105-1991 Specification for Criteria for Optical Line Automatic Protection Switching
- ANSI T1.105-1991 Specification for Overhead Channels to Support Standard Operation, Administration and Provisioning (OAM&P)

15.0 OPERATIONS, ADMINISTRATION & MAINTENANCE (OA&M)

SONET specifies network management support through the Operations, Administration & Maintenance (OA&M) functions. Additional octets (bytes) known as “overhead” are added to SONET frames to provide network management control and monitoring capabilities (see SONET Frame Structure section of this document for additional information on SONET overhead). The network management overhead consumes approximately 4% of available bandwidth. Network monitoring functions are primarily alarm generation functions, which include the following:

- Loss of Frames
- Loss of Pointers
- Loss of Signals
- System failures
- Loss of synchronization
- Parity errors
- Bit error rates

16.0 GLOSSARY OF TERMS

ANSI (American National Standards Institute) – An organization that defines industry standards for the U.S., and coordinates standards with the ISO (International Standards Organization).

ADM (Add/Drop Multiplexer) - Refers to the adding and dropping of payloads onto one of two channels.

ATM (Asynchronous Transfer Mode) - A set of standards from the ATM Forum that defines multiplexing technique and fixed length cells.

Broadband – A set of transmission services that handle transport capacity ranging from 50Mbps to 600Mbps.

CCITT (Consultative Committee International Telegraph & Telecommunications) – International standards body replaced by the ITU-T.

CEPT (Conference of European Postal and Telecommunications Administrations) – European Standards body responsible for defining telecommunications standards (e.g. E1, E3).

DS1/DS3 – Digital Signals with performance capacities of (DS1) 1.5Mbps and (DS3) 51Mbps.

Grooming – A function that allows traffic to be combined with or segregated from multiple sites, providing multipoint capability.

Interleave - A method used to combine multiple signals into a combined signal (STS-1).

ITU-T (International Telecommunication Union-Telecommunications standard) – International standards (formerly the CCITT) body responsible for defining such standards as the SONET standard.

Jitter – Variations in a short waveform caused by voltage fluctuations.

Narrowband – A set of transmission services that handle transport capacity of up to 1.5Mbps.

OA&M (Operations, Administration and Maintenance) – Network management functions to support SONET.

OCn (Optical Carrier) - Optical signals that carry SONET traffic.

Overhead – Bits added to the SONET digital stream to carry OA&M network management information.

Path – A logical connection between two end-points.

Payload – The portion of a SONET frame that carries service and signals (e.g. DS1)

Segregation – A function that allows traffic to be groomed, or dropped at certain sites and sent through to specific sites.

SDH (Synchronous Digital Hierarchy) – European defined version of SONET that uses the STS-3 as its standard size payload envelop (155Mbps).

SPE (SONET Payload Envelope) – Standard payload used to transmit SONET frames (STS-1 in North America, STS-3 in Europe).

STS-1 (Synchronous Transport Signal) – Standard frame size used in SONET by the North American market.

SONET (Synchronous Optical Network) – ITU-T standard that defines an optical transport service to carry synchronous transmissions.

VT (Virtual Tributary) – A signaling technique designed to handle sub-STS-1 payloads.

VT-G (Virtual Tributary-Group) – One or more VTs of the same rate bundled into an STS-1 payload.

Wideband - A set of transmission services that handle transport capacity ranging from 1.5Mbps to 50Mbps.