The Overselling of Fiber Optics?
Cable Planning for Educational Technology

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The new building at a large university is extensively laced with fiber optic cables. In fact, there are so many fiber optic cables that the cable supports are literally buckling from the weight of all the cable. In this true story, is there a happy ending for educational technologists, an ending where the fiber optic cables, once installed, economically support the university’s goals? Unfortunately, in this particular case the answer seems to be “No.” Over the next few years, the installation of fiber optic cable in this new building will cost the university at least several hundred thousand dollars more to use than other cable technologies.

When are fiber optic cables appropriate in education, and when is it better to consider other cabling techniques? The answer to this question requires a quick look at the common cabling schemes, and a review of the strengths and weaknesses of each.

Fiber optics: Single mode vs. Multi-mode

There are two common types of fiber optic cables, single mode and multi-mode. The most common type of multi-mode fiber has an optical diameter of 62.5 microns (a micron is one millionth of a meter) and typical single mode fiber has an optical diameter of 8.8 microns. This means that multi-mode fiber presents a “window” to the optical signal of 62.5 microns, while the single mode fiber presents a much smaller 8.8 micron window. (The “multi” and “single” descriptors refer to the light path, or “mode,” within the fiber. The important point for this discussion is that multi-mode fiber has a much larger diameter than single mode fiber).

To use fiber optic cable, an electrical signal must be converted into a light signal, and then injected into the fiber. At the far end of the fiber, the light signal is converted back into an electrical signal. For example, a system with a video camera connected to a monitor looks like the system in Figure 1 (See page 16). Notice that the video camera and the video monitor are connected to the fiber adapters using coaxial cable.

The typical multi-mode fiber adapter has electronic circuitry converting the camera’s electrical signal into a light signal. The fiber adapter has an LED (Light-Emitting Diode) that injects the light signal into the fiber. At the receiving end, the fiber adapter has an optical sensor which converts the light signal back into an electrical signal. Additional electronics recreate and amplify the electrical signal for display on the monitor. Single mode fiber adapters often use lasers to create a light signal with enough power to inject a signal into such a narrow opening. These laser fiber adapters are expensive and are usually reserved for high performance applications. High performance LED’s are also used in some single mode fiber adapters.

Fiber optic cables have certain advantages over more traditional copper cables. These advantages are:

- **Electrical insulation.** Fiber optic cables, made from glass, which does not conduct electricity. Fiber optic cables cannot carry pulses from lightning strikes or power line surges. And they are impervious to hum, strong electrical fields, and all other electrical noises.
- **Long distance.** Fiber optic cables, particularly single mode cables, can carry signals long distances without amplification. It is common for a single mode fiber to run 20 kilometers (12.5 miles) with no repeaters or line amplifiers. Multi-mode fiber cannot be run such long distances, but it can be easily used up to one kilometer, and can often run for as long as five kilometers (about 3 miles).
- **Wide bandwidth.** Fiber optic cables can carry a lot of information, either as analog or digital signals. Fiber has the potential to exceed coaxial cables. However, this potential is largely unrealized with current technology.
- **Light weight.** Fiber optic cables weigh significantly less than copper cables. This is important...
if the cables are installed in overhead raceways or cable trays.

Fiber optic technology has some disadvantages when compared with other cabling systems. These are:

- **Connector expense.** Fiber optic connectors are more expensive to install than connectors used for copper cables. For example, a multi-mode fiber connector costs about $5 to install. A single mode fiber connector costs about $25 to install. Compare this with a coaxial cable connector, which costs about $1 to install.

- **Cable fragility.** Fiber cables are mechanically fragile when compared to copper cables. Fiber cables must be curved carefully, and they do not tolerate mechanical stress well.

- **Signal path complexity.** The fiber adapters add complexity to the signal path. They add additional points where equipment may fail, and introduce distortion and noise into the signal path.

- **Overall expense.** Coaxial and fiber optic cables cost approximately the same. However, fiber optic cables require the use of fiber adapters. These adapters cost from $200 to $2,000 per pair, a significant expense if there will be many signal paths. Single mode adapters are considerably more expensive than multi-mode adapters. (In the university project mentioned at the beginning of this article, there is the possibility that signals may be sent to 600 locations via single mode fibers!)

### Coaxial Cable: Mature But Still Useful

Most television signals, and many data signals, are sent over coaxial cables. The coaxial cable system with which we are most familiar, our local cable TV company, brings dozens of television channels into our homes using coaxial cable. The most common computer network technology, Ethernet, uses coaxial cable in its least expensive version. Unfortunately, coaxial cable has been around for decades, and doesn’t have the same “high tech” aura as fiber optics. However, coaxial cable still works well in educational technology.

Coaxial cables come in many varieties. The most common varieties are RG-59 (which is used in cable TV and for video applications) and RG-58 (which is used for Ethernet and 2-way radio applications). Using the example of the TV camera connected to the video monitor, here is how the same equipment is connected using coaxial cables (see Figure 2). The coaxial cable directly connects the camera and monitor.

Like fiber optic cable, coaxial cable has its advantages and disadvantages. The advantages of coaxial cables are:

- **Simple signal path.** Electronic devices, such as computers, TV cameras, and monitors, deal with electrical signals. Coaxial cable carries these signals without adapters, and without the expense and potential distortion caused by adapters.

- **Wide bandwidth.** Using common cable TV technology, 80 channels of video and audio fit on a single cable. This signal can be distributed to thousands of locations, using simple and inexpensive distribution schemes.

- **Low cable requirements.** An ethernet data network can be connected on a single coaxial cable. (Ethernet requires two fiber optic cables.)

- **Mature standards.** The technologies that rely on coaxial cable are mature, with numerous vendors providing systems that work with other vendors’ products.

Coaxial cable has its disadvantages, too. These are:

- **Conductivity.** Copper is a conductor, and will faithfully carry lightning strikes, electrical pulses, and electrical noise from one location to another. Coaxial cable systems must be carefully designed to minimize or eliminate these unwanted electrical signals.

- **Short distance.** Coaxial cable is best when runs are less than 300 meters (about 1,000 feet). In fact, it is usually a good idea to keep coaxial cables less than 150 meters (about 500 feet).