Optical Fiber: Bringing Bandwidth to the Classroom Cost Effectively

Mike Lynch
Vice Chair, Fiber Optics LAN Section
Marketing Manager,
3M/Volition
6801 RiverPlace Blvd., Austin TX 78726
MJLynch2@mmm.com
512-984-4811

Overview

Fiber optics technology, usage, installation and costs have changed significantly during the past several years. However, there are many lingering misconceptions about fiber. One of the major misconceptions is the cost of fiber versus copper. Because of this misunderstanding, many schools, businesses, and enterprises have stayed away from using fiber as effectively as possible in their networks.

The reality is there are many ways to use fiber in a network, where it will be both beneficial, and cost effective. However, network managers need to implement fiber so that it's advantages are utilized, and thereby receive some of the cost savings as well. Fiber is not for everyplace, and is does have to be used exclusively. It is the combination of copper and fiber networks using fiber where it can provide the most benefit that will help give network managers and educators the most bandwidth for their "pipe" and "bang for their buck".

During the presentation, we will quickly review some basic fiber facts, and discuss how fiber advantages can help in your LAN. Generic fiber and copper network designs will be reviewed, and specific campus designs will be discussed. We will conclude by reviewing the FOLS cost analysis formula, and other costing white papers.

Basic Fiber Facts –

- Index of Refraction - The index of refraction is the ratio of the speed of light in a vacuum to the speed of light in a material. The material must be transparent enough to pass some light through it. Light always travels through a vacuum faster than through a material, therefore, the index of refraction will always be greater than one.

- Internal Reflection - A fiber optic strand is made of two components called the core and the cladding. Light enters the fiber, bounces down the core and exits at the opposite end. The core has a different index of refraction than that of the cladding. When the light that enters the core comes to the core/cladding boundary, it will be bent away from the cladding and back into the core. This process is called total internal reflection.

- Attenuation - In copper systems we have loss that is called resistance. We measure resistance in ohms. In fiber we have loss. We call this loss (or decrease in power) attenuation which we measure in dB (decibels). The lower the attenuation, the more light that is transmitted. Attenuation of the light can be caused by several factors:

1. Absorption of the light by materials in the glass.
2. Scattering of the light out of the core due to impurities.
3. Leakage of light out of the core due to exceeding the maximum bend radius of the fiber optic strand. This is called a macro bend. Once the light leaves the core, it is absorbed in the cladding.
4. Micro bends (high attenuation due to pin-point pressure). This can happen when water surrounds the fiber and then freezes, or a staple gun smashes a stable around a fiber cable.

- Electromagnetic Spectrum - The 4 basic wavelengths used in fiber optic data transmission are 850, 1300, 1310 and 1550nm. This is because fibers propagate the light of these wavelengths more efficiently (i.e. less loss or attenuation).
- Multi-mode & Single mode fiber - There are 2 types of fiber, single mode and multi-mode. Multi-mode means that there are multiple paths (or modes) for the light to travel down the fiber. The larger the core, the more modes it will carry. Standard sizes are 50um, and 62.5um. Multi-mode fibers are either step-index or graded-index. Step-index fibers have a distinct difference (a step) in the core's and cladding's index of refraction's. Single mode fiber is a step index fiber. It too has a distinct difference between the core and claddings index of refraction. Single mode fiber has a core that is about 10um in diameter.

Fiber Misconceptions –

Many people have inaccurate perceptions about fiber. These include factors around size, fire rating, connections, strength, and weight.

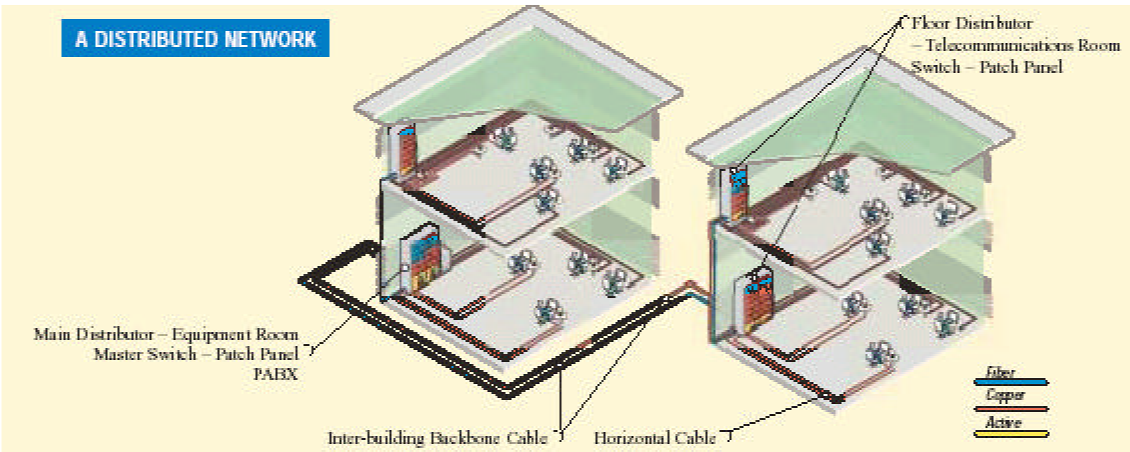
- There is a perception that copper cable is smaller than fiber cable. The fact is that fiber is 15% smaller.
- Another perception is that copper weights less than fiber. The fact is that fiber components are heavier, but fiber cable is lighter.
- The perception is that copper is more fire-resistant. The fact is that fiber is plenum-rated, compatible with various infrastructures.
- The perception is that fiber connections require special training, and take considerable time. The fact is that many small form factor connectors can be put together in under two minutes.
- A final perception is that fiber is fragile. The fact is the fiber is 4 times stronger than copper.

In addition to the misconceptions, fiber has several inherent benefits that are critical for its placement in a network. For example, network managers can run fiber three times longer than copper – at a minimum. Depending on the types of fiber, and the speeds being run, distances can be up to 10 times that of copper. Fiber is secure from physical 'break-in" or tapping. Fiber is also "interference-free". Electrical and mechanical surges will not interfere with the traffic on a fiber connection. Fiber has capacity for much more bandwidth than other cable mediums.

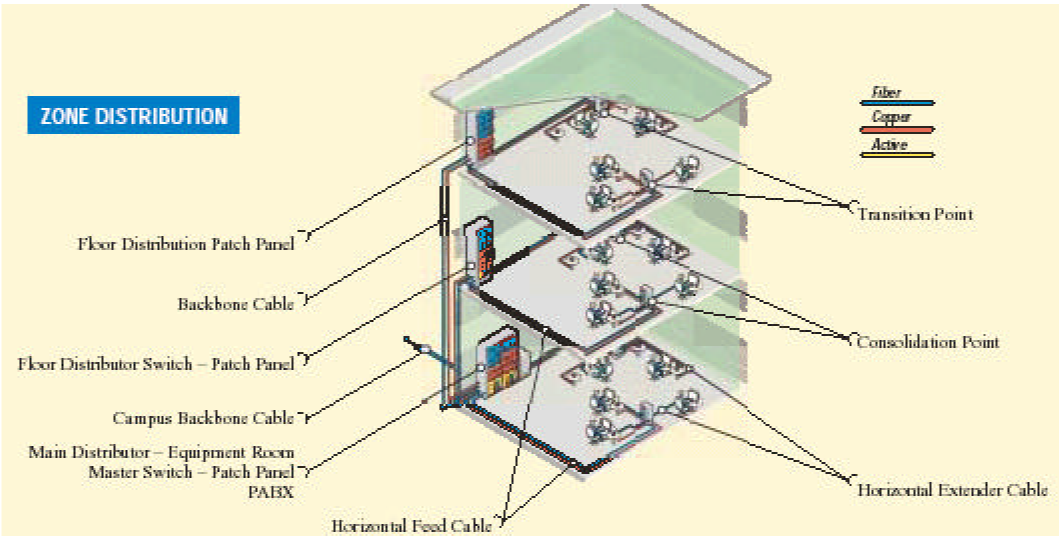
All of these features can be used to enhance a schools network when cost effectively integrated in a total fiber and copper architecture.

Fiber Network Configurations – Centralized, Zone, and Distributed Networks.

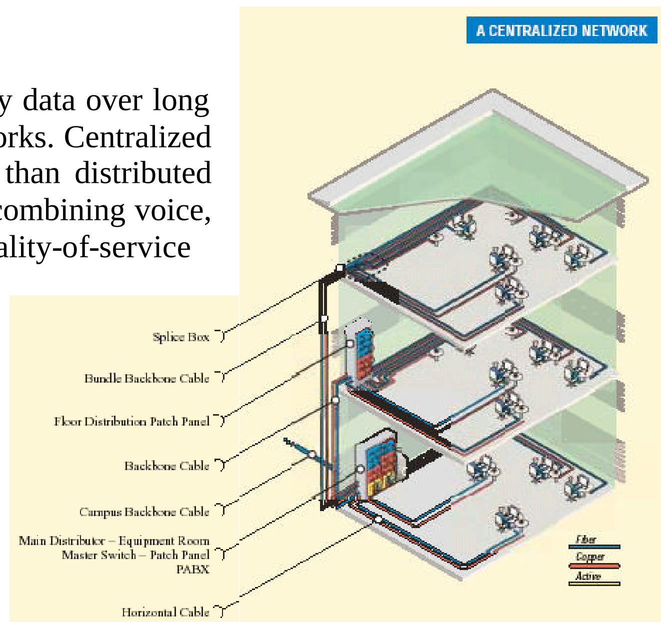
In the conventional distributed structured cabling design, backbone cable is optical fiber, where the horizontal segment of the network typically consists of twisted-pair copper cable or optical fiber cable. Backbone cables in an inter-building network travel from a main cross-connect (distributor) to one or more horizontal cross-connects within the telecommunication rooms on each floor.



Moves, adds or changes in an dorm or open-office environment can be accommodated quickly and efficiently through consolidation points by combining permanent feeder cabling with pre-terminated plug-and-play extender cables associated with the work area. Providing connectivity closer to end-users not only adds flexibility, but also reduces network downtime and re-cabling needs, which can result in significant cost

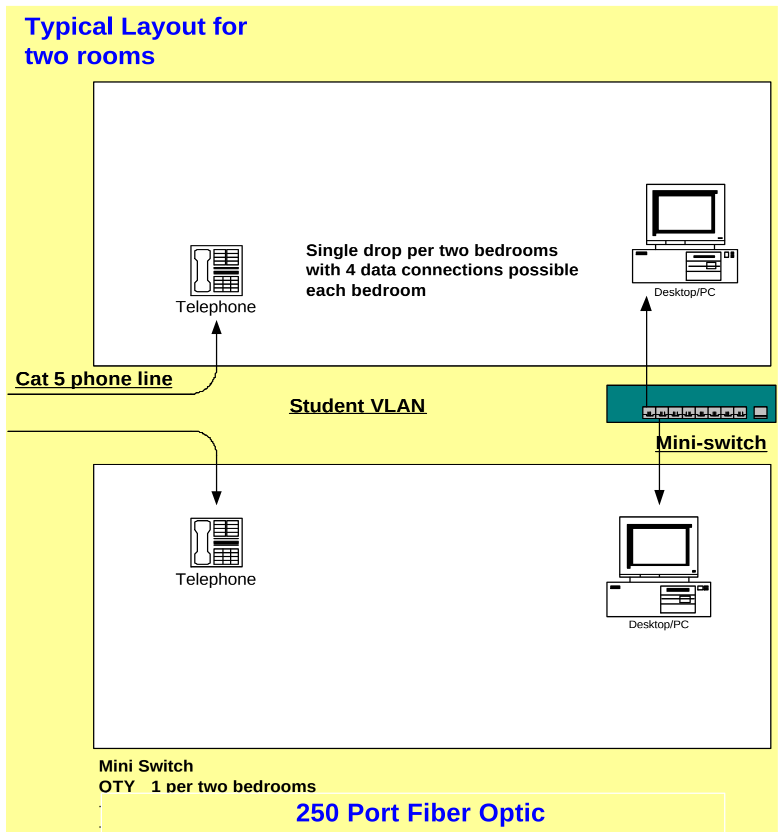


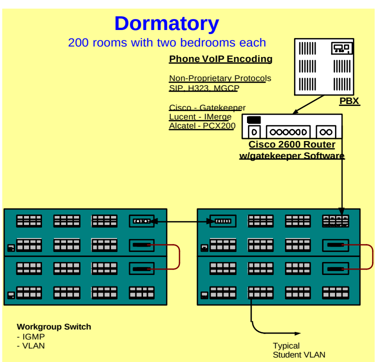
Optical fiber's bandwidth and ability to carry data over long distances is best utilized in centralized networks. Centralized networks have more unblocked bandwidth than distributed networks and are therefore better suited for combining voice, video and data traffic requiring quality-of-service implementation. Optical fiber eliminates intermediate closets, thus simplifying network layout, providing increased security, and reducing overall system cost. A centralized architecture is the most efficient, cost-effective and secure way to implement a network.



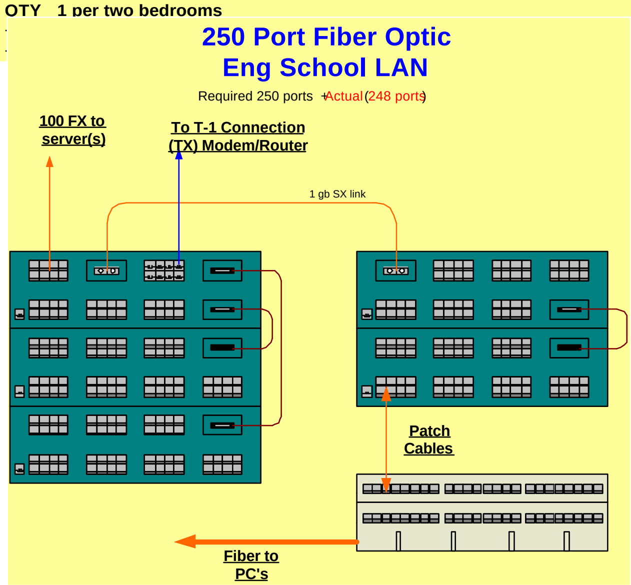
Generic Designs Applied to Specific College Networks –

Applying the general network designs to the specific college LANs is where creativity needs to be combined with technology. There are specific rules, but using fiber and copper to get the most efficient network requires flexibility. Do you need to combine your phone lines with your data lines? Should you coordinate security networks with data networks? Do you have distance learning, or video conferencing? These and many other factors need to be considered. Some basic configurations for different areas of a college are seen in some of the diagrams that follow:





In all of these configurations, there are new things to consider like “switch verters” that can be used in dorms, or classrooms. How to use “tiny telecommunications rooms” or zones for passive cabling, media conversation, or simple switching can also help in efficient designs.



All of these designs are important because they can help lower the overall costs of your network, particularly a fiber LAN. Cost comparison tools can help you make the right decisions.

How To Compare Costs -

Two cost comparison resources will be used during the presentation. The first is a study by the Tolly Group entitled “Migrating to Fiber – The Case for Centralized LAN Cabling”. This paper looked at all aspects of fiber and copper networks, and did a cost comparison between them. The cost savings included “hard” costs like, telecom closets, switches, cabling, connectors, installations, etc. It did NOT include “soft” costs like maintenance, upgrades, or moves, adds and changes. Their conclusion was that there could be considerable savings depending on your designs. Some of the specific conclusions included the following:

- Disparity in costs is largely attributable to the incorrect impression that fiber costs are higher than UTP.
- Designing fiber-optic networks based upon the design characteristics of fiber often will save thousands of dollars compared to copper.
- All fiber networks can save tens of thousands of dollars by shrinking (or even eliminating) some telecommunications rooms.
- To the list of fiber’s well-known benefits of exceptionally high bandwidth and immunity to electrical interference, we can now add the benefit of significant cost reductions.
- In part, fiber networks have lower costs than copper/fiber due to simplified connector design and high-density, small-form-factor connectors.
- There are significant capital savings associated with centralized cabling. IT managers can enjoy reduced recurring costs over the life of the cable installation.
- Centralizing this equipment in a single physical location allows for more efficient delivery of air conditioning, better network management and control, and tighter system security.
- Rather than providing Gigabit Ethernet uplinks to the main equipment room in the distributed model, a centralized model allows users to connect directly to a backbone switch and leverage the bandwidth of the switch backplane.
- Faster troubleshooting and problem resolution in a centralized network. In fiber architecture this requires 2 people, and it often takes up to three for UTP.
- Expediting repair and minimizing downtime naturally translates into increasing productivity, revenues and customer satisfaction.

A powerful decision making tool for network designers is the FOLS cost model. This is the second resource that will be used to analyze fiber and copper networking costs. Though this model is biased against fiber, it shows that the cost of many all fiber network configurations is lower than the cost of typical fiber UPT networks.

This interactive model includes many of the aspects of the Tolly study, but this model can be tailored to a specific situation. We will use a few standard examples, but will also use the model to demo specific examples from attendees. An example of some of the model follows.

per node	per node	man-hrs		ALL FIBER NETWORK	per node	per node	or cost,$
64.00				fiber NIC	100.00		
9.00				fiber jumper to wall plate	15.00		
2.29				wall plate	3.00		
5.00	9.60	0.16		jack or barrels+plugs	3.00	10.00	0.17
18.00				horizontal fiber cable	45.73		
5.00	0.20	0.16					
5.00	9.60	0.16		2 mechanical splices	16.00	10.00	0.17
5.59	5.00	0.08		wall mounted enclosure	3.00	15.00	0.25
176.93							
8.08	0.00						
2.08	30.00	0.50					
				sub total	185.73	35.00	
300.98	54.40		A	**cost/port**	185.73	35.00	
21.95	0.00						
6.67	9.60	0.16					
0.00							
8.00	10.00	0.17					
21.00				vertical riser fiber cable	30.00		
57.62	19.60			**sub total**	30.00	0.00	
1.20	0.41		B	**cost/port**	30.00	0.00	

Conclusion –

The use of fiber in networks has been slowed by misconceptions about costs – particularly how fiber can be used in an efficient copper-fiber integrated network. Forcing fiber into an all-copper network design can negatively impact the efficiency of fiber, and increase total network costs. It is the creative combination of copper and fiber network designs that will provide the best technology solutions coupled with optimal cost savings. Understanding advanced fiber architectures and using the FOLS cost comparison model can help you find the best network design.

References

Source: Fiber Optic LAN Section (FOLS) "Interactive Cost Model for Horizontal Cabling: Fiber vs. Copper", http://fols.org/pubs/costmodel.html

Source: "Optical Networking Crash Course", Steven Shepard: McGraw Hill, 2001

Source: Tolly Group Report: "Migrating to Fiber: The Case for Centralized LAN Cabling", July 2000

Source: Horizontal Cabling Costs: Fiber vs. Copper Calculations", Cabling Installation & Maintenance Magazine, May 2002.