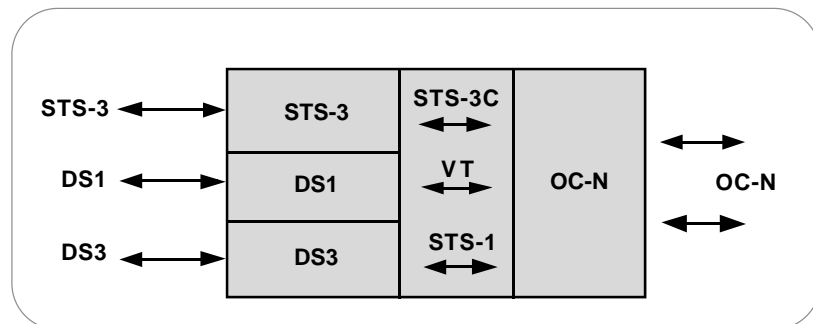## SONET Network Elements

### Terminal Multiplexer

The path terminating element (PTE), an entry level path terminating terminal multiplexer, acts as a concentrator of DS1s as well as other tributary signals. Its simplest deployment would involve two terminal multiplexers linked by fiber with or without a regenerator in the link. This implementation represents the simplest SONET link (a Section, Line, and Path all in one link). See Figure 19.
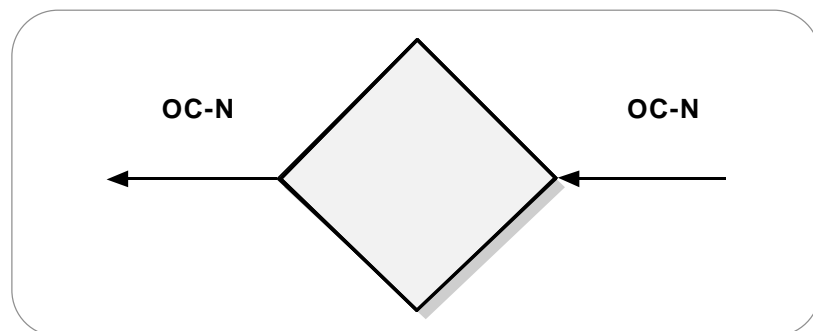
### Regenerator

A regenerator is needed when, due to the long distance between multiplexers, the signal level in the fiber becomes too low.

The regenerator clocks itself off of the received signal and replaces the Section Overhead bytes before re-transmitting the signal. The Line Overhead, payload, and Path Overhead are not altered. See Figure 20.



▶ **Figure 19.** Terminal multiplexer.



▶ **Figure 20.** Regenerator.

### Add/Drop Multiplexer (ADM)

Although network elements (NEs) are compatible at the OC-N level, they may differ in features from vendor to vendor. SONET does not restrict manufacturers to providing a single type of product, nor require them to provide all types. For example, one vendor might offer an add/drop multiplexer with access at DS1 only, whereas another might offer simultaneous access at DS1 and DS3 rates. See Figure 21.

A single-stage multiplexer/demultiplexer can multiplex various inputs into an OC-N signal. At an add/drop site, only those signals that need to be accessed are dropped or inserted. The remaining traffic continues through the network element without requiring special pass-through units or other signal processing.

In rural applications, an ADM can be deployed at a terminal site or any intermediate location for consolidating traffic from widely separated locations. Several ADMs can also be configured as a survivable ring.

SONET enables drop and repeat (also known as drop and continue) – a key capability in both telephony and cable TV applications. With drop and repeat, a signal terminates at one node, is duplicated (repeated), and is then sent to the next and subsequent nodes.

In ring-survivability applications, drop and repeat provides alternate routing for traffic passing through interconnecting rings in a "matched-nodes" configuration. If the connection cannot be made through one of the nodes, the signal is repeated and passed along an alternate route to the destination node.

In multi-node distribution applications, one transport channel can efficiently carry traffic between multiple distribution nodes. When transporting video, for example, each programming channel is delivered (dropped) at the node and repeated for delivery to the next and subsequent nodes. Not all bandwidth (program channels) need be terminated at all the nodes. Channels not terminating at a node can be passed through without physical intervention to other nodes.

The add-drop multiplexer provides interfaces between the different network signals and SONET signals.

Single-stage multiplexing can multiplex/demultiplex one or more Tributary (DS1) signals into/from an STS-N signal. It can be used in terminal sites, intermediate (add-drop) sites, or hub configurations. At an add-drop site, it can drop lower-rate signals to be transported on different facilities, or it can add lower-rate signals into the higher-rate STS-N signal. The rest of the traffic simply continues straight through.

## Wideband Digital Cross-Connects

A SONET cross-connect accepts various optical carrier rates, accesses the STS-1 signals, and switches at this level. It's ideally used at a SONET hub. One major difference between a cross-connect and an add-drop multiplexer is that a cross-connect may be used to interconnect a much larger number of STS-1s. The broadband cross-connect can be used for grooming (consolidating or segregating) of STS-1s or for broadband traffic management. For example, it may be used to segregate high-bandwidth from low-bandwidth traffic and send them separately to the high-bandwidth (e.g., video) switch and a low-bandwidth (voice) switch. It's the synchronous equivalent of a DS3 digital cross-connect and supports hubbed network architectures.

This type is similar to the broadband cross-connect except that the switching is done at VT levels (similar to DS1/DS2 levels). It is similar to a DS3/1 cross-connect because it accepts DS1s, DS3s, and is equipped with optical interfaces to accept optical carrier signals. It's suitable for DS1 level grooming applications at hub locations. One major advantage of wideband digital cross-connects is that less demultiplexing and multiplexing is required because only the required tributaries are accessed and switched.

The Wideband Digital Cross-Connect (W-DCS) is a digital cross-connect that terminates SONET and DS3 signals, as well as having the basic functionality of VT and DS1-level cross-connections. It's the SONET equivalent to the DS3/DS1 digital cross-connect, and accepts optical OC-N signals as well as STS-1s, DS1s and DS3s.
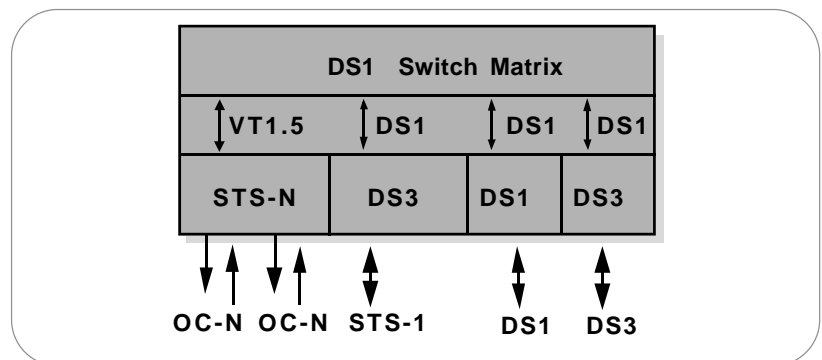
In a Wideband Digital Cross-Connect, the switching is done at the VT level (i.e., it cross-connects the constituent VTs between STS-N terminations).

Because SONET is synchronous, the low-speed tributaries are visible and accessible within the STS-1 signal. Therefore, the required tributaries can be accessed and switched without demultiplexing, which isn't possible with existing digital cross-connects. As well, the W-DCS cross-connects the constituent DS1s between DS3 terminations, and between DS3 and DS1 terminations.

The features of the W-DCS make it useful in several applications. Because it can automatically cross-connect VTs and DS1s, the W-DCS can be used as a network management system. This capability, in turn, makes the W-DCS ideal for grooming at a hub location. See Figure 22.
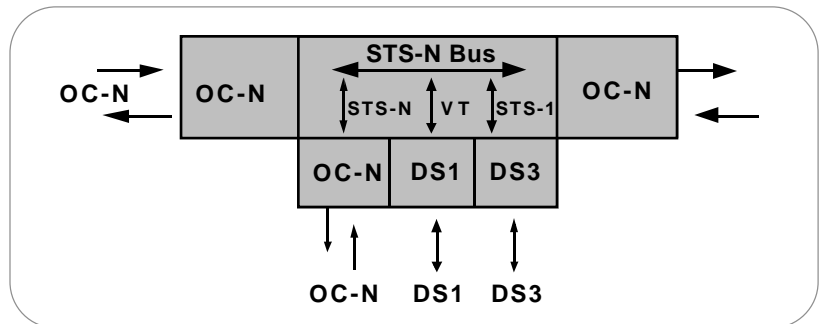


▶ **Figure 21.** Add/drop multiplexer.
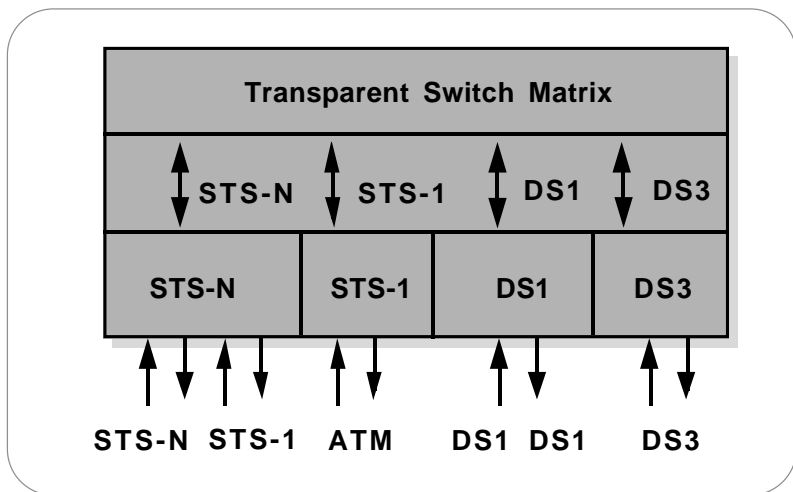


▶ **Figure 22.** Wideband digital cross-connect.
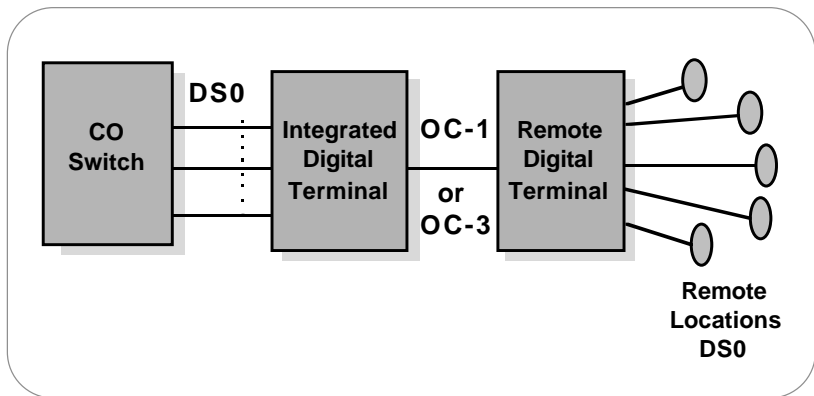
# SONET Telecommunications Standard
► Primer

## Broadband Digital Cross-Connect

The Broadband Digital Cross-Connect interfaces various SONET signals and DS3s. It accesses the STS-1 signals, and switches at this level. It's the synchronous equivalent of the DS3 digital cross-connect, except that the broadband digital cross-connect accepts optical signals and allows overhead to be maintained for integrated OAM&P (asynchronous systems prevent overhead from being passed from optical signal to signal).

The Broadband Digital Cross-Connect can make two-way cross-connections at the DS3, STS-1, and STS-Nc levels. It's best used as a SONET hub, where it can be used for grooming STS-1s, for broadband restoration purposes, or for routing traffic. See Figure 23.



► **Figure 23.** Broadband digital cross-connect.

## Digital Loop Carrier

The Digital Loop Carrier (DLC) may be considered a concentrator of low-speed services before they are brought into the local central office for distribution. If this concentration were not done, the number of subscribers (or lines) that a central office could serve would be limited by the number of lines served by the CO. The DLC itself is actually a system of multiplexers and switches designed to perform concentration from the remote terminals to the community dial office and, from there, to the central office.

Whereas a SONET multiplexer may be deployed at the customer premises, a DLC is intended for service in the central office or a controlled environment vault (CEV) that belongs to the carrier. Bellcore document TR-TSY-000303 describes a generic Integrated Digital Loop Carrier (IDLC), which consists of intelligent Remote Digital Terminals (RDTs) and digital switch elements called Integrated Digital Terminals (IDTs), which are connected by a digital line. The IDLCs are designed to more efficiently integrate DLC systems with existing digital switches. See Figure 24.



► **Figure 24.** Integrated digital loop carrier.