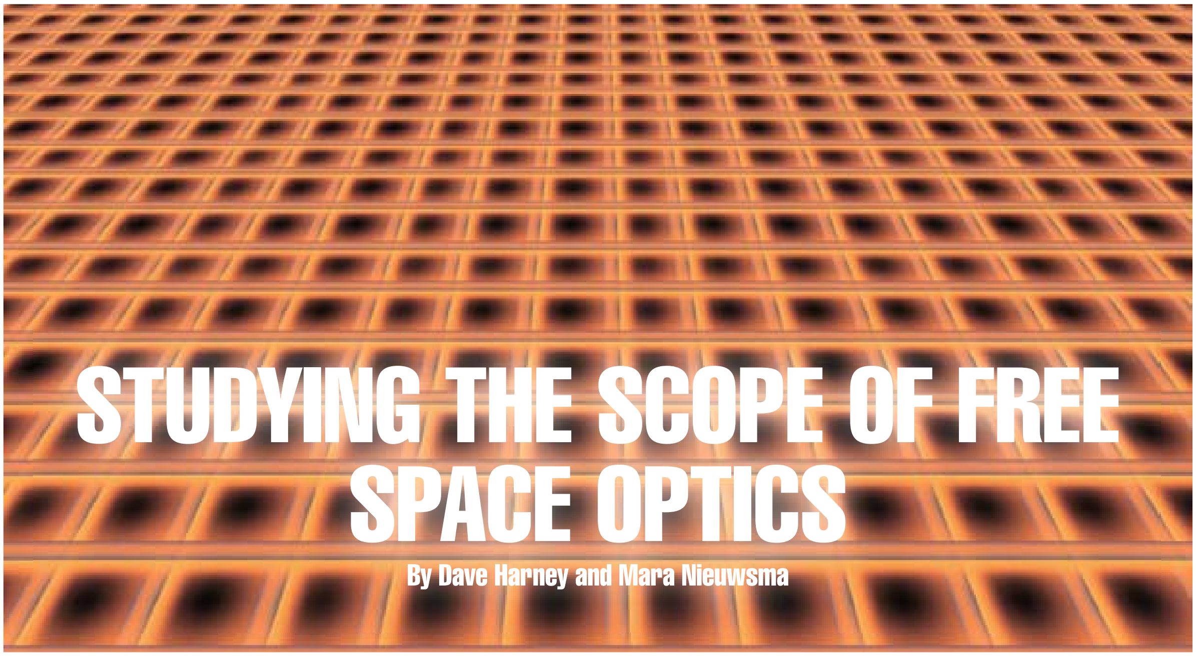

STUDYING THE SCOPE OF FREE SPACE OPTICS

By Dave Harney and Mara Nieuwsma

Linking commercial and residential buildings, college campus and municipal buildings with high-bandwidth trunks is as essential as it can be challenging. There are multiple options for connectivity including installing fiber optic cable, leasing dark fiber or service provider subscriber services, and installing bridged wireless systems. Highways, streets, parking lots, waterways, rail lines, full conduits and duct banks often create cost prohibitive barriers to enabling physical wired connection between buildings. High-bandwidth leased services, while highly reliable and simple to implement, are also a costly option. Bridged wireless technologies have gained popular acceptance due to their ease of implementation and reliability approaching that of wired networks. It is important to recognize that there is no best technology for all scenarios and that each connectivity option has inherent advantages. This article will focus on Free Space Optics (FSO), a bi-directional, point-to-point optical beam wireless technology that is an attractive, robust, affordable high bandwidth option for true broadband campus connectivity. It will also compare optical wireless systems to better-known RF based wireless systems for various applications and environments.

WHAT IS FREE SPACE OPTICS?

FSO utilizes a line-of-sight laser-generated beam of light to transmit broadband data, voice and video through the air from one unit to another. The technology can be considered optical wireless equivalent of optical wired transmission through fiber optic cable. FSO units are connected to the network via a TIA/EIA compliant copper or fiber optic structured cabling system. Any application including voice, data, video and security that can be sent via IP traffic can be transmitted over FSO.

FSO systems are offered in two different wavelength transmission windows: 780-850 nm and 1520-1600 nm. 780–850 nm systems are reliable, cost-effective and suitable for most applications, including 1 Gb/s Ethernet, while1520-1600 nm systems are able to transmit at higher power levels thus achieving longer transmission distances in clearer weather. Much has been written regarding 780-850 nm FSO system performance versus 1520-1600 nm system performance during atmospheric events, especially fog. In cases where the distance between units is less than 500 meters (a typical campus link), there appears to be no performance advantage between the two technologies, regardless of fog density. When considering cost impact, systems utilizing 1520 – 1600 nm wavelengths can cost as much as 10 times more than a 780-850 nm system.

EVALUATING A WIRELESS SYSTEM FOR IMPLEMENTATION

When evaluating any wireless system you must consider bandwidth capabilities, transmission throughput, reliability, security features, and cost to implement. The combination of these factors will help determine which type of system offers the greatest performance and value for the user's environment.

BANDWIDTH CAPABILITIES AND TRANSMISSION THROUGHPUT

The bandwidth range of common FSO products available for campus applications runs from 10 Mb/s systems all the way to 1.25 Gb/s systems. For campus applications, FSO has the bandwidth edge in high-speed networking.

With most FSO systems data throughput is limited by the actual performance of the network it is supporting. FSO throughput is not determined specifically by the transmission frequency as with an RF system, but rather by the ability to send and receive the transmitted optical signal. As long as adequate beam strength is maintained, transmission data throughput remains constant with an FSO system. Consider again the comparison to fiber optics. If attenuation is too high in a fiber optic link, effective transmission cannot occur. Received data doesn't fade in a fiber optic network due to an attenuated signal, either no data is transmitted or the transmission is full of errors. In an RF system, by contrast, as the signal strength is attenuated the system will respond by switching to lower data rates in order to maintain a link. An RF link that performs at 24 Mb/s throughput in clear weather might deteriorate to 18 Mb/s, 12 Mb/s, 6 Mb/s in a rainstorm.

RELIABILITY

Wireless systems are susceptible to outage or performance degradation due to atmospheric, environmental factors and obstructions. FSO systems are more rain tolerant than RF systems, are inherently more difficult to compromise without detection, and may have built in tracking systems that allow for tolerance to movement.

IMPACT OF WEATHER

When transmitting light, atmospheric events can cause scattering and attenuate the amount of laser light that passes between two units, causing signal loss or, in the worst case, transmission errors. The most impactful atmospheric event is fog. Because fog is a variable event, performance is loosely determined by visibility distance. Infrared light travels approximately two times the visibility distance in a fog event. Therefore, if it is possible to see approximately halfway to the opposite side under bad weather conditions, FSO systems can still maintain a link. Rain, snow, and pollutants can also effect signal attenuation, but generally within the campus distance limitations they are far less of a performance-limiting factor than fog. An effective countermeasure to weather events is to incorporate a focused beam assisted by auto alignment to moderate the impact on the transmitted signal.

IMPACT OF BEAM ALIGNMENT AND OBSTRUCTIONS

Maintaining beam alignment is an important factor in the performance of an FSO system. Even when properly installed, an FSO receiver is subject to the motion of the building where it is mounted. Motion can be caused by obvious factors such as wind, but it can also be caused by more subtle conditions such as temperature variation. Two basic approaches are used to account for alignment changes: a narrow, focused beam with automatic tracking, or a wide beam without tracking. Systems with automatic tracking are able to compensate for motion before it causes disruptions in transmission. Distance and transmission speed are major considerations when determining the need for auto tracking. Short (under 200 meters), environmentally stable 10 Mb/s links are less vulnerable than 500-meter, 1.25 Gb/s links mounted on top of 40-story buildings. A wide beam effectively enlarges the target receive area. The trade off is that a wider beam is also more vulnerable to attenuation and is therefore more susceptible to the effects of weather.

Line-of-sight obstructions can also diminish performance, however, a properly trained installer can take into account current and future permanent obstructions to minimize the potential for transmission interruptions. Temporary obstructions, such as birds, are not generally cause for interrupting transmission. If a bird flies across the path of the laser, the amount of light that is received will be reduced, but will still be adequate enough for data transmission. If a large object obstructs the beam completely, the data will be momentarily interrupted. If the network is using TCP/IP, the problem will be resolved by a retransmission of the data.

TABLE 1

FACTOR	FREE SPACE OPTICS	RF WIRELESS SYSTEM
Bandwidth	10 Mb/s – 1.25 Gb/s	11 Mb/s – 100 Mb/s
Transmission Throughput	Determined by network	Determined by frequency High attenuation = Deterioration
Weather	Better in rain	Better in fog
Obstructions	Can withstand small obstructions	Tolerant
Security	Signal difficult to intercept	Signal easy to intercept
Cost	$15,000 - $35,000	$1,000 - $50,000+

SECURITY

Security is of special concern with all wireless systems. Because RF systems radiate signals in all directions, they are easily intercepted. As a result encoding and hardware countermeasures are commonly implemented to improve the secure performance of RF networks. FSO's single directed beam of light makes interception difficult. Capturing the data broadcast via FSO means tapping or breaking a beam of light undetected. Since FSO systems are typically installed on rooftops or in windows at elevation, a violator would have to overcome this physical obstacle in order to catch the beam of light without breaking transmission. Additionally, many manufacturers' low profile designs closely resemble security cameras, another deterrent for potential intruders.

COST-EFFECTIVENESS

FSO is a cost-effective choice within its distance parameters. In fact, FSO systems can cost up to 80 percent less than laying traditional fiber optic cable for the same application, and can be functional within a few days. Digging a trench is not only expensive, but can torical areas. Several U.S. cities are considering a moratorium on fiber trenching due to these issues. FSO links can also be less expensive and more attractive as a business asset than leasing lines from the phone company. Unlike wired and leased line options, an FSO system is a hard piece of equipment that can be deployed and redeployed as required by the user.

EVALUATION OF FACTORS: FSO VERSUS RF

Given the aforementioned capabilities of FSO within various factors, it is important to consider the comparison to RF-based wireless systems for each application. Table 1 evaluates the benefits of each system.

FSO AT WORK

FSO has been embraced by many different organizations and companies needing to rapidly deploy reliable, inexpensive, and secure broadband links between their buildings. Two recent examples demonstrate the unique advantage of FSO wireless networking in applications where historic buildings are involved. In one case, jack-hammering the sidewalk to establish a Gigabit Ethernet connection for LAN extension to a recently renovated protected historical suffered a massive storm that dropped nearly six inches of rain on the city in less than two hours. Despite the deluge, the FSO system continued to work without interruption, providing a reliable link between the buildings.

In the other case, a security initiative to deploy surveillance cameras was inhibited by the lack of hard cabling to link the cameras to the security network. The barrier was a protected historic landmark. For the agency involved the highly secure FSO link had a special appeal for their application.

The impact of physical barriers such as highways, railroads and even other buildings in an industrial park are major triggers for implementing wireless systems. The need to establish a broadband link between buildings separated by a four-lane highway prompted one high tech manufacturer to implement an FSO system. However, FSO is not just for high tech companies. A paper packaging company implemented FSO due to the barriers caused by concrete, other structures and a very hot RF environment surrounding their facilities.

As mentioned earlier, FSO's use of line-of-sight technology means that it is virtually impossible to intercept or pirate the data it transmits. This was a critical consideration for a major financial firm who recently found its hard wired are now expanding the use of FSO as a primary backup for network redundancy. Risk management is critical to major hospitals and health care centers, who must comply with federal law requiring them to keep patient records confidential. This is why one major provider installed FSO to create a secure network link between their medical center and leased offices in a building approximately a quarter mile away. In addition to being secure, the link needed to be established quickly and it had to bridge a nearby road. FSO answers all of these needs, and its high-bandwidth capabilities handle transmission of large medical-imaging files between the buildings with ease.

It is important to recognize that there is no best technology for all scenarios and that each connectivity option has inherent advantages. Highly effective FSO wireless networks are a reality when the network designer considers the impact of common weather problems in their area, the wireless link distance, the users' bandwidth requirements and potential complimentary backup systems. The ability to rapidly deploy a license free, secure, high bandwidth, protocol independent, wireless system has FSO poised for major market acceptance. ■

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MOLEX CANOBEAM FREE SPACE OPTICS SYSTEMS

Molex now offers Canobeam Free Space Optics (FSO) Point-to-Point Wireless systems by Canon, featuring real-time beam auto tracking functionality. Molex's exclusive OEM partnership with Canon enables them to provide Free Space Optics as a natural extension of their structured cabling systems.

Canobeam is capable of bridging distances as great as 2km (1.24 miles) with a wide range of data speeds of from 25 Mb/s (Megabits per second) to 1.25 Gb/s (Gigabits per second).

Canon's Canobeam series of FSO transmission systems is a leading choice for broadband, last-mile data networking connectivity. The top-of-the-line Canobeam model MFSO-130 delivers Ethernet networking at data speeds of 1.25 Gb/s at a range of 100 m to 1,000 m (approximately two-thirds of a mile). Other models in Canobeam's MFSO-100 series include the MFSO-110, which delivers a wide range of data speeds from 25 Mb/s to 156 Mb/s at a range of from 20 m to 500 m. The Canobeam MFSO-120 provides the same data speeds as the MFSO-110, but at a range of from 100 m to 2 km.

Canobeam also features Auto Tracking, which is standard on all three MFSO-100 Series models. This feature automatically adjusts the FSO light beam to "instantly" compensate for vibrations that may be caused by wind, temperature changes, HVAC systems within a building, or other factors. With its built-in Auto Tracking feature, Canobeam's optical beam axis continually self-corrects, maintaining precise, continuous, and reliable data transmission between the bi-directional transmit and receive sites of Canobeam systems at all times. Canon is the only manufacturer to offer auto tracking as a standard feature at price points that are highly competitive with systems that do not offer tracking as standard equipment.

If a broadband connection of more than 2 km is required—or if it doesn't have clear line of sight—pairs of Canobeam units can be connected to relay the signal. The Canobeam MFSO-130's 3R Function (re-shaping, re-timing, and re-generating), allows its data signal to be relayed without loss of strength or quality.

Canobeam MFSO-100 series data transceivers can be installed indoors for window-to-window or window-to-roof transmission as long as the two units are located with a direct line of sight. And Canobeam's Management Board is built-in as a standard feature of all MFSO-100 series Canobeams. This feature enables users to monitor the status of Canobeam transceivers via SNMP or Telnet (for monitoring and setting). In addition, diagnostic logs can be stored in a PC via FTP (for log data transmission).

All Molex Free Space Optics Systems are backed by an industry standard 1-year Product Replacement Warranty when installed by a Molex Certified Installer. When you specify a Molex Premise Networks solution you benefit from global resources, industry standards exceeding performance and innovative solutions. For more information regarding Free Space Optics and supporting products, contact Molex at 866-733-6659 or visit the Web site at www.molexpn.com.