Introduction To SONET

SONET (Synchronous Optical NETwork) is a standard for optical telecommunications transport. It was formulated by the Exchange Carriers Standards Association (ECSA) for the American National Standards Institute (ANSI), which sets industry standards in the U.S. for telecommunications and other industries. The comprehensive SONET/SDH standard is expected to provide the transport infrastructure for worldwide telecommunications for at least the next two or three decades.

The increased configuration flexibility and bandwidth availability of SONET provides significant advantages over the older telecommunications system. These advantages include:

- Reduction in equipment requirements and an increase in network reliability
- Provision of overhead and payload bytes – the overhead bytes permit management of the payload bytes on an individual basis and facilitate centralized fault sectionalization
- Definition of a synchronous multiplexing format for carrying lower level digital signals (such as DS1, DS3) and a synchronous structure which greatly simplifies the interface to digital switches, digital cross-connect switches, and add-drop multiplexers
- Availability of a set of generic standards which enable products from different vendors to be connected
- Definition of a flexible architecture capable of accommodating future applications, with a variety of transmission rates

In brief, SONET defines optical carrier (OC) levels and electrically equivalent synchronous transport signals (STSs) for the fiber-optic based transmission hierarchy.

Background

Before SONET, the first generations of fiber optic systems in the public telephone network used proprietary architectures, equipment, line codes, multiplexing formats, and maintenance procedures. The users of this equipment – Regional Bell Operating Companies and inter-exchange carriers (IXCs) in the U.S., Canada, Korea, Taiwan, and Hong Kong – wanted standards so they could mix and match equipment from different suppliers. The task of creating such a standard was taken up in 1984 by the Exchange Carriers Standards Association (ECSA) to establish a standard for connecting one fiber system to another. This standard is called SONET for Synchronous Optical NETwork.

Synchronization of Digital Signals

To correctly understand the concepts and details of SONET, it's important to be clear about the meaning of Synchronous, Asynchronous, and Plesiochronous.

In a set of Synchronous signals, the digital transitions in the signals occur at exactly the same rate. There may, however, be a phase difference between the transitions of the two signals, and this would lie within specified limits. These phase differences may be due to propagation time delays or jitter introduced into the transmission network. In a synchronous network, all the clocks are traceable to one Stratum 1 Primary Reference Clock (PRC). The accuracy of the PRC is better than ±1 in 10^{11} and is derived from a cesium atomic standard.

If two digital signals are Plesiochronous, their transitions occur at "almost" the same rate, with any variation being constrained within tight limits. For example, if two networks need to interwork, their clocks may be derived from two different PRCs. Although these clocks are extremely accurate, there is a difference between one clock and the other. This is known as a plesiochronous difference.

In the case of Asynchronous signals, the transitions of the signals do not necessarily occur at the same nominal rate. Asynchronous, in this case, means that the difference between two clocks is much greater than a plesiochronous difference. For example, if two clocks are derived from free-running quartz oscillators, they could be described as asynchronous.

Basic SONET Signal

SONET defines a technology for carrying many signals of different capacities through a synchronous, flexible, optical hierarchy. This is accomplished by means of a byte-interleaved multiplexing scheme. Byte-interleaving simplifies multiplexing, and offers end-to-end network management.

The first step in the SONET multiplexing process involves the generation of the lowest level or base signal. In SONET, this base signal is referred to as Synchronous Transport Signal level-1, or simply STS-1, which operates at 51.84 Mb/s. Higher-level signals are integer multiples of STS-1, creating the family of STS-N signals in Table 1. An STS-N signal is composed of N byte-interleaved STS-1 signals. This table also includes the optical counterpart for each STS-N signal, designated OC-N (Optical Carrier level-N).

Synchronous and Non-synchronous line rates and the relationships between each are shown in Tables 1 and 2.

Table 1. SONET Hierarchy

Signal	Bit Rate	Capacity
STS-1, OC-1	51.840 Mb/s	28 DS1s or 1 DS3
STS-3, OC-3	155.520 Mb/s	84 DS1s or 3 DS3s
STS-12, OC-12	622.080 Mb/s	336 DS1s or 12 DS3s
STS-48, OC-48	2488.320 Mb/s	1344 DS1s or 48 DS3s
STS-192, OC-192	9953.280 Mb/s	5376 DS1s or 192 DS3s
STS-768, OC-768	39813.12 Mb/s	21504 DS1s or 768 DS3s

STS = Synchronous Transport Signal

OC = Optical Carrier

Table 2. Non-Synchronous Hierarchy

Signal	Bit Rate	Channels
DS0	64 kb/s	1 DS0
DS1	1.544 Mb/s	24 DS0s
DS2	6.312 Mb/s	96 DS0s
DS3	44.736 Mb/s	28 DS1s