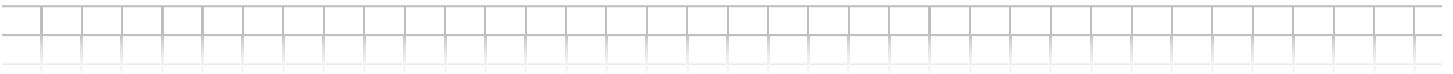
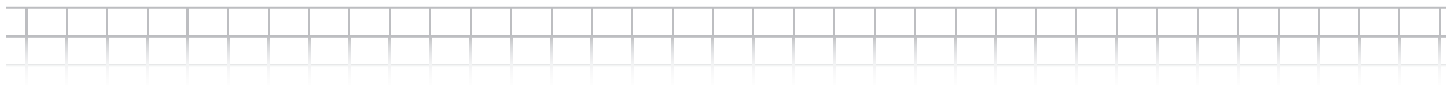


Starved for Fiber?

Understanding **WDM Technology** and Which Option is Best for You





Users of today’s voice, video, and data networks are becoming more complex – requiring more bandwidth and faster data transmission rates over farther distances. To meet these demands, network managers are relying more and more on fiber optics. But the reality that many Service Providers and Enterprise Corporations are facing is that once their available fiber infrastructure is exhausted, laying more fiber is no longer an economical or feasible option. So, now what?

Many are turning to Wave Division Multiplexing (WDM) technologies in order to increase capacity on the fiber links that are already in place. WDM is a technology which multiplexes multiple optical signals on a single fiber by using different wavelengths, or colors, of laser light to carry the different signals. By utilizing bidirectional communications over a single fiber, network managers can realize a multiplication effect in their available fiber’s capacity.

A quick study of WDM yields three major options: Bidirectional Wave Division Multiplexing (BWDM), Coarse Wave Division Multiplexing (CWDM) and Dense Wave Division Multiplexing (DWDM). This paper will take a look at the benefits and drawbacks of all three, as well as provide cost comparisons between each option. In order to provide consistent cost comparisons, only one manufacturer will be illustrated in the various examples. Due to their widespread market familiarity, we have chosen to use Cisco’s SFP, CWDM, and DWDM equipment in these comparisons.

Bidirectional Wave Division Multiplexing (BWDM)

BWDM (also referred to as: bi-di, simplex, and single strand) is the least expensive WDM solution, but also the most limiting as far as future proofing and anticipating tomorrow’s requirements of your network. When examining the pros and cons of BWDM you will find:

Benefits of BWDM:

- Inexpensive
- Requires little or no changes to the general construction of the current network
- Doubles the capacity of existing fiber routes

Drawbacks of BWDM:

- Doubling the capacity may not be enough
- Requires having separate spares for each end of the link (up and downstream)



While BWDM has the ability to double the amount of fiber capacity in a network, the major question that still remains is: How much time until that extra space is consumed and further steps need to be taken to increase capacity?

Using the Cisco SFP module pricing from www.cdw.com, the average per channel (complete link) cost of a single strand gigabit SFP is:

QTY	PART	PRICE	EXTENDED
8	GLC-BX-U	\$884.99	\$7079.92
8	GLC-BX-D	\$884.99	\$7079.92
TOTAL			\$14,159.84
PER CHANNEL			\$1,769.98/ea
FIBER STRANDS NEEDED			8

Compared to a similar solution using Duplex SFP modules from Cisco and the same price source:

QTY	PART	PRICE	EXTENDED
16	GLC-LH-SM	\$706.99/ea	\$11,311.84
TOTAL			\$11,311.84
PER CHANNEL			\$1,413.98/ea
FIBER STRANDS NEEDED			16

For an average cost increase of 25% per channel, you can effectively double the capacity of your existing fiber infrastructure. If doubling your fiber capacity is not enough future proofing, then moving to CWDM or DWDM would be required.

Coarse Wave Division Multiplexing (CWDM)

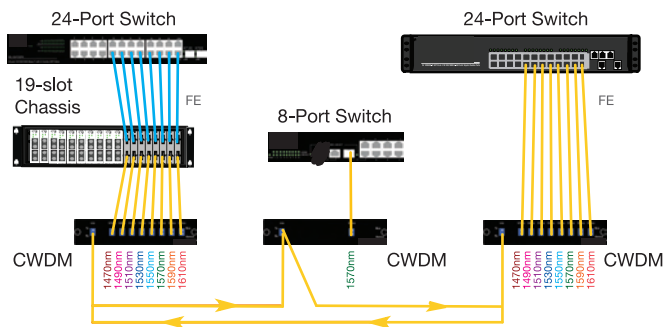
CWDM increases fiber capacity in either 4, 8, or 16 channel increments. By increasing the channel spacing between wavelengths on the fiber, CWDM allows for a simple and affordable method of carrying up to 16 channels on a single fiber. Benefits and drawbacks of CWDM are:

Benefits of CWDM:

- Passive equipment that uses no electrical power
- Much lower cost per channel than DWDM
- Scalability to grow the fiber capacity as needed with little or no increased cost
- Protocol transparent
- Ease of use

Drawbacks of CWDM:

- 16 channels may not be enough
- Passive equipment that has no management capabilities
- Costs significantly more per channel than BWDM



Since CWDM is a passive technology, it allows for any protocol to be transported over the link, as long as it is at a specific wavelength (i.e. T1 over fiber at 1570nm along side 10Gbps Ethernet at 1590nm). This allows for future proofing of the networking infrastructure because the device simply refracts light at any network speed, regardless of the protocol being deployed. Another benefit to a passive CWDM technology is that no configuration is necessary, which makes CWDM a low cost and effortless technology to implement. The most complex step in CWDM integration is plugging in the patch cables from the correct wavelength SFP to the correct port on each end of the link.

Many CWDM implementations begin with an 8 channel CWDM mux because there is an immediate need to expand fiber capacity, yet there is no anticipated need for running more than 8 channels over a pair of fibers in the future. However customers can also purchase 8 channels with an add port on them, in order to combine an additional 8 wavelengths at a later date and grow their system to 16 channels.

CWDM is more expensive than BWDM because of the insertion loss of the equipment and the optics needed for the distance of transmission. For example, a standard CWDM wavelength SFP module is designed for 80km transmission rather than anything shorter. Here is a price comparison between a >10km solution and a CWDM price per link using Cisco equipment and Belkin patch cables:

QTY	PART	DESCRIPTION	PRICE	EXTENDED
2	CWDM-MUX8A	8 channel mux	\$6,120.00/ea	\$12,240.00
16	CWDM-SFP-1xx0	80km CWDM SFP	\$3,683.00/ea	\$58,928.00
16	F2F802L7-02M	2m SM patch cables	\$28.95/ea	\$463.20
TOTAL				\$71,631.20
PER CHANNEL				\$8,953.90/ea
FIBER STRANDS NEEDED				2

Now there is a very significant price difference per channel, compared to BWDM, but the shock fades somewhat when the solution is compared with the Cisco 80km Duplex SFP modules per channel cost (remember the CWDM-SFP-1xx0 SFP modules are for 80km):

QTY	PART	DESCRIPTION	PRICE	EXTENDED
16	GLC-ZX-SM	80km SFP	\$2,823.00/ea	\$45,168.00
TOTAL				\$45,168.00
PER CHANNEL				\$5,646.00/ea
FIBER STRANDS NEEDED				16

Assuming a deployment distance of roughly 10-70km, the cost increase is 59% to reduce the fiber usage by a factor of 8 (taking 16 strands down to 2). In effect increasing the capacity of the fiber by 800% for 1.5 times the total cost of the equipment.

Dense Wave Division Multiplexing (DWDM)

The last option available is a DWDM solution. DWDM comes in two different versions: an active solution and a passive solution. An active solution is going to require wavelength management and is a good fit for applications involving more than 32 links over the same fiber. In most cases, passive DWDM is looked at as a more realistic alternative to active DWDM. Here are the benefits and drawbacks of a DWDM solution:

Benefits of DWDM:

- Up to 32 channels can be done passively
- Up to 160 channels with an active solution
- Active solutions involve optical amplifiers to achieve longer distances

Drawbacks of DWDM:

- DWDM solutions are quite expensive
- Active solutions require a lot of set-up and maintenance expense
- Very little scalability for deployments under 32 channels



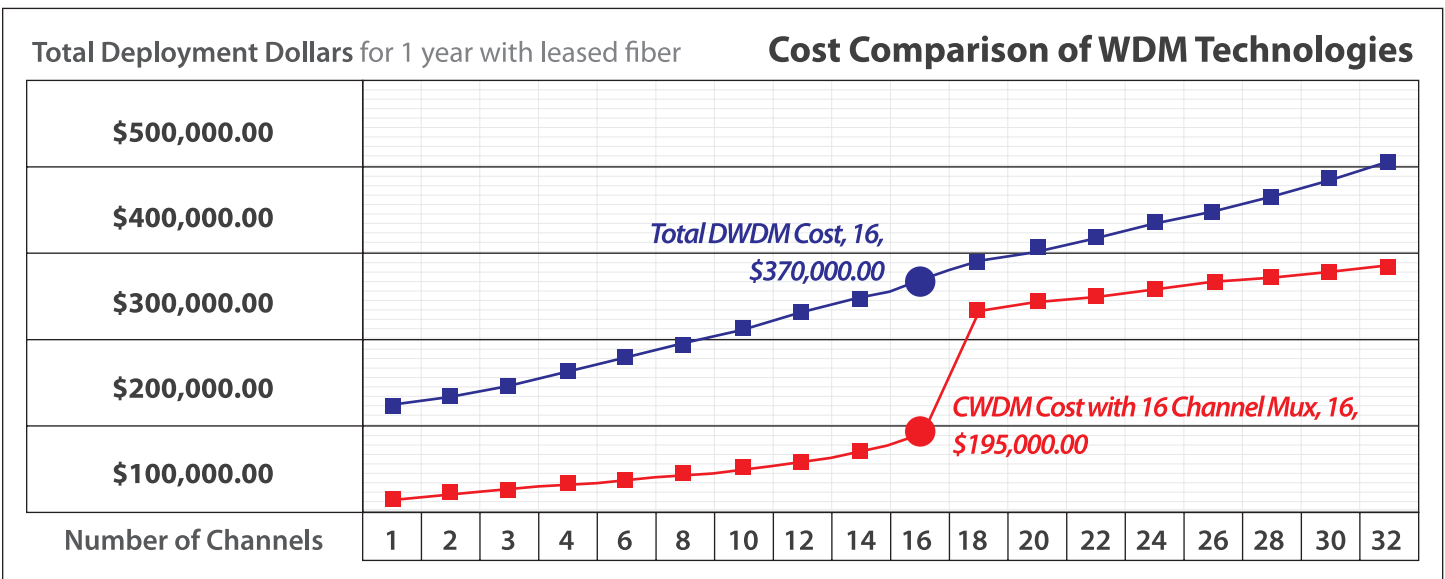
DWDM offers essentially the same benefits of CWDM, especially when evaluating a passive solution. An active DWDM solution, on the other hand, is very labor intensive and complicated to design and configure. However the extra distance capabilities of optical amplifiers and the immense amount of channels make active DWDM an attractive solution for large capacity optical rings that are servicing hundreds of customers or locations. The down side to a passive DWDM solution, that needs to be taken into account, is that rarely are the extra channels being provided actually being used. Thus without utilizing the full 32 channels over a single fiber link, a lot of unnecessary cost is being incurred per channel with no offsetting gain. Here is a price model of a 32 channel passive DWDM solution configured to provide 16 channels:



QTY	PART	DESCRIPTION	PRICE	EXTENDED
2	ONS-15454	MSTP Chassis	\$3,250.00/ea	\$6,500.00
2	15454-32MUX-O	32 Channel Mux	\$28,875.71/ea	\$57,751.42
2	15454-32DMX-O	32 Channel Demux	\$28,875.71/ea	\$57,751.42
16	DWDM-SFP-xxxx	80km DWDM SFP	\$4,000.00/ea	\$64,000.00
16	F2F802L7-02M	2m SM patch cables	\$28.95/ea	\$463.20
TOTAL				\$186,466.04
PER CHANNEL				\$23,308.25/ea
FIBER STRANDS NEEDED				2

Conclusion

Often times it is a difficult proposition to compare passive DWDM and CWDM solutions against one another. With the benefits and drawbacks of each being nearly identical, the true differentiators end up being the number of channels needed by the customer and the cost associated with deploying each system. The graph below takes into account the cost per strand (\$1.00/m) for leasing 10km of fiber over the course of one year. As you can see, the graph illustrates that at 16 channels and below, CWDM is indeed the more economical WDM solution to implement.



It should also be noted that Transition Networks' CWDM solution, with its free technical support and lifetime warranty, offers an even greater savings than the Cisco cost comparison examples referenced throughout this document as illustrated below:

QTY	PART	DESCRIPTION	PRICE	EXTENDED
2	CWDM-M1631LCR	16 Channel Mux	\$4,660.00/ea	\$9,320.00
16	CWDM-SFP-1xx0	80km CWDM SFP	\$1,875.00/ea	\$30,000.00
16	F2F802L7-02M	2m SM patch cables	\$28.95/ea	\$463.20
TOTAL				\$39,783.20
PER CHANNEL				\$4,972.90/ea
FIBER STRANDS NEEDED				2

View additional information online:
[Course Wavelength Division Multiplexing \(CWDM\)](#)
[CWDM Products and Conversion for Optical Networks](#)

