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White Paper

Connecting it all together – Fiber Optics in Security & Surveillance Solutions

An executive briefing for chief security officers (CSOs), directors and managers on understanding the benefits and ways that fiber optics enhances the operation and business bottom line of your surveillance solutions.

With a transition from analog to digital video surveillance continuing, there remains a crucial requirement for reliable transmission of the video signal during today's period of co-existence. With many legacy installations, it has been coaxial cable handling images from a camera to monitoring or recording or both. Coax has its limitations: restricted transmission distance, signal degradation over long cable runs, and interference, to name a few.

Networking, digital and Internet Protocol (IP) have ushered in Cat 5/Unshielded Twisted Pair (UTP) cable and high-speed Ethernet, employing IP to carry the digitalized video images. In some installations, wireless transmission – radio frequency, microwave, WiFi and mesh nets – play a role. Most enterprise security video designs are not totally wireless. Instead, the technology is applied to meet certain geographic or operational challenges.

When to Implement Fiber?

And then there is fiber optic cabling with its interference immunity, better inherent security, robust cabling distances and huge bandwidth capability.

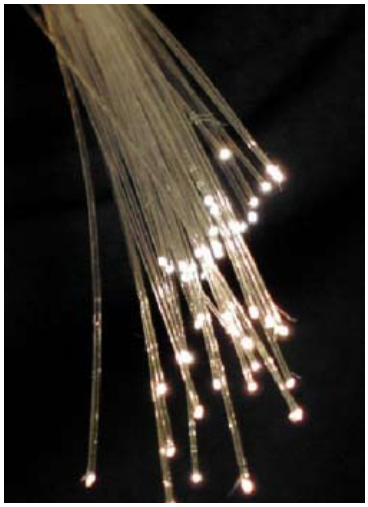


Figure 1: Is it time to implement fiber optics for security video transmission? There are many advantages over traditional coaxial and IT-centric Cat 5/unshielded twisted pair wiring.

As before, we'll look over the shoulders of CSO Terry Jones and Helena Smith, his second-in-command, who work for a mid-sized enterprise, as they now face the decisions and intricacies involved in selecting fiber optics and better understand its advantages, installation and – most importantly – bottom line business benefits.

This white paper, in an industry service series by Infinova spotlights the means of video transmission, with emphasis on fiber optics.

The first paper in this white paper series examined in an overview way the co-existence strategy at the foundation of a cost-effective move from analog to digital security video. That white paper also covered the impact on infrastructure including sharing the enterprise data network, bandwidth and compression/decompression schemes. A second white paper explored cameras – analog to IP-based as well as megapixel and high definition. Both previous white papers are available for download at www.infinova.com.

Getting back to video signal transmission, there are differences among transmission methods. Security end users, their designers, integrators and installers must consider and balance the methods with the needed functionality of cameras in light of:

- Maximum cable run distances
- Power requirements
- Installation issues
- Installation time
- Quality of video
- Integration with other systems
- Cost

Coaxial cabling has for years been the traditional transmission method of video surveillance traffic. The presence of a coax BNC connector on most every security camera underlines this traditional method for signal transmission.

Coax Can't Go the Distance

The most common coax cable is RG-59U. It provides what many believe is an acceptable quality video path from a camera to the head end out to 750 feet. That's because the maximum recommended distance between an analog security camera and a digital video recorder, head-end or monitor is that 750 ft.

When it comes to power to the camera, many installations employ so-called Siamese cable -- a single RG-59U wedded to an attached 18/2 cable for both power and video. Still, some distances will increase voltage drop, and it is necessary to select a power supply and cabling which match necessary voltage to distances. Today, and especially when it comes to new and upgraded installations containing scores of cameras, a minority have coaxial, while a majority boast Cat 5/UTP and fiber optics.

In some ways, the security shift has been spurred by popularity of local area networks in most enterprises. Information Technology's (IT) means of transmission gravitated to Cat 5/UTP wiring as well as fiber optics, often as an overall communications backbone. Cameras can be more easily installed using existing UTP cabling or fiber previously laid for enterprise network use. Corporate and government IP-based platforms have accelerated the transition. That naturally has swung security to such designs, especially when it involves video surveillance.

One warning when it comes to UTP: Existing enterprise cables must be verified to be within security industry standards for video performance.

UTP cabling is lighter and easier to install – translate that to lower end user installation cost – than RG-59U, and the material itself is less expensive than comparable lengths of RG-59U.

There still remain challenges and costs when pushing analog video signals through UTP cable. It requires conversion of the camera's unbalanced BNC output into a balanced signal that can be carried on one pair of the UTP. When reaching a head-end or recorder, the signal must be reconverted to handle a standard BNC-type connector. That means use of a balun.

The Bottom Line on the Balun

When Terry asked what a balun is, Helena was quick to explain that it's a device that connects a balanced line to an unbalanced line. It allows a signal of one impedance value to be transmitted over a cable that uses a different impedance. Impedance is simply a measure of opposition to alternating current. A video balun allows us, she says, to send video signals over a cable not meant for video. A common situation involving video baluns is use with Cat5 cable. Coax cable, which transmits video, has an impedance of 75 ohm while Cat5 has a 100 ohm impedance.

So baluns convert the original impedance to the impedance of the cable and then back. Baluns are used in pairs; one on each end of the cable. Transmitting video over Cat 5 without the use of video baluns produces ghosting images since delays in the signal will occur. There are passive and active baluns: Passive baluns convert the signal while active baluns impart an amplification method to increase transmission distance. UTP/balun uses a single pair of a typically four-pair cable to handle the video, so three pairs can potentially provide power and pan/tilt/zoom from a head end to a camera. And combinations of baluns are called hubs.

But it is fiber optic technology, a method of sending and receiving information over great distances using light as the carrier, which boasts significant advantages, whether as a backbone or a total transmission solution.

Among fiber optics advantages:

- Better quality transmission
- No interference -- lightning strikes, short circuits, "cross talk," EMI, RFI
- No interference -- high voltages in fluorescent lights, card access door strikes and outdoor lighting systems
- Lightweight
- Stable within a wide temperature range
- Long service life
- More secure – not easily tapped into or interfered with
- Extremely high bandwidth
- Tech growth – ongoing developments increase the amount of data transmitted

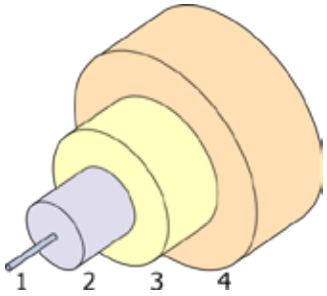
Fiber optics has been around for many years and should not be considered a "bleeding edge" technology. In fact, the principle that makes fiber optics possible was first demonstrated in the early 1840s. Practical applications developed early in the Twentieth Century before modern optical fibers, where the glass fiber is coated with a transparent cladding to offer a more suitable refractive index. Just as consumer camcorders spurred CCD sensors into security video, consumer-driven cellular, television and Internet uses more generally will accelerate developments of fiber carrying images.

Consider Transmission Loss

Attenuation in fiber optics, also known as transmission loss, is the reduction in intensity of the light beam (or signal) with respect to distance travelled through a transmission medium. It is far less than the equivalent loss in copper cables, leading to long-haul fiber connections with repeater distances of 43-93 miles or 70–150 kilometers. So there is no doubt that fiber optics can handle massive amounts of digital information across vast distances, securely and with immunity to interference.

Figure 2: The structure of a typical single-mode fiber, form an illustration from Wikipedia.org..

1. Core: 8 µm diameter
2. Cladding: 125 µm diameter
3. Buffer: 250 µm diameter
4. Jacket: 400 µm diameter



Such functionality is built into fiber. A cross section of fiber cable shows a Kevlar inner wrap and, because of this strong nonmetallic component, the cable cannot carry lightning pulses or transient voltages, say, from an outdoor camera into a facility. And within the fiber core composed of glass strands, a blinking LED or laser light is unaffected by electrical and radio frequency anomalies.

Like other decisions faced by Terry and Helena, there are challenges with fiber including materials and installation cost, operation of the installation itself and ongoing maintenance. Smart security dealers and integrators, staying on top of their game and with their clients in mind, have invested in technician training and the proper tools and testers to handle fiber connections. And, after installation, they know how best to troubleshoot.

There always remains the debate between creating and maintaining a stand-alone security systems transmission infrastructure or piggybacking on the corporate backbone. It is not necessarily one or the other; some designs can play it both ways.

However, an obvious outcome of a separate, dedicated IT infrastructure for video and other physical security applications is isolating that traffic from the general enterprise network. There are no "competition" or video quality issues and there is sometimes a finer focus on security system functionality and dependability. Yet, there are technology advances – both on the physical security and IT sides such as higher speed general networking, video compression/decompression modes and analytics at the edge, which are tending to moot the stand-alone points. From organizational and budgetary perspectives, closer collaboration and sharing between security and IT are beneficial and being encouraged today.

Uniquely, with fiber, physical security can have its own strands in the shared fiber bundle, thus achieving a stand-alone posture while also being part of the overall enterprise infrastructure.

The Superiority of Fiber

"How much dark do we already have?" is the next question Terry asks during their planning meeting. Dark fiber or what some call unlit fiber refers to unused optical fibers available in buildings and throughout local, regional and national networks. A good guess is that there is an estimated 80 million dark fibers installed in North America, thanks to the .com bubble of past years, new construction practices and technological advances in getting more traffic through the installed base. Often on the IT side, installers have almost always included extra fiber strands when installing structured cabling backbones between telecommunications closets and separate buildings, for example.

That's because the cost of individual fiber strands is quite low, so extra strands have little impact on the budget. During installation, it's not uncommon to break a fiber, so spares are handy to have with the aim that enough usable fibers will be available. And additional spare fibers often future-proof an installation.

Taking Advantage of Dark, Unlit Fiber

So Jones' firm as well as many others may have existing fiber links not being used. Initial investment is cut and what installers call long cable pulls significantly reduced. There still needs to be testing of dark fiber before considering it for security video transmission. And, warns Helena, the type, quality and lengths of existing fiber links to be used, and the style of connectors installed on each end of the link, must be known.

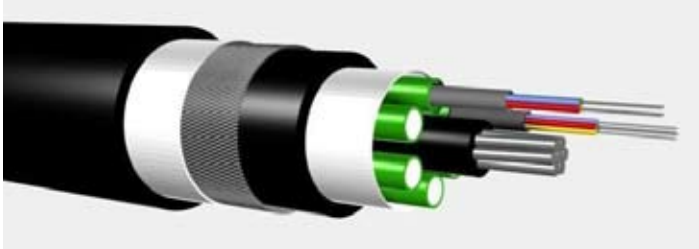


Figure 3: Glass strands carry security video data in fiber optic cabling. Many organizations may already have dark or unlit fiber and security can take advantage of that oversupply of strands. Illustration from Wikipedia.org

Fiber optic cabling comes in two basic types: multimode and single-mode. Multimode fiber has a core size of either 62.5 or 50 microns and commonly is found providing connections between telecommunications closets within a building or campus. Preferred for most physical security applications, multimode uses low-cost LEDs or inexpensive lasers for transmission. It's easier to terminate and test. The multimode drawback: It has a distance limitation – usually out to three miles -- as compared to single-mode. The latter fiber, with a core size of 7 to 10 microns, typically handles longer distances of more than 50 miles in high bandwidth applications.

Table 1: There are three predominant methods of encoding a transmission signal. Amplitude modulation (AM) and frequency modulation (FM) are both analog modulation schemes. The third method is digital modulation. The Table outlines the basic characteristics of the three modulation schemes as created by Fiber-Optics.info.

Comparison of AM, FM, and Digital Encoding Techniques			
Parameter	**AM**	**FM**	**Digital**
Signal-to-Noise Ratio	Low-to-Moderate	Moderate-High	High
Performance vs. Attenuation	Sensitive	Tolerant	Invariant
Transmitter Cost	Moderate-High	Moderate	High
Receiver Cost	Moderate	Moderate-High	High
Receiver Gain Adjustment	Often Required	Not Required	Not Required
Installation	Adjustments Requires	No Adjustments Required	No Adjustments Required
Multichannel Capabilities	Require High Linearity Optics	Fewer Channels	Good
Performance Over Time	Moderate	Excellent	Excellent
Environmental Factors	Moderate	Excellent	Excellent

Helena, with previous fiber applications under her belt, already realizes that fiber is superior to copper cabling in all performance measures. Available bandwidth of standard multimode fiber is estimated at 45 times that of Cat 5 UTP. And don't forget that scores of cameras can transmit their signals over only one or two fiber strands, she tells her boss.

There is noticeable return on investment in cabling distances with inexpensive fiber devices can move images up to two miles from end to end on multimode fiber, while high-bandwidth single-mode fiber can carry signals up to 60 miles before regeneration of the signal is needed.

Whatever the mode, fiber knocks out Cat 5/UTP. The bandwidth capacity of a single strand of standard multimode fiber is more than 45 times that of a Cat5 cable, while the maximum bandwidth capacity of single-mode fiber has yet to be reached, according to fiber optics experts. So even though IP-based video is gaining users, there remains a serious distance limitation with UTP cabling infrastructure, hindering placement of cameras. For example, if a camera is located 1,000 feet from the head-end, without any active signal conditioning at some cost, about 37 percent of the information will be lost in transmission, not counting the need and cost for signal amplification, ground fault correction and surge protection.

Fiber as a prime security tool opens the applications doorway extraordinarily wide. There are almost unlimited capabilities of security video transmission and pan/tilt/zoom controls, for instance. Helena also pointed out that a single fiber strand deals with bi-directional signaling, so one fiber between two points can carry multiple streams of security video in one direction while pan/tilt/zoom control can go in the opposite direction, all simultaneously.

Multimode and Single-mode Fiber

Fiber within most buildings is multimode, for the most part. Some infrastructures, such as those for Terry and Helena, have a combination of multimode and single-mode. No matter the mode, there need to be a way to convert the video signal over to an optical format and back again.

So there are devices that are part of a fiber optics transmission system. As examples: receivers and transmitters, which can be combined into transceivers; video to fiber converters; connectors; and adapters.

Fiber connectors, for instance, are in several common styles, such as ST (round), SC (square) and LC (also square). This comes in play when realizing that devices for interfacing physical security equipment to fiber optic links usually can be ordered with either the ST or SC connector. Various adapters convert connections, such as connecting an ST video fiber encoder to an SC connector on a network fiber patch panel.

When facing co-existence of analog and digital IP, there is cost of analog to fiber. The increasing speed of the migration to IP will continue, however, to change that equation. In addition to providing a means for transparently connecting one type of media to another, media conversion can provide a cost-effective method for integrating a hybrid video security system into one, seamless and manageable whole. Cost savings can be realized thanks to an existing, analog-based

security video infrastructure, while co-existing with the latest technology of IP-based cameras for video capture, storage or analysis as well as for expanded application of megapixel and HD cameras at added locations.

Coax, Cat 5/UTP or fiber optics? Take your pick. But in co-existing analog/IP security video situations and truly when it comes, sooner or later, to fully digital and IP environments, fiber optics can light the way.

For applications where the distance, bandwidth or image quality requirements strain the capabilities of standard coaxial transmission, Infinova offers fiber optic transmission solutions based on digital products and accessories. There are audio, data, video and combined solutions including Expandable Transmission System with Configurable Data, Audio and Contact Closure. A specific example: The N3790 Series fiber transmitter is a digitally encoded, highly expandable and flexible fiber optics transmission system. Data formats support RS-232, RS-422, 2-wire/4-wire RS-485, Manchester/ Biphase and contact closures. Using state-of-the-art coarse wavelength division multiplexing or CWDM technology, they transmit up to 64 channels NTSC, PAL, or SECAM video, 32 channels audio, 32 channels data, 32 channels contact closure signal or eight channels intercom.

Infinova has a stable of technology that emphasizes the co-existence strategy which can gradually and intelligently jump from analog to IP video. There are analog fixed cameras and fixed minidomes, PTZ domes and PTZ cameras, and IR illuminated cameras. There are IP fixed cameras and fixed minidomes as well as PTZ domes and cameras.

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By helping channel partners provide their customers with complete, affordable, best-in-class, large and small video surveillance solutions, Infinova helps integrators generate more business more profitably. Leveraging a manufacturing process certified to ISO 9001:2000 standards and over 250 engineers with a list of video industry firsts, Infinova channel partners provide their end-users with industry-acknowledged product reliability and technical leadership.

So that Infinova channel partners can create complete solutions, Infinova provides IP surveillance cameras and components, CCTV analog cameras, DVRs and components, camera accessories, monitors, power supplies and fiber optics communications devices. Infinova also has the technical ability and manufacturing flexibility to let integrators propose customized solutions. In addition, Infinova will partner with other manufacturers making other surveillance equipment and software to help its channel partners create turnkey solutions. Contrary to most other companies, Infinova will back-up their partners' products as well as its own to assure both the integrator and its customers that one call – to Infinova only – takes care of everything.

Infinova works diligently to assure its channel partners can provide cost-conscious solutions. With Infinova's hybrid systems, channel partners can propose systems that protect a customer's investment in its already-installed analog surveillance system but that also put them on a dynamic migration pathway to IP systems.

Infinova is lauded for its exceptional maintenance programs. A major highlight is the company's 24-hour advanced replacement policy in which a substitute product is shipped immediately upon notice of a problem.

With such customer focus, Infinova is often referred to as "the integrators' manufacturer."

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