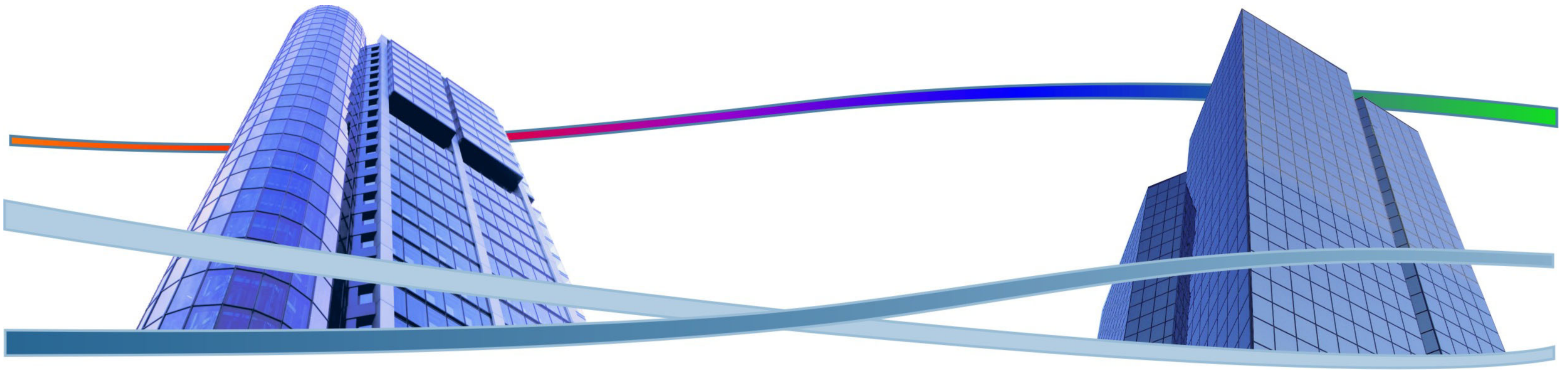
CWDM CASE STUDY



Line Systems, Inc. uses iConverter CWDM Multiplexers to overlay Ethernet onto SONET rings

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Expanding Possibilities with CWDM

Anthony Abate was facing a challenge. As Director of Network Engineering at Line Systems, Inc., Anthony is responsible for network infrastructure, and was tasked with adding a new Gigabit Ethernet backbone to an existing SONET OC-12 network. The goal was to expand the capacity of the SONET fiber infrastructure to meet the increasing demand for next-generation Carrier Ethernet Business Services. In addition, he was to achieve this in the most cost-effective means possible, quickly implement the Ethernet services without interruption to the existing services and provide future growth potential.

Line Systems is a full-service communications consulting firm, serving business users of communication products and services. Line Systems offers a comprehensive portfolio, supporting a full range of voice, Voice over IP, data, and internet services, including wholesaling to Regional Bell Operating Companies.

The challenge of adding new customers, new services and bandwidth to existing fiber networks, while controlling capital expenditure costs is not unique to Line Systems. ILECs, CLECs, Cable Operators, ISPs and even operators of large enterprise networks face similar circumstances of needing to add capacity to their fiber networks, while facing pressures to lower costs.

Line Systems operates a network in the Philadelphia Tri-State area that extends through Philadelphia and the surrounding suburbs and Southern New Jersey out to Atlantic City. The network consists of three SONET OC-12 rings with a central hub providing Carrier Class TDM voice and data to thousands of customers.

Anthony Abate considered three options to increase the capacity of the fiber optic network: install new fiber, upgrade the SONET equipment, or utilize Wavelength Division Multiplexing.

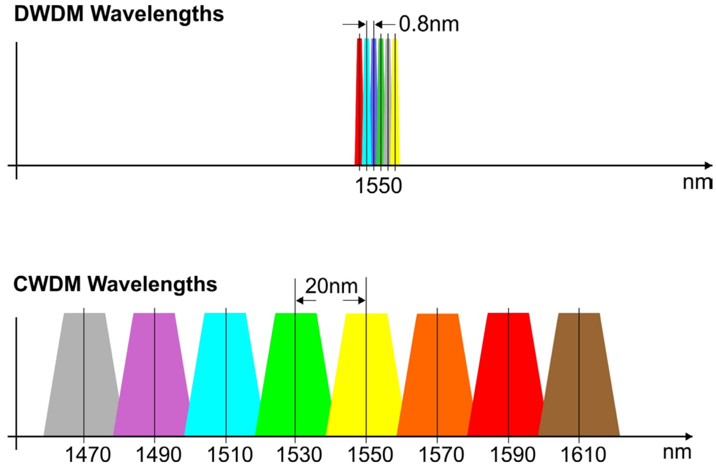
Option 1 – Install New Fiber
Fiber is a very cost-effective cabling medium. The installation is where it gets expensive. Estimates run from $50,000 to $250,000 per mile, depending on whether the installation is in rural or urban areas, and on the method of installation (trenching, blown fiber or aerial). In addition, fiber installs can take many months of zoning, project planning, construction work and disruption.

Option 2 – Upgrade SONET Equipment
TDM networking equipment, particularly SONET multiplexers and routers can be very expensive, and so can the cost of upgrading SONET equipment to higher data rates and running Ethernet over SONET. In addition, the complexities of TDM circuit emulation equipment that carries Ethernet over SONET increases training and support costs.

Option 3 – Wavelength Division Multiplexing
In a typical fiber optic network, data signals are transmitted via 1310nm or 1550nm wavelengths. Wavelength Division Multiplexing (WDM) enables multiple wavelengths, or colors of light, to be transmitted over a fiber optic link, creating independent and simultaneous data streams of different data rates and network protocols. These wavelengths are combined (multiplexed) at the source end, then separated (de-multiplexed) with color filters at the destination end. WDM wavelengths are also referred to as channels because data from virtually any type of communications protocol and data rates up to 10 Gigabit can be carried over a WDM network, including Ethernet ATM, TDM, SONET, Fibre Channel and Serial. The primary benefit is that the fiber bandwidth capacity is significantly increased, enabling more information to be sent over the existing fiber media.

WDM Options

Two typical implementations of WDM technology are Dense Wavelength Division Multiplexing (DWDM) and Coarse Wavelength Division Multiplexing (CWDM). DWDM systems use temperature-stable lasers with narrow-band filters to provide 1nm wavelength spacing or less with up to 160 wavelengths. DWDM has been widely implemented in long-haul optical networking, but its use in access and metro networks is typically cost prohibitive.



CWDM systems use less expensive non-stabilized lasers with broadband filters to provide 20nm spacing with up to eighteen wavelengths. CWDM provides a cost-effective solution to maximize fiber capacity in Enterprise, Utility, Municipal and Service Provider access networks.

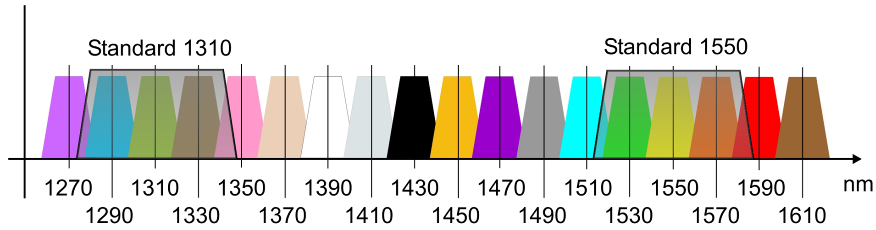
Anthony Abate selected CWDM to increase the capacity of the SONET network for two reasons. First, "Dark Fiber is an expensive resource. We had already made a significant investment in the fiber network to deploy SONET OC-12. When we wanted to add new Ethernet services, CWDM gave us the ability to leverage the existing fiber without making an additional costly physical build." Secondly, "We considered upgrading the OC-12 to a higher bandwidth SONET such as OC-48 or OC-192 and running Ethernet over SONET. However, the associated optics costs coupled with the additional complexities of the conversion between Ethernet and SONET made this option much less desirable than CWDM."

The wavelengths used with CWDM implementations are defined by the International Telecommunications Union; reference ITU-T G.694.2, listing eighteen wavelengths from 1270nm to 1610nm with 20nm wavelength spacing. CWDM wavelengths can be used for a wide variety of functions and applications. The actual center wavelength in ITU-T G.694.2 CWDM wavelengths are 1271, 1291, etc., but are typically referred to as 1270, 1290, etc. These are actually the same wavelengths, the only difference is semantics. CWDM wavelengths can be dedicated to different customers' traffic, different speeds and services, or used for non-intrusive testing, monitoring and management.

To connect a communication device into a CWDM network, the device must transmit an optical signal using one of the eighteen specific CWDM wavelengths and be multiplexed into the network's common link, which is a fiber cable that carries all the CWDM wavelengths. Source and destination devices that communicate across a CWDM common link must use the same wavelength (i.e. both devices use 1490nm). New wavelengths can be added to the common link to connect devices, as long as each wavelength is unique.

The heart of a CWDM network is a device called the CWDM multiplexer (MUX) that multiplexes, or combines, unique wavelengths from different communications sources onto a fiber optic cable. This fiber is referred to as the common link. At the other end of the common link, another MUX device is used to demultiplex, or filter the individual wavelengths and deliver them to their destinations. Each CWDM channel is connected to the CWDM MUX via channel ports.

Note that standard (or native) 1310nm and 1550nm wavelengths are not the same as CWDM 1310nm and CWDM 1550nm wavelengths. The center wavelength tolerances for legacy 1310nm and 1550nm are much wider than the CWDM equivalents, and therefore not precise enough to run through CWDM filters.

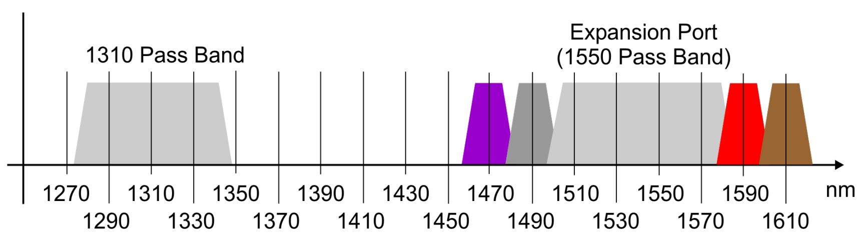


When implementing a CWDM network, a standard wavelength can be converted to CWDM wavelength, or a CWDM MUX with a pass band port can overlay the standard wavelength onto the CWDM common link. A pass band port is an additional channel port on a CWDM MUX that allows a legacy 1310nm or 1550nm signal to pass through the network within a reserved band. The legacy device is connected directly to the pass band port via fiber cabling. Standard wavelengths can be converted to CWDM wavelengths using CWDM Small Form Pluggable (SFP) transceivers, transponders, and media converters that support SFPs.

Another port available on a CWDM MUX is called the expansion port. This port enables the cascading of several CWDM MUX devices, allowing a network designer to expand the channel capacity of a CWDM network. Two 4-channel CWDM/X devices, for example, can be cascaded (daisy chained) to create an eight channel CWDM network with this feature. Expansion ports typically utilize the 1510nm to 1570nm region of the CWDM spectrum, and can also function as pass band ports for legacy 1550 networks.

The CWDM Solution

Anthony Abate built a single CWDM Gigabit Ethernet redundant ring around all three SONET rings using the 1470nm wavelength, providing two independent paths running Spanning Tree Protocol (STP). He selected CWDM MUXes that support the 1470nm, 1490nm, 1590nm and 1610nm wavelengths. This configuration offered him the flexibility to use either the 1310 pass band port or the 1550 expansion (1550 pass band) port, because another challenge he faced was mixed wavelengths in the legacy network. When the network was originally built, the 1310nm OC-12 optics could not reach the distance required on three segments extending from the hub site. Anthony purchased Omnitron fiber-to-fiber media converters that provided 1310nm to 1550nm conversion with higher powered optics to span the longer segments.

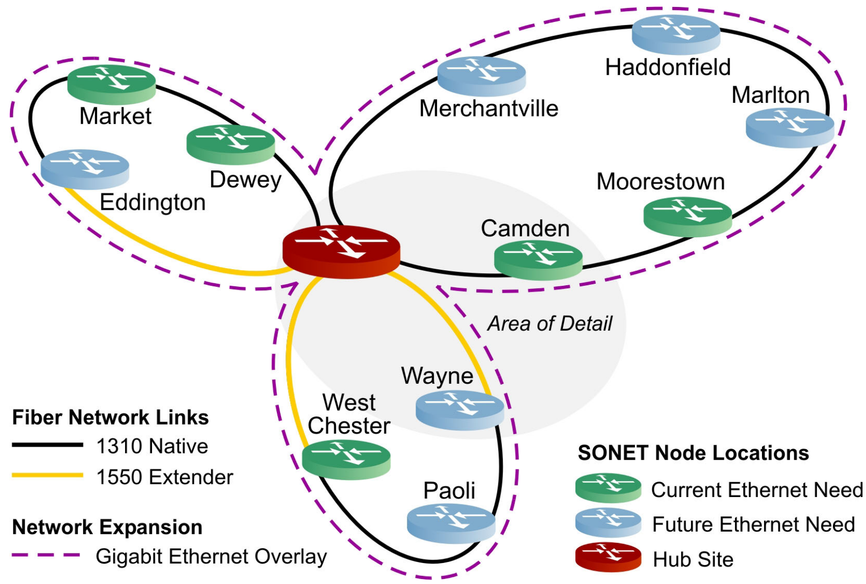


Omnitron provided design support for the CWDM project. “Since Omnitron had already had prior experience with our network, their design engineers were able to easily understand what we had and what we were trying to achieve. They organized conference calls with us, made suggestions, and took care and concern that the design they were offering would function properly.”

When overlaying a CWDM network onto a SONET ring network, each SONET node is physically bypassed because the CWDM wavelengths cannot pass through the SONET devices. This is accomplished by installing CWDM MUXes on each side of the SONET nodes, and connecting the 1310 or 1550 native to the pass band ports on the CWDM MUXes. The CWDM channel (the 1470nm Gigabit Ethernet) and the legacy OC-12 network (1310nm or 1550nm) are multiplexed across common links between the CWDM MUXes.

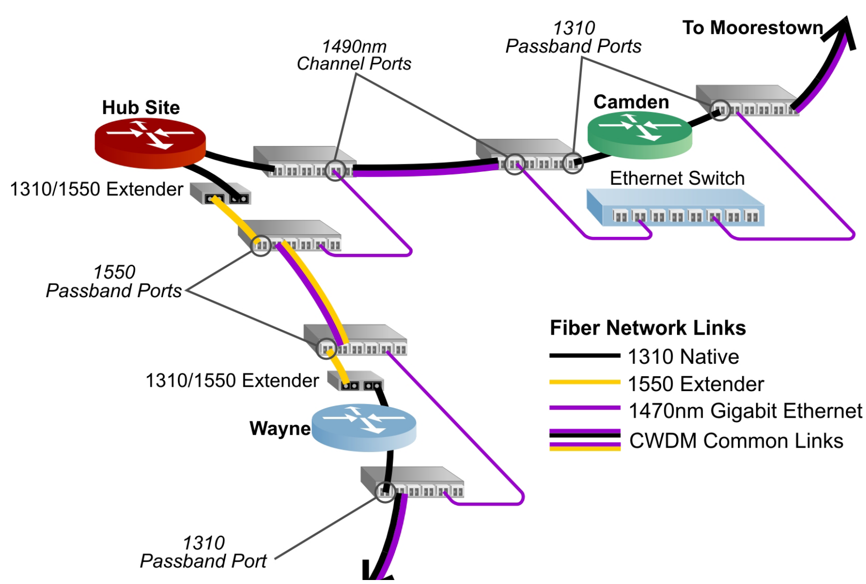
A Gigabit Ethernet Switch was installed in locations that required Ethernet access. Anthony Abate bypassed the SONET Nodes by connecting the switches to the channel ports on the CWDM MUXes with fiber patch cables (see Camden in the detail diagram). Connecting the Ethernet switches to the CWDM network is accomplished with SFP transceivers that support CWDM wavelengths. An SFP that supports the 1470nm CWDM wavelength is installed in the switch and connected to 1470nm channel port on the CWDM MUX at each location.

The selection of the appropriate SFP transceivers depended on the distances between each location, the fiber loss and loss inserted by each CWDM multiplexer. Anthony Abate consulted the Omnitron design team to ensure the transceiver used at each location met the optical loss budget of each network segment.



At locations where Ethernet access was not yet required, a single patch cable was used to bypass the SONET Node (see Wayne).

At the central hub site, the SONET Node was bypassed by connecting the 1470nm channel ports on the CWDM MUXes with fiber patch cables.



The CWDM network was installed in just a few days, and Anthony Abate was quite satisfied. "The results were excellent. CWDM effectively provided us with a clean slate of dark fiber with zero impact on the existing OC-12 service. We had no issues during the installation and a seamless turn-up process. Our new Gigabit Ethernet backbone is working flawlessly."

The beauty of SONET networks is the resiliency to re-route network links. SONET rings operate in both directions, so when the CWDM MUXes were installed, there was no down time on the SONET network.

CWDM enabled Line Systems to generate new revenues by providing Carrier Ethernet and Layer 2 Bridging Services to multisite customers. "We can now offer a full complement of Metro Ethernet Services such as E-Line, E-Lan, and E-Tree. Furthermore, having a dedicated Layer-2 backbone enables Line Systems to be one of the few MEF Certified Carriers offering Layer-2 services to the SMB marketplace."

The 4-Channel CWDM Multiplexers Anthony installed in the network enabled the delivery of new services without the major expenses of fiber installations or SONET equipment upgrades. "The CWDM

MUXes also provide room to grow with additional channels still available for new rings or point-to-point access networks. Line Systems has future proof expandability to 10 Gigabit Ethernet, FTTX, and other services without making any additional investment in physical facilities."

Why Anthony Chose Omnitron Systems

"We had already had an excellent experience with Omnitron in the past. When building the initial OC-12 ring, we had some segments where the 1310nm OC-12 optics could not reach the distance required. After doing some research I found Omnitron as a provider of fiber converters. We purchased several 1310-1550 extenders that enabled our lower powered optics span the longer segments.

However, at first there was an interoperability issue on the 1310 side of the extender and we could not get a reliable signal between the Omnitron extender and our SONET equipment. We contacted Omnitron support who immediately took control and responsibility of the issue, whereas most vendors could have easily just pointed the finger at our gear. Instead, they contacted our equipment manufacturer, obtained specs for the optics, and found new optics for their extender that were compatible.

They then took back the extenders we had purchased and replaced them with a special build using the new optics, all in less than a week! The new extenders worked perfectly and are still in use today. This level of response from a company is unparalleled and as such Omnitron will always be my first choice for anything fiber related."

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