W

Wide Area Networks

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INTRODUCTION

When network services must be distributed over large geographic areas, it is essential to have an understanding of the telecommunication systems on which such distribution depends. One of the most significant differences between wide area networks (WANs) and local area networks (LANs) is the general dependency on third-party carriers to provide these transmission services. Whenever data is being sent across a WAN it must be routed between locations.

PHYSICAL WIDE AREA NETWORKING TRANSMISSION

WAN transmission technologies and services fall into two overall categories. This categorization is based largely on WAN services as they are organized by and purchased from carriers. Local loop transmission provides bandwidth to customer locations. Local loop transmission services generally provide access to the carrier network. Broadband transmission typically refers to transmission services offering greater than 1.544Mbps transmission rates.

The 1.544Mbps standard is part of a hierarchy of standards known as the Digital Service Hierarchy or DS standards. Table 1 shows the digital services hierarchy for both North America and Europe (CCITT). The digital service standards are independent of the standards for transmission, which provide the bandwidth on the circuit. Technically speaking, a DS-1 is not the same as T-1 but the two terms are often used interchangeably. To be exact, a T-1 transmission service modulates a DS-1 signal on two twisted pair of wires.

Table 1. Digital service hierarchies

US Digital Service Hierarchy			
Digital Service Level	**Number of Voice Channels**	**Transmission Rate**	**Corresponding Transmission Service**
DS-0	1	64 Kbps	DC-0
DS-1	24	1.544 Mbps	T-1
DS-1C	48	3.152 Mbps	T1-C
DS-2	96	6.312 Mbps	T-2
DS-3	672	44.736 Mbps	T-3
DS-4	4,032	274.176 Mbps	T-4
CCITT Digital Hierarchy			
Digital Service Level	**Number of Voice Channels**	**Transmission Rate**	**Corresponding Transmission Service**
1	30	2.048 Mbps	E-1
2	120	8.448 Mbps	E-2
3	480	34.368 Mbps	E-3
4	1920	139.264 Mbps	E-4
5	7680	565.148 Mbps	E-5

T-1 Transmission

Standards were required to define the size and structure of digital communications links. The standard for digital transmission circuits in North America is known as a T-1 with a bandwidth of 1.544Mbps. The E-1 standard for digital transmission utilized in other parts of the world provides a bandwidth of 2.048Mbps.

The T-1 transmission standard is divided into twenty-four 64kbps channels, each of which is known as a DS-0. Each channel consists of a group of eight bits known as a time slot. Each time slot represents one voice sample or a byte of data to be transmitted through the T-1 switching architecture using time division multiplexing (TDM) techniques.

T-1 circuits are examples of leased or private communication lines. As a dedicated service, the T-1 differs from circuit-switched lines in several ways: Leased lines do not provide dial tone; the circuit should remain up and operational at all times.

In some cases, multiple 64kbps channels within a T-1 transport circuit are provided to a customer that does not require the full T-1 bandwidth. A Fractional T-1 or FT-1 only provides a subset of the 24 available DS-0s within a T-1. While the full T-1 circuit must be physically delivered to the customer premises, the customer only pays for the number of 64kbps channels enabled. The ability of FT-1 to provide the bandwidth necessary for customer applications, in 64kbps increments, has made it very attractive service offering.

In order to access a T-1 service, customers may use a variety of T-1 access technologies. The fundamental T-1 access technology is the CSU/DSU (channel service unit/data service unit). This device interfaces directly to the carrier's termination of the T-1 service and the customer's equipment.

SONET and SDH

SONET (synchronous optical network) is an optical transmission service similar to the T-1 transmission service. The primary difference between T-1 and SONET transmission services is the higher transmission capacity of SONET due to its fiber optic media. SONET is defined by ANSI (American National Standards Institute) in the T1.105 and T1.106 standards.

Just as the digital service hierarchy defined levels of service for traditional digital services, optical transmission has its own hierarchy of service levels. In the United States, SONET is used; however, international countries use the synchronous digital hierarchy (SDH). Whereas the SONET hierarchy makes use of synchronous transport signals (STS), the SDH hierarchy makes use of synchronous transport modules (STM). As shown in Table 2, these two service hierarchies utilize the same data rates, but at different service levels. Fortunately, service levels of the same transmission rate allow for interoperability between North American and international network systems.

SONET is flexible in its definition of the use of its payload area. It can map DS-0 (64Kbps) channels into the payload area or it can map an entire T-1. These flexibly defined channels are known as virtual tributaries or VTs.

The architecture of a SONET network is based on a layered hierarchy of transport elements and associated technology. Understanding the differences between these various SONET transport elements is vital to understanding how to build a SONET network.

Accessing SONET services requires the local carrier to bring the fiber-based ring directly to a location and to assign dedicated bandwidth to each SONET customer. Add-drop multiplexers, sometimes referred to as broadband bandwidth managers or cross-connect switches, are the customary type of hardware used to

Table 2. SONET and SDH transmission rates

SONET Level	SDH Level	Transmission Rate
STS-1	STM-0	51.84 Mbps
STS-3	STM-1	155.52 Mbps
STS-12	STM-4	622.08 Mbps
STS-48	STM-16	2.488 Gbps
STS-192	STM-64	9.953 Gbps
STS-768	STM-256	39.81 Gbps