Recent growth in bandwidth needs has, of course, placed additional demands on fiber optic networks. In most cases, there’s a simple fix: coarse wavelength division multiplexing (CWDM) technology. The idea is a century old; copper wire can transmit multiple signals at different frequencies. For fiber, CWDM adds bandwidth while increasing the flexibility, accessibility, adaptability, manageability and protection of the network; distances up to 60 km (35 miles) are easy to bridge.

CWDM can be viewed as a “third generation” of WDM technology. WDM was originally developed so that data and RF video signals could be carried on the same strand of glass; it traditionally employed 1310 nm and 1550 nm wavelength signals. Next, as providers with a fixed number of fibers ran short of bandwidth due to rapid growth or unforeseen demand, they began multiplexing a signal on top of the existing 1310 nm wavelength to create additional channels. However, demand continued to increase dramatically, creating the need for very fine channel spacing to add even more wavelengths (or channels) to each fiber.

Dense WDM (DWDM) was a major breakthrough; equipment providers pushed to offer new DWDM equipment, promising nearly unlimited bandwidth potential. DWDM was quickly adopted for long-haul and transoceanic optical networking, but its use in regional, metropolitan and campus environments was, in most cases, cost prohibitive; local traffic usually does not require all the wavelengths DWDM can provide.

A more targeted and cost-effective solution soon followed: CWDM, which uses a standard of channel spacing developed by the International Telecommunication Union (ITU) in 2002. This standard calls for a 20 nm channel spacing grid using wavelengths between 1270 nm and 1610 nm (see Figure 1). The cost of deploying CWDM architectures today is significantly lower than its DWDM predecessors.

Even though the ITU’s 20 nm channel spacing offers 20 wavelengths for CWDM, the reality is that wavelengths below 1470 nm are considered “unusable” on older fibers meeting the ITU G.625 specification due to the increased attenuation in the 1310–1470 nm bands. However, new fibers with little or no “included water” in the glass (they conform to the newer G.652.C and G.652.D standards) nearly eliminate the “water peak” attenuation area.

This enables a CWDM system to operate effectively at the low end of the ITU grid as well. For example, an Ethernet LX-4 physical layer uses a CWDM consisting of four wavelengths near the 1310 nm wavelength, each carrying a 3.125 Gbps data stream. Together, the four wavelengths can carry 10 Gbps of aggregate data across a single fiber.

One issue of little import to network builders: The ITU CWDM standard uses signals that are not spaced appropriately for amplification by EDFAs (erbium-doped fiber amplifier lasers). This limits the total CWDM optical span between amplification stages to the 60

![Figure 1. CWDM wavelength grid as specified by ITU-T G.694.2. Today’s standardized CWDM is better defined as a cost-effective solution for building a metropolitan access network that promises all the key characteristics of a network architecture service providers dream about – offering transparency, scalability, and low cost.](image-url)
km mentioned earlier for the full bandwidth. However, this distance is suitable for use in metropolitan applications. The relaxed optical frequency stabilization requirements also allow the associated costs of CWDM to approach those of non-WDM optical components.

**Basic Implementation**

Market studies have indicated accrued costs between $10,000 and $70,000 per mile to deploy new fiber cable. The large disparity is due to different situations – for example, it costs far more to tear up a city street than to simply trench fiber in a rural setting. But the key issue is that network architects can incorporate a CWDM system for much less cost and still achieve the bandwidth increases necessary to meet demand today and well into the foreseeable future.

Basically, a CWDM implementation involves placing passive devices – transmitters and receivers – at each end of the network segment. CWDM devices perform two functions. First, they filter the light to ensure only the desired combination of wavelengths is used. The second function involves multiplexing and demultiplexing the signal across a single fiber link.

In the multiplex operation, the multiple wavelength bands are combined onto a single fiber for transport. In the demultiplex operation, the multiple wavelength bands are separated from the single fiber to multiple outputs (Figure 2). ADC’s modules, for example, can easily be incorporated into central office (CO), multiple service operator (MSO), and mobile switching center (MSC) environments for leveraging the benefits of CWDM. The MSC uses CWDM to multiplex the different hosts on a wireless coverage system to multiple remotes using minimal fiber strands. Even a single fiber can service 4, 6, or 8 different remote units. From there, an antenna is attached to each device to enable indoor wireless coverage.

**Designated, Dedicated Wavelengths**

CWDM also offers the benefit of individual wavelengths for allocating specific functions and applications. Out-of-band testing capability is achieved by simply dedicating a separate wavelength or channel for non-intrusive testing and monitoring. In fact, any number of different applications can be applied to specific wavelengths. For example, a particular wavelength might be dedicated specifically for running overhead or management software systems.

This is a common practice in using CWDM for cable television networks, where different wavelengths are dedicated for downstream and upstream signals.

It should be noted that the downstream and upstream wavelengths are usually widely separated. For instance, the downstream signal might be at 1310 nm while the upstream signal is at 1550 nm.

Another recent development in CWDM is the creation of small form factor pluggable (SFP) transceivers that use standardized CWDM wavelengths. These devices enable a nearly seamless upgrade in even legacy systems that support SFP interfaces, making the migration to CWDM more cost effective than ever before. A legacy system is easily converted to allow wavelength multiplexed transport over one fiber by simply choosing specific transceiver wavelengths, combined with an inexpensive passive optical multiplexing device.

**Learn More**

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