

Working With Others

Designing a network requires working with other personnel involved in the project, even beyond the customer. These may include network engineers usually from IT (information technology) departments, architects and engineers overseeing a major project and contractors involved with building the projects. Other groups like engineers or designers involved in aspects of project design such as security, CATV or industrial system designers or specialized designers for premises cabling may also be overseeing various parts of a project that involves the design and installation of fiber optic cable plants and systems. Even company non-technical management may become involved when parts of the system are desired to be on exhibit to visitors.

Qualifications For Fiber Optic Network Designers

It's the job of the designer to understand not only the technology of communications cabling, but also the technology of communications, and to keep abreast of the latest developments in not only the technology but the applications of both. Designers should have an in-depth knowledge of fiber optic components and systems and installation processes as well as all applicable standards, codes and any other local regulations. They must also be familiar with most telecom technology (cabled or wireless), site surveys, local politics, codes and standards, and where to find experts in those fields when help is needed. Obviously, the fiber optic network designer must be familiar with electrical power systems, since the electronic hardware must be provided with high quality uninterruptible power at every location. And if they work for a contractor, estimating will be a very important issue, as that is where a profit or loss can be determined!

Those involved in fiber optic project design should already have a background in fiber optics, such as having completed a FOA CFOT certification course, and may have other training in the specialties of cable plant design and/or electrical contracting. It's also very important to know how to find in-depth information, mostly on the web, about products, standards, codes and, for the OSP networks, how to use online mapping services like Google Maps. Experience with CAD systems is a definite plus.

Copper, Fiber or Wireless?

While discussions of which is better – copper, fiber or wireless – has enlivened cabling discussions for decades, it's becoming moot. Communications technology and the end user market, it seems, have already made decisions that generally dictate the media and many networks combine all three. The designer of cabling networks, especially fiber optic networks, and their customers today generally have a pretty easy task deciding which media to use once the communications systems are chosen.

The Communications System

Before one can begin to design a fiber optic cable plant, one needs to establish with the end user or network owner where the network will be built and what communications signals it will carry. The contractor should be familiar with premises networks, where computer networks (LANs or local area networks) and security systems use structured cabling systems built around well-defined industry standards. Once the cabling exits a building, even for short links for example in a campus or metropolitan network, requirements for fiber and cable types change. Long distance links for telecommunications, CATV or utility networks have other, more stringent requirements, necessary to support longer high speed links, that must be considered.

But while the contractor generally considers the cabling requirements first, the real design starts with the communications system requirements established by the end user. One must first look at the types of equipment required for the communications systems, the speed of the network and the distances to be covered before considering anything related to the cable plant. The communications equipment will determine if fiber is necessary or preferable and what type of fiber is required.

Outside Plant Networks

Telephone networks are mainly outside plant (OSP) systems, connecting buildings over distances as short as a few hundred meters to hundreds or thousands of kilometers. Data rates for telecom are typically 2.5 to 10 gigabits per second using very high power lasers that operate exclusively over singlemode fibers. The big push for telecom is now taking fiber directly to a commercial building or the home, since the signals are now too fast for traditional twisted copper pairs.

CATV also uses singlemode fibers with systems that are either hybrid fiber-coax (HFC) or digital where the backbone is fiber and the connection to the home is on coax. Coax still works for CATV since it has very high bandwidth itself. Some CATV providers have discussed or even tried some fiber to the home, but have not seen the economics become attractive yet. Besides telecom and CATV, there are many other OSP applications of fiber. Intelligent highways are dotted with security cameras and signs and/or signals connected on fiber. Security monitoring systems in large buildings like airports, government and commercial buildings, casinos, etc. are generally connected on fiber due to the long distances involved. Like other networks, premises applications are usually multimode while OSP is singlemode to support longer links.

Metropolitan networks owned and operated by cities can carry a variety of traffic, including surveillance cameras, emergency services, educational systems, telephone, LAN, security, traffic monitoring and control and sometimes even traffic for commercial interests using leased bandwidth on dark fibers or city-owned fibers. However, since most are designed to support longer links than premises or campus applications, singlemode is the fiber of choice.

For all except premises applications, fiber is the communications medium of choice, since its greater distance and bandwidth capabilities make it either the only choice or considerably less expensive than copper or wireless. Only inside buildings is

there a choice to be made, and that choice is affected by economics, network architecture and the tradition of using copper inside buildings. Next, we'll look at the fiber/copper/wireless choices in more detail.

Premises Networks

Premises cable systems are designed to carry computer networks based on Ethernet which currently may operate at speeds from 10 megabits per second to 10 gigabits per second. Other systems may carry security systems with digital or analog video, perimeter alarms or entry systems, which are usually low speeds, at least as far as fiber is concerned. Premises telephone systems can be carried on traditional twisted pair cables or, as is becoming more common, utilize LAN cabling with voice over IP (VoIP) technology.

Premises networks are usually short, often less than the 100 meters (about 330 feet) used as the limit for standardized structured cabling systems that allow twisted pair copper or fiber optic cabling, with backbones on campus networks used in industrial complexes or institutions as long as 500 m or more, requiring optical fiber.

Premises networks generally operate over multimode fiber. Multimode systems are less expensive than singlemode systems, not because the fiber is cheaper (it isn't) nor because cable is cheaper (the same), but because the large core of multimode fiber allows the use of cheaper LED or VCSEL sources in transmitters, making the electronics much cheaper. Astute designers and end users often include both multimode and singlemode fibers in their backbone cables (called hybrid cables) since singlemode fibers are very inexpensive and it provides a virtually unlimited ability to expand the systems.

Premises networks will include an entrance facility where outside plant and premises communications systems meet. This facility must include not only cabling connections but compatible communications equipment. Since it is indoors, it must consider issues for building and electrical codes, such as the common requirement that bare OSP cables can only come 50 feet (about 15 meters) before being terminated in fire-rated cables unless it is in conduit.

Cabling Design

Long Distance and Outside Plant Cabling

Other than telco systems that still use copper for the final connection to the home, practically every cable in the telephone system is fiber optic. CATV companies use a high performance coax into the home, but it connects to a fiber optic backbone. The Internet backbone is all fiber. Most commercial buildings in populous areas have direct fiber connections from communications suppliers. Cities use SM fiber to connect municipal buildings, surveillance cameras, traffic signals and sometimes offer commercial and residential connections, all over singlemode fiber. Even cellular antenna towers along highways and on tall buildings usually have fiber connections. Remote areas such as central Africa depend on satellite communications since cables are too expensive to run long distances for the small amounts of traffic involved.

Designing long distance or outside plant applications generally means choosing cabling containing singlemode (SM) fiber over all other media. Most of these systems are designed to be used over distances and speeds that preclude anything but SM fiber. Occasionally other options may be more cost effective, for example if a company has two buildings on opposite sides of a highway, a line-of-sight or radio optical wireless network may be easier to use since they have lower cost of installation and are easier to obtain relevant permits.

The choice of the actual singlemode fiber, however, can depend on the application. Depending on the length of the link, the wavelength of the transmitters, data rate of the transmission and if CWDM or DWDM are planned, different types of fiber may be optimal. Refer to Chapter 5 on fiber for more details.

Premises Cabling

The desire for mobility, along with the expansion of connected services, appears to lead to a new type of corporate network. Fiber optic backbone with copper to the desktop where people want direct connections and multiple wireless access points, more than is common in the past, for full coverage and maintaining a reasonable number of users per access point is the new norm for corporate networks.

Most building management systems use proprietary copper cabling, for example thermostat wiring and paging/audio speaker systems. Security monitoring and entry systems, certainly the lower cost ones, still depend on coax copper cable, although high security facilities like government and military installations often pay the additional cost for fiber's more secure nature. Surveillance systems are becoming more prevalent in buildings, especially governmental, banking, or other buildings that are considered possible security risks. While coax connections are common in short links and structured cabling advocates say you can run cameras limited distances on Cat 5E or Cat 6 UTP like computer networks, fiber has become a much more common choice. Besides offering greater flexibility in camera placement because of its distance capability, fiber optic cabling is much smaller and lightweight, allowing easier installation, especially in older facilities like airports or large buildings that may have available spaces already filled with many generations of copper cabling.

When these premises communications systems connect to the outside world, it is generally to singlemode optical fiber. The entrance facility and equipment room must accommodate the equipment needed to make those connections.

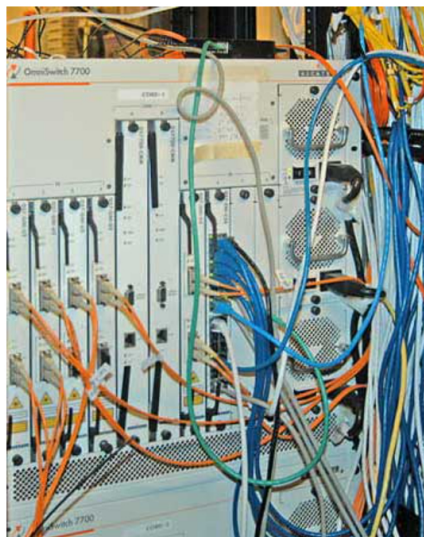
Use of Cabling Standards

Many documents relating to cable plant design focus on industry standards for both communications systems and cable plants. US standards come from the TIA or Telcordia while worldwide standards may come from ISO/IEC or ITU.

It is important to realize why and by whom these standards are written. These standards are written by manufacturers of products to ensure that various manufacturers' products work together properly. Whenever users specify standards for any

project, it is important that the contractor/installer understand what standards are being referenced and ensure that such standards are relevant to the job being done.

Choosing Transmission Equipment



Choosing transmission equipment is the next step in designing a fiber optic network. This step will usually be a cooperative venture involving the customer, who knows what kinds of data they need to communicate, the designer and installer, and the manufacturers of transmission equipment. Transmission equipment and the cable plant are tightly interrelated. The distance and bandwidth will help determine the fiber type necessary and that will dictate the optical interfaces on the cable plant. The ease of choosing equipment may depend on the type of communications equipment needed.

Telecom has been standardized on fiber optics for 30 years now, so they have plenty of experience building and installing equipment. Since most telecom equipment uses industry conventions, you can usually find equipment for telecom transmission that will be available for short links (usually metropolitan networks, maybe up to 20-30 km), long distance and then really long distance like undersea runs. All run on singlemode fiber, but may specify different types of singlemode. Shorter telecom links will use 1310 nm lasers on regular singlemode fiber, often referred to as G.652 fiber, it's international standard. Longer links will use a dispersion-shifted fiber optimized for operation with 1550 nm lasers (G.652 fiber). For most applications, one of these will be used. Most telco equipment companies offer both options.

Most CATV links are AM (analog) systems based on special linear lasers called distributed feedback (DFB) lasers using either 1310 nm or 1550 nm operating on regular singlemode fibers. As CATV moves to digital transmission, it will use technology more like telecom, which is already all digital.

The choices become more complex when it comes to data and CCTV because the applications are so varied and standards may not exist. In addition, equipment may not be available with fiber optic transmission options, requiring conversion from copper ports to fiber using devices called media converters.

In computer networks, the Ethernet standards, created by the IEEE 802.3 committee, are fully standardized. You can read the standards and see how far each equipment option can transmit over different types of fiber, choosing the one that meets your needs. Most network hardware like switches or routers are available with optional fiber optic interfaces, but PCs generally only come with UTP copper interfaces that require media converters. An Internet search for "fiber optic media converters" will provide you with dozens of sources of these inexpensive devices. Media converters will also allow the choice of media appropriate for the customer application, allowing use with multimode or singlemode fiber and may even offer transceiver options for the distance that must be covered by the link.

CCTV is a similar application. More cameras now come with fiber interfaces since so many CCTV systems are in locations like big buildings, airports, or areas where the distances exceed the capability of coax transmission. If not, video media converters, usually available from the same vendors as the Ethernet media converters, are readily available and also inexpensive. Again, choose converters that meet the link requirements set by the customer application, which in the case of video, not only includes distance but also functions, as some video links carry control signals to the camera for camera pan, zoom and tilt in addition to video back to a central location.

What about industrial data links? Many factories use fiber optics for its immunity to electromagnetic interference. But industrial links may use proprietary means to send data converted from old copper standards like RS-232, the ancient serial interface once available on every PC, SCADA popular in the utility industry, or even simple relay closures. Many companies that build these control links offer fiber optic interfaces themselves in response to customer requests. Some of these links have been available for decades, as industrial applications were some of the first premises uses of fiber optics, dating back to before 1980.

Whatever the application, it's important for the end user and the cabling contractor to discuss the actual application with the manufacturer of the transmission hardware to ensure getting the proper equipment. While the telecom and CATV applications are cut and dried and the data (Ethernet) applications covered by standards, it is our experience that not all manufacturers

are cut and dried and the data (Ethernet) applications covered by standards, it is our experience that not all manufacturers specify their products in exactly the same way.

One company in the industrial marketplace offered about fifteen different fiber optic products, mainly media converters for their control equipment. However, those fifteen products had been designed by at least a dozen different engineers, not all of whom were familiar with fiber optics and especially fiber jargon and specifications. As a result, one could not compare the products to make a choice or design them into a network based on specifications. Until their design, sales and applications engineers were trained in fiber optics and created guidelines for product applications, they suffered from continual problems in customer application.

The only way to make sure you are choosing the proper transmission equipment is to make absolutely certain the customer and equipment vendor – and you – are communicating clearly what you are planning to do.

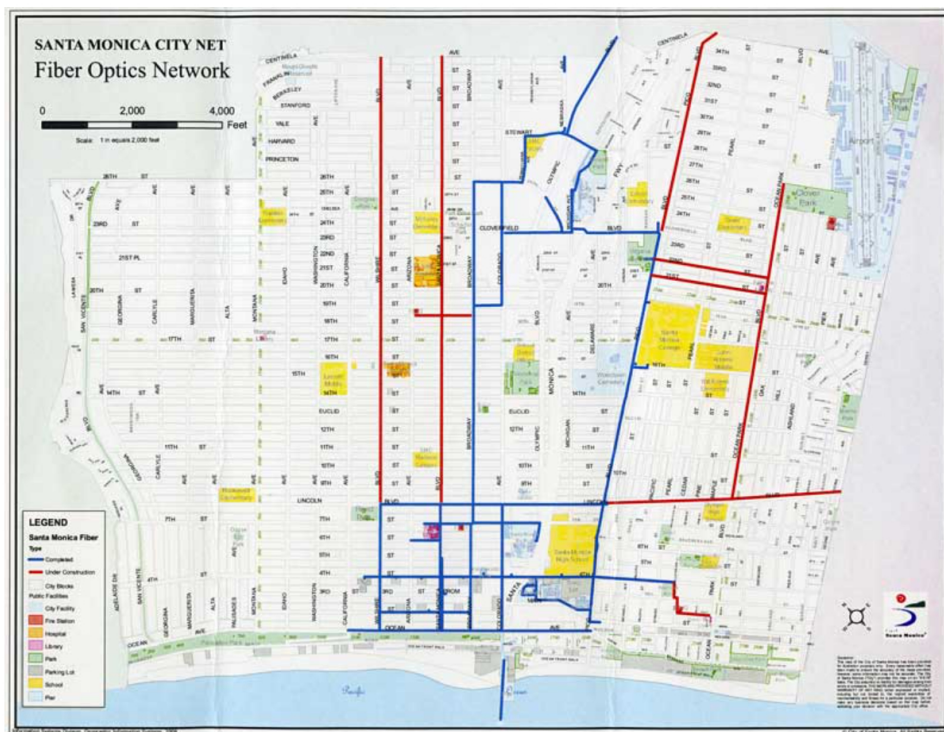
Planning The Route

Having decided to use fiber optics and chosen equipment appropriate for the application, it's time to determine exactly where the cable plant and hardware will be located. One thing to remember – every installation will be unique. The actual placement of the cable plant will be determined by the physical locations along the route, local building codes or laws and other individuals involved in the designs. As usual, premises and outside plant installations are different so we will consider them separately.

Premises and campus installations can be simpler since the physical area involved is smaller and the options fewer. Start with a good set of architectural drawings and, if possible, contact the architect, contractor and/or building manager. Having access to them means you have someone to ask for information and advice. Hopefully the drawings are available as CAD files so you can have a copy to do the network cabling design in your computer, which makes tweaking and documenting the design so much easier.

If the building is still in the design stage, you may have the opportunity to provide inputs on the needs of the cable plant. Ideally, that means you can influence the location of equipment rooms, routing of cable trays and conduits, availability of adequate conditioned power and separate data grounds, sufficient air-conditioning and other needs of the network. For pre-existing buildings, detailed architectural drawings will provide you with the ability to route cabling and network equipment around the obstacles invariably in your way.

Outside plant (OSP) cabling installations have enormous variety depending on the route the cable must take. The route may cross long lengths of open fields, run along paved rural or urban roads, cross roads, ravines, rivers or lakes, or, more likely, some combination of all of these. It could require buried cables, aerial cables or underwater cables. Cable may be in conduit, innerduct or direct buried, aerial cables may be self-supporting or lashed to a messenger. Longer runs often include crossing water, so the cable may be underwater or be lashed across a bridge with other cables.



Site Visits

And as soon as possible, you must visit the site or route where the network will be installed. Outside plant routes need to be driven or walked every foot of the way to determine the best options for cable placement, obstacles to be avoided or overcome, and to determine what local entities may have input into the routing. Often cities or other governments will know of available conduits or rules on using utility poles that can save design time and effort.

For installations inside current buildings, you should inspect every area to be absolutely certain you know what the building