FiberLocator

DARK FIBER 101

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What Is Dark Fiber?

In fiber-optic communications, “dark fiber” or unlit fiber (sometimes known as fibre) is the name given to fiber optic cables not in service by a carrier or provider. The cables haven’t been connected to an optical device on either end of the fiber run, and the fiber is installed with the purpose of being used at some point in the future. Dark fiber can indicate fiber infrastructure that has been laid in the ground and not yet put in service by a provider or end user, or the term can refer to a new fiber construction project to be owned by an end user customer or wholesale provider.

The term “dark fiber” was coined when the potential network capacity of telecommunication infrastructure was discussed but now also refers to the increasingly common practice of leasing fiber optic cables from a network service provider.

Dark fiber is physical infrastructure, not an intangible service. Traditional telecom is sold (or leased) as a service with a guarantee or service-level agreement (SLA). Such a product is often called “lit service” and is based on leasing a part of the carrier’s available bandwidth, including the equipment to deliver the service, for a certain price and throughput over a specified term.

Dark Fiber

Fiber optical cable not yet in use that provides virtually unlimited bandwidth with a single pair or multiple pairs of fibers; available through new construction or existing fiber infrastructure.

Overview

- The fundamental framework upon which another infrastructure is built or applications are delivered
- Enables complete control over network and maintenance windows
- Provides virtually unlimited capacity, A–Z custom routing and choice of protocol
- Offers cost-effective scaling and bursting at customer’s discretion
- Longer contract terms enable low monthly costs for the customer
- Dedicated fiber network, with diverse fiber routes/laterals, provides robust security and reliability

With a lit or managed service, the carrier is responsible for maintaining the network and all the equipment required to deliver service. If the network goes down or is underperforming based on clearly stated and mutually agreed upon metrics, the customer reports the problem to the service provider. The service provider then troubleshoots the issue, applies the appropriate remediation and, if applicable, credits the customer for the downtime.

Unlike other telecom services, when a customer leases dark fiber, it is leasing the infrastructure on which its service is delivered. The customer is responsible for all the equipment and applications required to deliver service between locations. The fiber itself provides no service to the customer but allows the customer to build a network with its equipment and offer services at any speed based on the equipment deployed.

Contrary to lit services, most dark fiber network providers do not offer SLAs. In the event of a fiber cut, the dark fiber network provider will offer a mean time to repair (MTTR) guarantee. In effect, the network provider will guarantee that a repair crew will be dispatched within a certain number of hours of a reported outage, typically within 4 hours. Once the crew arrives on the scene, they will issue an estimate of MTTR.

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Fiber Characteristics

The physical characteristics of fiber optics are fascinating. The fiber itself consists of a bundle of individual strands.

At the general level, the medium of fiber optics enables a digital electrical signal to be converted to an optical signal and transmitted across a strand of optical fiber using light. It is received by a light concentrating device (LCD) that converts the optical signal back into a digital electrical signal.

Several factors affect the receiver's ability to interpret the contents of the signal correctly. The key characteristics of dark fiber are distance, decibel loss, and dispersion. These characteristics have a significant impact on the equipment required to deliver service over the fiber. It is essential to understand these characteristics to understand where dark fiber can save you money.

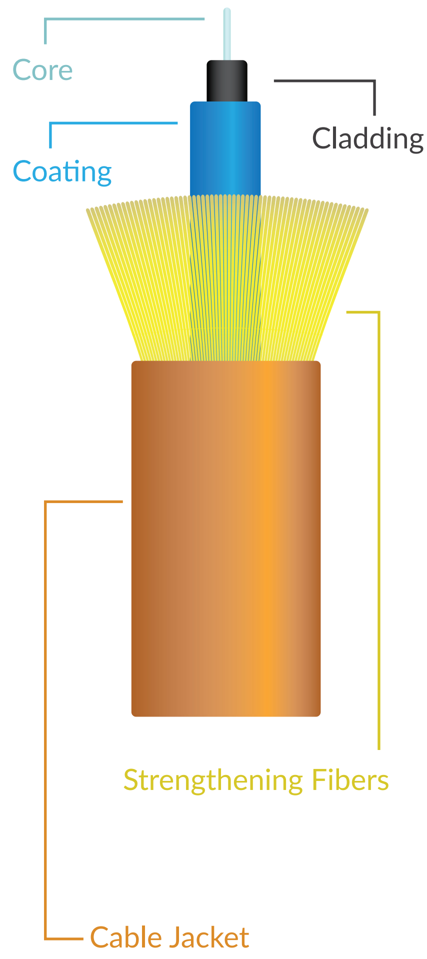
Distance

Many of the operational networks within today's cities are made of bandwidth-limited copper and are not able to handle the heaviest Internet and data traffic. Dark fiber refers to glass fiber optic cable with a narrow core and construction that limits the diffraction and absorption of light during the transmission. The integrity of a signal through fiber means that greater distances are possible before decibel loss affects the transmissions.

Because single-mode fiber typically uses a 1,300 nanometer (nm) wavelength source, dark fiber cables can be run between 25 and 40 miles before repeaters are required. Thus, dark fiber can provide a higher strength and continuity of signal over longer distances with less need to purchase repeaters to boost a signal.

Some networks use LEAF fiber that runs at 1,550 nm and provides up to 70 miles—or sometimes more with highly advanced hardware.

Fiber Optic Cable Construction



Increasing Distance

There are several factors that will affect the signal distance attainable with dark fiber. External hardware devices can increase the distance an optical signal will travel between endpoints. The specific element of physics to be counteracted determines the type of equipment used to extend the attainable distance. One of two devices is typically used to extend distances within a dark fiber network—an optical fiber amplifier (OFA) or a regenerator.

OFA

An OFA is used to overcome attenuation issues on the fiber. With an OFA, light (power) will be added (amplified) to existing wavelengths without reverting the signal to an electrical state. The amount of power added is dependent on the number of wavelengths being amplified, the efficiencies of the amplifier, and the strength of the wavelengths being amplified. There are many different OFAs available in the industry. The primary disadvantage of OFAs is that unwanted signals are amplified, in addition to the original signal, increasing noise in the system. Thus, there are limits to how many times an OFA can be used in increasing the distance before a costlier method of regeneration is used.

Regeneration

Regeneration compensates for both attenuation and dispersion but may be more costly to design and deploy. Regeneration translates the optical signal back into its original electrical format, cleaning up noise and converting it back to an optical signal for retransmission. This process provides reshaping, retiming,and reamplifying of the signal, which is known as a 3R regeneration.

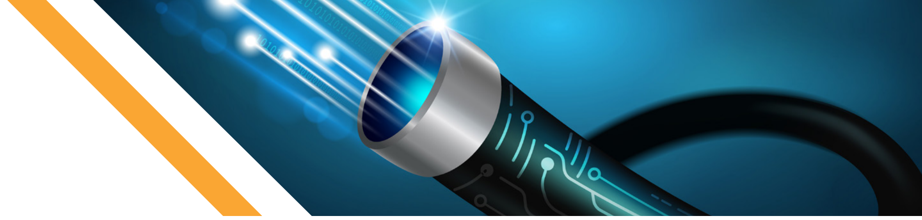
Reshape: *wherein the wavelength is restored back to a clear signal pattern*
Retime: *wherein the electrical signal is put through a noise buffer and the signal timing is realigned*
Reamplify: *wherein the wavelength is relaunched with renewed signal strength*

Decibel Loss

Decibel loss refers to the attenuation in the optical signal strength and is calculated on a logarithmic scale. Often referred to as "link loss," decibel loss is different from milliwatts, as it does not represent an absolute value. When the signal is weakened, the receiver is not able to process the signal. So, it is possible to consider the decibels of loss but not the decibel strength. The key factor in decibel loss is the amount of loss in signal strength that the signal can undergo until the receiver cannot interpret the signal. Attenuation can be attributed to a number of physical factors: fiber distance, dirty fiber connectors, and number of splices and patch panel connections. The decibel loss can also vary with the actual wavelength that is being used. The shorter the wavelength, the higher the fiber loss incurred per mile.

Dispersion

Finally, dark fiber should, and can, have low dispersion (in the 1,400 nm band) for cost-effective 10 gigabits-per-second (Gbps) operation and to best support use of coarse systems operating across all bands. Fiber optimized for metro environments, for example, should be working in the entire wavelength range from 1,280 nm to 1,625 nm. Secondly, a low-value polarization mode dispersion (PMD) is optimal for avoiding limits on data rate through the fiber. Excellent fiber cladding and core characteristics allow low-cost fusion splicing—connecting the ends of individual fibers—using standard techniques.



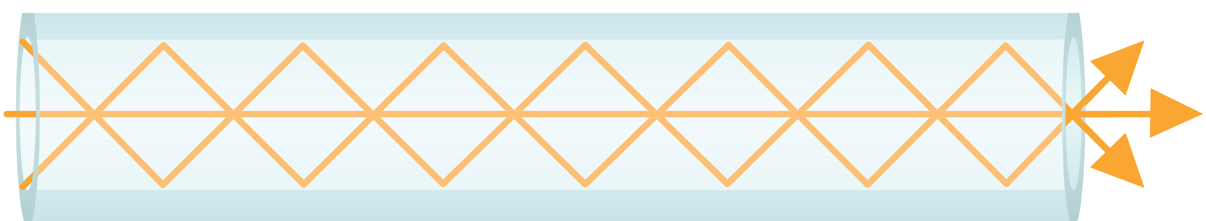
Types of Fiber Optic Cable

Operating a fiber optic system with maximal efficiency requires knowing what type of fiber is being used and why. Understanding the characteristics of different fiber types will help you choose the optimal application and achieve the best performance.

There are two basic types of fiber: multimode fiber and single-mode fiber. Multimode fiber is best designed for short transmission distances and is suited for use in local-area network (LAN) systems and video surveillance. Single-mode fiber is best designed for longer transmission distances, making it suitable for long-distance telephony and multichannel television broadcast systems.

Multimode Fiber

Multimode fiber, the first to be manufactured and commercialized, refers to fiber in which numerous modes or light rays are carried simultaneously through the waveguide. Modes result from the fact that light will only propagate in the fiber core at discrete angles within the cone of acceptance. This fiber type has a much larger core diameter, compared to single mode fiber, allowing for the larger number of modes; and multimode fiber is easier to splice than single-mode optical fiber.



Muli-Mode Fiber Diagram

Multimode fiber is commonly used for intra-building connections and short distance applications. The key benefit of multimode fiber is the inexpensive electronics used to terminate the fiber. Multimode fiber can also be categorized as step-index or graded-index fiber.

Multimode Step-Index Fiber

In step-index fiber, three different light waves travel down the fiber in distinct form. One mode travels straight down the center of the core. A second mode travels at a steep angle and bounces back and forth by total internal reflection. The third mode exceeds the critical angle and refracts into the cladding. This causes the second mode to travel a longer overall distance than the first mode, causing the two modes to arrive at separate times.

The index of refraction in the core is higher than the index of refraction of the cladding. The light that enters at less than the critical angle is guided along the fiber. The principle of total internal reflection applies to multimode step-index fiber.

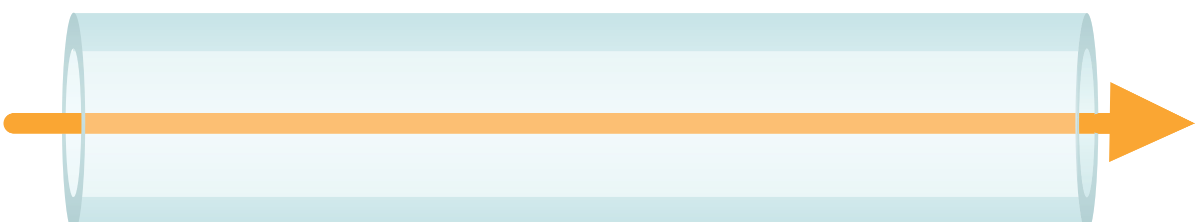
The disparity between arrival times of the different light rays is due to dispersion. The result of this dispersion is a muddied signal at the receiving end. It is important to note that high dispersion is an unavoidable characteristic of multimode step-index fiber.

Multimode Graded-Index Fiber

Graded-index refers to the refractive index of the core decreasing gradually farther from the center of the core. The light rays will follow a relatively smooth serpentine path being slowly bent back toward the center by the refractive index. This reduces the arrival time disparity because all modes arrive at about the same time. The modes traveling in a straight line are in a higher refractive index, so they travel slower than the serpentine modes, which travel farther but move faster, in the lower refractive index of the outer core region.

Single-Mode Fiber

Single-mode fiber allows for higher capacity to transmit information. It can retain the fidelity of each light pulse over longer distances, and it exhibits no dispersion caused by multiple modes. Single-mode fiber also enjoys lower fiber attenuation than multi-mode fiber. As such, more information can be transmitted per unit of time. Like multimode fiber, early single-mode fiber was generally characterized as step-index fiber (the refractive index of the fiber core is a step above that of the cladding rather than graduated as it is in graded-index fiber). Modern single-mode fibers have evolved into more complex designs, such as matched clad, depressed clad, and other exotic structures.



Single-Mode Fiber Diagram

Single-mode fiber does have its disadvantages. The smaller core diameter makes coupling light into the core more difficult. The tolerances for single-mode connectors and splices are also much more demanding. Another critical characteristic of single-mode fibers is that they commonly experience nonlinearities that can significantly affect system performance.

Common types of single-mode fiber deployed in dark fiber networks include SMF 28 and LEAF fiber. SMF 28 fiber is the most widely deployed fiber in the world. Typically used in short- and moderate-distance metropolitan and access networks, SMF 28 is known for its reliability as well as for its ease of splicing and strippable coating. SMF 28 offers full-spectrum performance and operates existing metropolitan and access networks, as well as supports newer technologies and broader fiber deployment.

LEAF fiber, non-zero-dispersion shifted fiber with a large effective area, was designed to provide cost-effective, high bit rate long-haul networks. LEAF fiber can, in its latest iterations, transmit higher levels of power through moderate dispersion and minimize the nonlinear effects that often degrade system performance. Particularly useful for emerging technologies, LEAF fiber is compatible with a variety of modulation formats.

Single-mode fiber is commonly used for longer distance applications given its lower attenuation characteristics. SMF 28 is used for shorter distances and TDM-based networks. LEAF is used for longer distances and DWDM applications. The single biggest drawback to single-mode fiber is the cost of the electronics used to terminate the fiber.

Types of Fiber Optic Cable

There are four types of providers offering increased bandwidth and delivering telecommunications services to end users:

- ILECs (incumbent local exchange carriers)
- CLECs (competitive local exchange carriers)
- MSOs (cable companies)
- Wireless providers

While they all use a slightly different medium or business model to deliver services, there are two clear similarities among these providers: The growing desire for bandwidth is fueling network expansion, and for each carrier type, old copper infrastructure is being replaced by fiber infrastructure.

As networks become more and more taxed with heavy data traffic, the infrastructure must grow and expand to meet the end user requirements. In some cases, providers are upgrading networks—and even racing to put in place fiber to remain competitive and preserve customer satisfaction. Leasing infrastructure is typically the growth mechanism of choice for CLECs and wireless carriers, while cable companies use a hybrid approach of building their fiber networks and leasing, depending on their purpose. Only the ILECs use building versus leasing as their primary approach to network growth.

The physical network apparatus of this growth is in fiber optic cables. Today billions of dollars are being invested in fiber optic infrastructure by ILECs, CLECs, MSOs, and wireless carriers to deliver service. Even the leading telecom research and development coming out of places like Bell Labs has fueled AT&T and Verizon—the two leading telecom players—to spend a combined $45 billion in new or upgraded fiber optic networks. While the optical equipment, fiber capacity, and last mile medium may evolve, the fiber optic backbone infrastructure is deeply and safely rooted as the vehicle of choice for the foreseeable future in telecommunications.

Construction Project vs. Simple Install

Because dark fiber is infrastructure, connecting to an existing backbone or location can sometimes require construction to reach enterprise locations. Some buildings are connected or “lit,” meaning that a dark fiber provider has already installed fiber in the building, but others require lateral construction.

A “lateral” is defined as the network segment that connects a building’s minimum point of entry (MPOE) to the existing fiber infrastructure. In layman’s terms, the lateral is the physical entrance of the fiber from the existing path in the street to the basement of a building.

In some cases, existing conduit from a variety of sources can be utilized to connect to the provider’s backbone. Some examples are the local exchange carriers (LECs), cable companies, electric companies, and sometimes the building owner. The dark fiber provider will “petition” the owner of the conduit for a right to use. If no additional conduits are available, the provider will then apply for a permit to trench from the manhole to the basement of the building. This is a less desirable option because of the time required to obtain permits and the cost of construction.

Before entering the building, the network provider must have a license granted by the building owner. Many times, this is referred to as an access agreement. It states the rules to which the provider must adhere and the locations that the provider can place splice cases and conduit. It will also contain insurance and indemnity clauses.

Once the dark fiber provider terminates at the MPOE (specified by the building owner but typically within 50 feet of the network penetration), an inside plant (ISP) must be located or constructed to get the fiber to the customer premises. As an example, a customer’s office is on the 23rd floor of an office building. The ISP will need to extend from the MPOE, typically in the basement, through conduit and cabling, called a riser, to the 23rd floor. If a customer is negotiating a lease for office space and considering dark fiber, it would be prudent to have the building owner provide “riser rights” as part of the lease. This would allow use of the existing facilities or an existing path from the leased office to the telecommunications demarcation point.

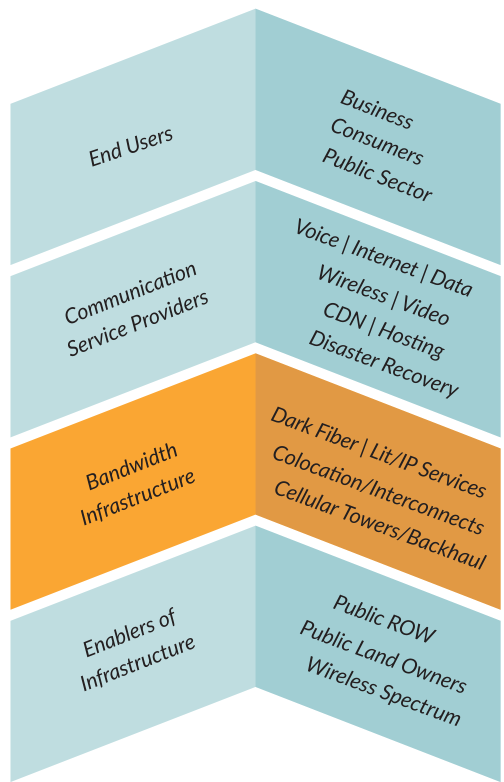
Using existing risers can save tens of thousands of dollars in construction costs. Once the physical path is completed and all network elements are spliced together, the provider must complete a test and turnup package. This involves shooting light from one end of the connection to the other. The test, called an OTDR test, will provide information on the characteristics of the fiber. The key components are distance, decibel loss, and dispersion. These characteristics have a substantial impact on the equipment required to deliver service over the fiber.

Monetary Impact of Fiber Lease vs. IRU

When building a dark fiber network, there is more to consider than just technology and business application drivers. Depending on the contractual structure of a network and equipment, there are also accounting implications to consider. Being aware of the possible tax advantages and disadvantages of dark fiber enables organizations to implement the network that benefits them financially as well as technologically.

The key to gaining an understanding of the accounting impact of leasing, as opposed to a prepaid indefeasible right of use (IRU), lies in the fundamental nature of each of these contract types. According to the generally accepted accounting principles (GAAPs), a lease contract is considered an expense, and a prepaid IRU contract is considered an asset. Lease contracts, according to the GAAPs, are accounted as an expense; thus, the lease of dark fiber is accounted as a current liability. Also, the entire remaining contract is accounted as a noncurrent liability. Because the lease does not encompass much of the useful life of the asset being used, it is considered an operating expense. This affects the balance sheet and cash flow worksheet in terms of how it is reported to the managers, board members, and stakeholders of an organization. As the GAAP lease accounting format has been applied to dark fiber, no new or significant accounting issues have been raised.

Telecom Enablement Structure



A lateral is defined as the network segment that connects a building's minimum point of entry (MPOE) to the existing fiber infrastructure.

Alternatively, prepaid IRUs are accounted as an asset according to the GAAP. Therefore, the organization purchasing the dark fiber would record the cost of the dark fiber as an asset to be amortized over the life of the contract benefit period, typically 20 years. The amortization table and method will be determined by an organization's accounting department or certified public accountant (CPA). The purchasing organization makes a onetime payment for the right to use the dark fiber, which includes its operations and maintenance. Along with the right to use, the purchaser is entitled to service credits if the dark fiber suffers an outage and the purchaser suffers a financial loss. The purchaser can transfer the risks associated with the ownership of the dark fiber, including operation and maintenance of the dark fiber. The purchaser takes on the risks of the flow of traffic, routing, electronic delivery equipment, and obsolescence.

Dark fiber has numerous benefits for an enterprise:

- Cost savings over lit services
- Dedicated and virtually unlimited bandwidth
- High degree of security for compliance and regulatory industries
- Flexibility and scalability for evolving needs
- Complete control for in-house IT staff
- Ability to design the lowest possible latency routes in the area
- Affordable, flat monthly rates or long-term IRU options

The essential difference in the accounting impact of leasing and prepaid IRUs is whether it is classified as an asset or liability and the effect it has on the cash flow, balance sheet, and taxes of the organization. Being aware of the possible tax implications is wise when embarking upon building a dark fiber network. An accounting or tax professional can advise an organization as to which situation is most advantageous for an organization.

Is Dark Fiber the Answer?

The Pros and Cons

Planning a network with dark fiber is more complicated than merely ordering service from a lit service provider; for the right end user organization, the benefits of dark fiber far outweigh its complicated installation. The complete freedom and control the customer gains by provisioning its service is the most compelling reason to choose dark fiber. Once the customer owns the infrastructure, the customer is no longer at the mercy of the service provider for maintenance schedules, service upgrades, and capacity increases—and the pricing of the managed service.

A significant advantage to choosing dark fiber is the ability to upgrade bandwidth as needed without incurring any additional monthly cost for the network. Other benefits include choosing ideal maintenance windows and schedule upgrades to equipment at convenient times for the organization, not the carrier. With dark fiber, a customer has a nearly infinite amount of capacity, making the network scalable and cost-effective

Determining if dark fiber is the right option for your connectivity needs is complex—involving technical, financial, and operational considerations. However, for the many organizations, choosing a dark fiber solution may be the only option that meets critical requirements for security, reliability, control, scalability and, ultimately, cost.

The information presented provided a high-level overview of optical fiber technical concepts, factors affecting fiber network designs, considerations in making the right network choice for your business, and how to factor in financial elements. This high-level overview, however, won't equip you to start building your network tomorrow. Some of the concepts may dissuade you from considering dark fiber. Before you decide the trade-off between work and reward, let's look at the upside of a dark fiber solution through a few case study examples.

Case Study: Healthcare Group Meets Goals by Deploying a Dark Fiber Network

Optical networks such as Wavelength Division Multiplexing (WDM) are becoming increasingly popular among government agencies and healthcare organizations because of their speed, scalability, and security/compliance. By operating a sound and secure communications infrastructure, an organization can enjoy the benefits of rapidly advancing technologies, enhanced connectivity, and improved customer/constituent satisfaction.

A hospital group recently needed to invest in improved IT infrastructure to support their evolving medical application needs, as well as address heightened patient care expectations. However, they first needed a more reliable connectivity solution to transport information. Their network also needed to support the transfer of data between hospitals. Their goals were simple for upgrading their telecommunications services: Deliver superior patient care with more efficiency while controlling costs.

Finding the solution for the hospital group required assessing their communications network needs along with researching and comparing the availability and services of networks in their area. Because the hospital group had high bandwidth requirements coupled with tight security regulations, a traditional lit network was not the right fit. Instead, a dark fiber alternative was readily accessible and more efficiently and effectively deployed to meet the needs and objectives of the healthcare group.

Case Study: Healthcare Group Benefits from Faster Speeds, Lower Costs

A dark fiber network was created to connect several key buildings within a 100-kilometer radius. The hospital group leased dark fiber from a regional provider and invested in scalable equipment so that as their data traffic and technology needs change, their network can accommodate the emerging technologies and support the organizational growth.

Now the hospital group benefits from a private telecommunications network that is scalable, cost-effective, and high performing. With an improvement in speed and reliability, predictable maintenance schedules, and Health Insurance Portability and Accountability Act (HIPAA) compliance in check, the hospital group realized its goals of enhancing patient care, improving network efficiency, and gaining an affordable communications solution. In fact, the hospital group was able to deploy a completely scalable, next-generation network that provides *five times the bandwidth of a traditional local exchange carrier lit service network for less than half the cost.*

Case Study: Financial Services Industry Prepares for All Contingencies with Dark Fiber

With recent natural disasters and the ever-present threat of incidents, either accidental or malicious, the financial services industry has had to make critical changes in telecommunications infrastructure. Business Continuity/Disaster Recover (BC/DR) programs have many financial services organizations proactively pursuing initiatives to protect their information network.

In addition to network resiliency, the financial services sector also has a careful eye on network speed—and achieving the lowest latency possible. In telecom networks, “latency” is the term used to describe the amount of time it takes for data to travel round-trip from a point to a destination and back. Extrinsic factors businesses face, such as competition, compliance, or software applications, drive the need for latency-sensitive networks. For some businesses, latency is a critical requirement in their IT infrastructure planning and for others a “nice to have” element of their network.

In general, the goals that financial services businesses have for their enhanced networks include:

- Enhancing security
- Increasing scalability
- Decreasing risk
- Minimizing latency
- Eliminating (or reducing) downtime
- Complying with government mandates
- Controlling costs

By designing and deploying a dark fiber network, these organizations can achieve their stated goals, as well as realize critical time- and cost-savings benefits. More specifically, a growing number of finance companies require off-site data storage, multiple data centers, and high speeds to communicate between their offices. Traditional lit services are often no longer the solution because they lack flexibility and affordability.

Case Study: Financial Services Companies Realize Connectivity and Security Goals with Dark Fiber

Because of the availability of dark fiber and the ability of customers to upgrade bandwidth and service without incurring additional cost, many Fiserv organizations are finding the best connectivity option is a custom dark fiber network. Financial services companies, through their enhanced networks, are also able to handle increasing volumes of time-sensitive traffic and implement critical, robust enterprise applications, such as data mining.

Specifically, dark fiber enables financial service companies to meet each of their connectivity goals.

- Enhanced security: *With physical-layer isolation, companies comply with government regulations and enjoy a heightened level of network security.*
- Increasing scalability: *Dark fiber enables customers to upgrade bandwidth at any time without waiting on a carrier to provision service.*
- Decreasing risk: *By having a user-friendly network that supports the backup of critical IT systems, companies minimize their exposure to losing critical data and nearly eliminate user error.*
- Minimizing latency: *Custom dark fiber networks can address speed concerns by controlling physical path distance and by using the latest advancements in equipment.*
- Reducing downtime: *Dark fiber enables organizations to control maintenance schedules and exposes a network to less traffic than lit services—both of which support the financial services industry's need for zero downtime.*
- Complying with government mandates: *A dark fiber network allows for the storage and transmission of large data blocks across long distances in adherence to recent legislation.*
- Controlling costs: *All of these benefits of dark fiber are available to organizations at a rate that is less than high bandwidth managed or lit services alternatives.*

FiberLocator

The most trusted telecom network, data center, and lit building online database.

Fresh | Flexible | Trusted

FiberLocator is an invaluable resource for developing a custom fiber network, planning data center sites, locating on-net buildings, and more. Whether you're a carrier, enterprise, agent, commercial real estate broker, or other professional, gain access to maps and data to help you maximize your communications ROI.

- **On-Net Buildings:** FiberLocator's extensive database includes enterprise lit buildings, points of presence (PoPs), carrier hotels, central offices, and data centers. If it is connected to a network, it's probably in FiberLocator.
- **Metro Fiber:** Metro fiber maps are continually evolving, and as soon as you've requested one, chances are it's outdated. Instead of making an individual request to a carrier, rely on continuously updated FiberLocator.
- **Long-Haul Fiber:** Use FiberLocator's national long-haul network database to plan connectivity between the coasts or simply between distant offices. The visual map interface displays actual fiber routes, while the lit building layer reveals local PoPs.
- **Data Centers:** Nearly every network project involves connection to at least one data center. With thousands of data centers in FiberLocator, finding the right ones and learning what carriers are present in each are just a few clicks away.
- **Submarine Cables:** Need international connectivity? FiberLocator includes undersea cable routes and information including fiber capacities, landing station locations, and available carriers.

CONVERGED NETWORK SERVICES GROUP

"I wish I had known about this tool 5 years ago. In a few minutes, I am able to see data which would have taken hours to compile. It is one of those tools that makes me wonder how we did business without it."

-John A. Schwarze, Managing Partner, Converged Network Services Group

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