What Is Wavelength Division Multiplexing (WDM)

Transmitting many different colors (wavelengths) of laser light down the same optical fiber at the same time, in order to increase the amount of information that can be transferred along a single media

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As an optical network consists of optical fibers carrying flashes of light from a laser, you can improve the speed of information transfer by increasing the number of laser light flashes per second (increasing the bit-rate). However, a point comes at which the technology of lasers cannot meet the demands of an optical network. The digital "on/off" rate can no longer support the amount of data being require to be moved or the costs associated with manufacturing this highest quality laser exceeds the value of the data being moved. The solution it turns out was found years ago in the electrical realm. Utilize wavelength division multiplexing (WDM) to move multiple data fields over the same media (fiber in this case instead of air for RF solutions) simultaneously.

In an optical network, you can increase the number of lasers and have them all sending their light down the optical fiber at the same time. However, there is a catch. If all of the lasers were operating at the same frequency or wavelength then it would be extremely difficult to separate data streams. The solution is to have each data stream transmitted on a frequency slightly separated from its nearest neighbor. In optics this frequency shift is can be viewed as a color shift. If all the different lasers give out different colors (different wavelengths) of light so that their information can be separated at the other end of the network then truly a single media can be used to carry multiple data streams. The sending of many different wavelengths down the same optical fiber is known as Wavelength Division Multiplexing (WDM) and it allows for tremendous data capacity expansion of a single optical fiber without having drive laser switching times every faster.

Modern networks in which individual lasers can transmit at 10 Gigabits per second can now have several different lasers each giving out 10 Gbit/s through the same fiber at the same time. The number of wavelengths is usually a power of 2. So WDM systems will use two different wavelengths, or 4, 16, 32, 64, 128, etc. Systems being deployed at present will usually have no more than maybe 32 wavelengths, but technology advancements will continue to make a higher number of wavelengths possible limited only by the ability for lasers to provide fidelity across narrow bandwidths.

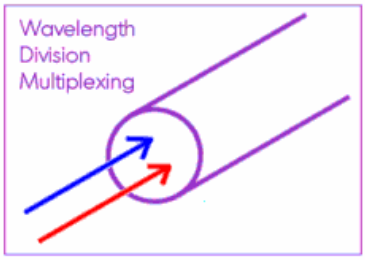
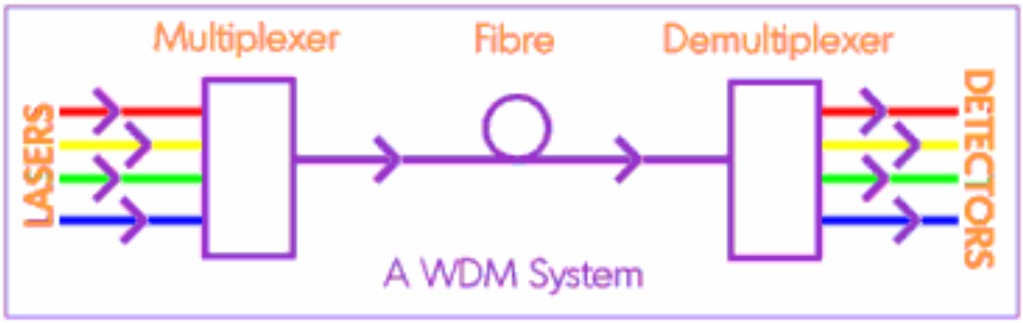


Figure 1: Multiple Light Frequencies On A Single Optical Fiber Media (WDM)

The act of combining several different wavelengths on the same fiber is known as multiplexing. At the receiving end, these wavelengths need to be separated again, which is known, logically enough, as *de*multiplexing. Each wavelength needs its own light detector to convert it back into an electrical signal for subsequent processing.

Figure 2: Wavedivision Multiplexing Scenario



The exact wavelengths of light being used are usually around the 1550 nanometer. This is driven by the inherent physical absorption characteristics of current technology optical fiber (it has very "low loss" or "low attenuation" at this wavelength). In WDM applications each different wavelength will be separated by a multiple of 0.8nm (sometimes referred to as "100GHz spacing," which is the frequency separation; or as the "ITU-Grid," named after the standards body that set the figure). So if a system has four wavelengths they may be at 1549.2nm, 1550nm, 1550.8nm, and 1551.6nm. However, they could be separated each by 1.6nm, or even 2.4nm, as long as it is some multiple of 0.8nm. Newer designs that aim to fit even more wavelengths into an even tighter space may even have half the regular spacing (0.4nm) or a quarter (0.2nm). There can be problems with wavelengths spreading out (known as dispersion) and affecting neighboring wavelengths; so this and other more complicated issues need to be considered carefully when designing a WDM system.