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# Optical Wireless: Secure High-Capacity Bridging

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# Optical Wireless: Secure High-Capacity Bridging

White Paper

# Abstract

Today's information economy depends on the transmission of data, voice and multimedia across telecommunication networks. Despite new technologies that enable legacy copper telephone lines to carry information more efficiently, optical networks remain the most ideal medium for high-bandwidth communications.

There are two distinct types of optical communications: fiber optics (fiber-optic cable) and optical wireless based on free-space optics (FSO) technology. For long-haul network deployments, nothing is better than fiber. When coupled with new Dense Wavelength Division Multiplex (DWDM) technologies, fiber optics is capable of carrying information at 40 Gbps (gigabits per second). However, for making connections over relatively short distances in cities—the "last mile" between the fiber and the metro concentration of end-users—fiber and optical wireless often rely on one another for success. The two technologies not only come from the same family tree, they are nearly identical twins.

The last two decades have seen huge investments in building a global fiber network core, leveraged with the promise of generating increased bandwidth access and services to meet growing needs. Meeting projected bandwidth needs, however, depends on customers having access to optical networks. This has yet to fully occur in the metropolitan areas, which remain a relatively untapped bandwidth access market where a mere 7 percent of end-users are connected to fiber optic networks.

Fiber optics is being deployed at a measured and sustained pace, but the cost to do so is often high, the process long and the investment irreversible. Conversely, optical wireless complements fiber optics in metro networks and local area networks (LANs) with considerably less expense and faster deployment.

# Introduction

Amid the pervasive talk about the promises of the information economy, it's easy to overlook the logistical challenges of delivering the infrastructure to ensure everyone is connected—no matter where they live. Projected rapid growth in demand for bandwidth will go wanting without network access, and the real challenge is creating connections despite the very real physical and economic obstacles that cities present.

At one point, many telecommunications industry leaders and technology observers dreamed of an all-fiber metropolitan network, but this vision is impractical for several reasons. The process of laying fiber in metropolitan areas is time consuming and prohibitively expensive. Ongoing preservation and restoration of fiber-optic systems in the event of accidental disruptions or natural disasters is also time-consuming and technically challenging, as service providers must address the concerns of bandwidth dependent customers frustrated with every hour of lost network access. That said, all-optical fiber optic networks, with their high-bandwidth capacities, are promising. A world complete with fiber connections for all is decades from reality. A combination of broadband access technologies provides the most cost efficient and reliable solutions for addressing both primary connections and backhaul.

# Parallel Histories

It may seem to telecommunications carriers and industry analysts that FSO-based products recently appeared, like a beam of light, to the optical communications landscape. But FSO is only new in one respect: as a solution for public and private networking challenges. FSO technology itself is older than fiber optics.

Technically, optical communications includes all forms of communications using light, including mirror signals and lighthouses, offering a rich and storied history. The electrically powered optical technologies referred to by the term "optical" or "electro-optical" began with the introduction of the laser in 1960, which enabled the transmission of digital information as pulses of light.

## FREE-SPACE OPTICS

FSO technology has its roots in government applications dating back to World War I when military units and covert agencies needed secure communication systems that did not require cable and could withstand intentional interference, also known as "radio jamming." Portability of these early FSO systems was a hallmark and made them particularly valuable to military personnel who needed secure communications equipment that was simple to set up, transmit information and move from location to location.

Additional optical communications developments occurred during World War II, and post-war economic restructuring led to further telecommunications technology progress. While electronics innovations such as the transistor and integrated circuits enabled post-war telecommunications progress, the laser's launching of electro-optical communication fueled research and development of advanced optical communications using the only medium for laser transmission available then to military and aerospace industry physicists: the atmosphere, or "free space," hence the term free-space optics. Research and application of FSO continues to thrive in the aerospace industry to this day for applications beyond commercial and private telecommunications networks.

## FIBER

After 1970, the introduction of the fiber-optic cable as optical transmitter—along with the establishment of digital technology—combined to usher in a worldwide telecommunications revolution. Key among fiber's attributes is its immunity to electrical interference (no electricity is run through the fibers, so fiber signals do not interfere with each other); therefore, fiber can be run in areas without regard to interference from electrical equipment. Other benefits of fiber are:

- *Security.* It is resistant to taps and doesn't emit electromagnetic signals.
- *Compact size.* Less duct space is required for these hair-strand sized fibers.
- *High-bandwidth capabilities and low attenuation.* Less fading or weakening of signals occur over long distances, which means fewer amplifiers are needed to boost the optical signals.

Given these advantages, fiber-optic cable held the promise of revolutionizing the telecommunications sector, which was eager to build the initial fiber networks. The first practical fiber systems were deployed by the telephone industry in 1977 and consisted of multimode fiber.[1] Single-mode fiber, a more recent development, was first installed by MCI in a long-haul network system that went into service in 1983.[2] The result of fiber-optic cable deployment is an extensive network of fiber crisscrossing the land. During the 1990s, the telecommunications network capacities grew nearly 10 times as much as the traffic itself, with most of the bandwidth concentrated in dark fibers along the network backbone often inaccessible to the end-user.[3] The massive investment to put optical capacity in the long-haul telecommunications network backbone looks relatively simple compared with today's metropolitan network challenges.

Beginning in 2000, carriers intensified their focus to building fiber-optic cable connections between the United States' 25 largest metropolitan areas to the nation's long haul backbone networks. This network gap is often called the "last mile," where only 7 percent of end-users have access to fiber.

"Routes in cities typically run to incumbent telephone company central offices and carrier hotels, which often are clustered together in the same areas, frequently near AT&T's switches. From there, they have runs to customers, data centers, Internet service providers and application service providers."[4] While this network configuration sounds relatively simple, the logistics of laying fiber connections in metropolitan areas are quite complicated and time-consuming.

The expense of construction and right-of-way permits for laying fiber often amounts to 20 percent of the cost of building fiber routes for networks. Moreover, the convoluted process of obtaining permits can delay projects for 12 months to 16 months or longer. Time delays can be created by municipal public works departments whose staff members feel a responsibility to protect public investments in road surfaces, water mains and gas lines, plus quality of life concerns regarding noise, dust and traffic disruption during construction projects to lay fiber.

## Today's Emerging Synergistic Optical Wireless/Fiber Landscape

From rural farms to suburban hospital campuses to big city high-rise offices, high-speed network connections must be made available everywhere people live and work if the information age is to reach full realization. Although rural, suburban and metropolitan connections each have their own sets of challenges; the metropolitan market is presenting the greatest difficulty for true high-bandwidth connectivity. While some may consider an all-fiber network the ideal connectivity solution, the medium's high-bandwidth capacity comes at a high price that is not feasible everywhere.

[1] "*Just the Facts,*" Corning Incorporated, 1995
[2] "*The Essential Guide to Telecommunications,*" Annabel Zodd, 2002
[3] "*What Ever Happened to Broadband?,*" Erick Schonfeld, Business 2.0, October 2002
[4] "*The Essential Guide to Telecommunications,*" Annabel Zodd, 2002

### EVOLVING INFRASTRUCTURES

Because metropolitan telecommunications network architectures—particularly those in the United States and Western Europe—have evolved as a patchwork of technologies, communications data is often slowed by protocols translations to manage and direct high-bandwidth information through metro networks. In growing economies such as Latin America, China, and India, the growth in bandwidth demands presents a different challenge, due to relative lack of network infrastructure.

### TECHNOLOGICAL ADVANTAGES

Optical wireless and fiber are the two optical technologies today that deliver high-speed optical bandwidth to meet market needs. Their integration offers several technological advantages. First, fiber optics and FSO-based optical wireless systems share several characteristics. Optical wireless can use the same optical transmission wavelengths as fiber optics (850nm or 1550 nm). Optical wireless and fiber can utilize the same system components such as lasers, receivers and amplifiers. Third, both fiber and optical wireless can transmit digital information using a range of protocols. Fourth—and critically important in meeting technological demands—optical wireless delivers the bandwidth (Gig-E and more) necessary to complement fiber networks.

### COMPLEMENTARY FUTURE

The future of the information economy depends on connectivity. Flexible networks that can adjust to changing customer concentrations and metro environments are needed. Combining optical wireless and fiber to create optical MANs, WANs and LANs offers the best solution to these problems. The reward for successfully combining these two optical technologies is attainable and economically viable.

## Conclusion

The most exciting possibilities for the future of the information economy will only be practical and profitable when network connectivity is expanded to reach a broad customer base. Telephone lines have this connectivity, but they don't offer the capacity to enable true high-bandwidth communications. The network fiber backbone or "core" can carry the bandwidth, but has yet to be connected to the majority of potential users.

A new paradigm for building optical networks offers an alternative to expensive and time-consuming fiber-only metro networks. By combining optical wireless and fiber, networks can be built quickly and provide affordable and scalable connections to end-users, who are expected to continue increasing demand for bandwidth.

www.lightpointe.com

LIGHTPOINTE™

**Corporate Office**
10140 Barnes Canyon Road
San Diego, California 92121
Tel: +1.858.643.5200
Fax: +1.858.643.5201

**LightPointe Europe, GmbH**
Werkstättenstraße 16
D-01157 Dresden, Germany
Tel: +49.351.339.4500
Fax: +49.351.339.4599