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Protecting Networks with Fiber Monitoring

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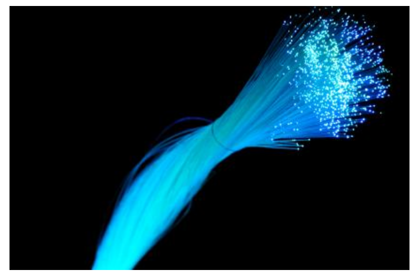

When you flip open your computer and hit play on a Netflix movie—or even when you read an old medium such as a newspaper in a new digital format—you can thank fiber optics. Somewhere along the way, fiber optics were involved with the making of most of our favorite pastimes, and many times we don't pay any attention to the great science and advancement that makes these things so effortless.

Powering our constantly connected society are billions of miles of fiber buried just three to four feet below where we currently stand (or beneath the seabed, hidden from view). Every day, people and businesses rely on fiber to transport Internet, data, and video traffic—a single fiber link is able to connect thousands of people, businesses, and enterprises. No doubt, the miracle of fiber's evolution and the connectivity it affords us today warrants a minute of appreciation; however, networks are already being tasked to do more and more. Fiber optic networks are constantly evolving to enable the technologies that allow us to work even smarter, faster, and more efficiently. (Think 5G, IoT, and more.)

At once vital and delicate, fiber cables and their protection should be thought about every bit as often as we consider how to advance their technological capabilities. The impact of a broken fiber cable has the ability to disrupt video calls, mission-critical data transfers, movie streams, and more. In a world where such breaks must be responded to immediately, time-consuming and manual processes for identifying causes and locations of interruptions are archaic compared to the importance of our networks.

Luckily, sensing for these critical networks is almost as old as the networks themselves. In this piece, we'll explore the evolution and current state of fiber optic networks, how they've historically been protected, and new methods emerging to protect this critical infrastructure.

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The state of fiber optic networks today

Altogether, there are more than five billion optical fiber kilometers installed around the world, including submarine, aerial, and underground cables enabling critical traffic we rely on every day to stay connected. Networks range from the massive—like the SEA-WE-ME3, the world's longest fiber optic link spanning more than 17,000 miles across multiple continents—to smaller, last-mile connections powering businesses and homes.

In the United States alone, telecommunications fiber-to-the-home (FTTH) lines are projected to surpass 82 million U.S. households by 2027, which is more than double than today's 44 million households, according to a report by a group of Cowen

analysts. For businesses, fiber lines are critical to keep operations moving and profits flowing. Today's businesses demand fiber because it's faster, scalable, more secure, and cost effective. Knowing that speed is important, businesses are looking for fiber services that have solid connectivity and networks that are closer to the edge for increased speed, which results in increased productivity and workplace efficiency.

Since the onset of the pandemic, fiber networks have made possible a massive switch in our ways of working, and they'll also be expected to power the technology of tomorrow. According to the latest estimates, the fiber optic market is expected to continue growing at a compound annual growth rate (CAGR) of 10.3 percent through 2027 thanks in large part to the role fiber plays in enabling video streaming, gaming activities, and overall higher bandwidth demand due to a larger number of Internet users and the need to enable 5G. More than 83 percent of those surveyed in a 5G Operator Survey by the Telecommunications Industry Association (TIA) say that fiber is "very important" to the future of 5G. Because fiber is the preferred backhaul option for 5G networks to connect to their base stations and towers, realizing use cases such as autonomous vehicles (AV) and smart cities demands the underpinning of fiber networks to enable lightning-fast technologies.

While the fiber service is critical, the technology is simple: light pulses sent through extremely thin glass fibers transport the data, converting each pulse into helpful information. Like sound, the performance of the fiber is tracked in decibels (dB), which indicates the power of the pulses

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as they travel through the cables. A dB loss test can use a power meter and light source to measure how much of the light passes through a cable, thereby indicating the performance of the data running through the cable. Since dB loss occurs through contamination such as dirt, moisture, and dust entering the cable, it's imperative the fiber cables stay intact and are monitored underground.

To keep fiber operating optimally, today's operators are eyeing new ways to monitor cables for issues such as dB loss, outside digging events, and natural disasters, which can result in massive monetary and reputational issues for critical infrastructure operators. It's the best way to make sure these assets stay secure underground and stay online consistently for customers. Nearly as long as fiber networks have existed, so has fiber monitoring.

The history of fiber sensing

The very first fiber optic sensor received a patent in the 1960s and just 10 years later, fiber optic sensors were invented, offering measurements that provided reliable data on fiber cables. Fast forward to today and fiber optic sensing technology is used in a variety of industries, including the oil and gas industries, to provide valuable data and sound alarms when there are issues such as leak detection. When we talk about network evolution, we also should talk about the evolution of network monitoring and sensing that includes fiber optic sensor technologies such as Optical Time-Domain Reflectometers (OTDR)s, Fiber-Optic Gyroscopes (FOG)s, and IoTs.

Fiber optic sensors (FOS) can gauge the stress of a fiber optic structure to alert of issues that can result in data speed deficiencies. The fiber optic technologies used to help with these critical alerts include:

- OTDR, which utilizes a measurement of "time of flight" to both detect and locate breaks in optical fiber

- FOGs, which act as a gyroscope that can utilize light to calculate motion, which in turn can measure the speed of a fiber optic cable

- (IoT), which are a collective network of devices that use real-time collection and the exchange of data to monitor networks at specific locations

Today, distributed acoustic sensing, vibration ranging, and detection technology are some of the newest technologies that deliver sensing capabilities through the fiber trands themselves. Because of their wide reach, fiber optic infrastructure can be

leveraged as a massive, dense, long-range gapless sensing array. Utilizing advances in photonics, hybrid cloud computing, machine learning, and artificial intelligence, distributed fiber sensing (DFS) inside cables is essentially leveraging standard telecommunication optical fiber for a new paradigm in digital awareness. With DFS, new sensing-as-a-service (SaaS) products are providing 24/7/365 cable monitoring, which secures and improves performance, resilience, and maintenance of fiber infrastructure while detecting a wide range of occurrences around the cables, including:

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- Live cable strike monitoring
- Burial condition awareness
- Geotechnical surveying below fiber
- Rapid response to earthquakes
- Storm monitoring
- Leak detection

As a result of the popularity of today's newest sensing technology and the need for enterprises to employ effective sensing strategies, the global distributed fiber optic sensing market, which was valued at $1.3 billion USD in 2021, is expected to grow at a CAGR of 7.3 percent through 2030.

Protecting networks through the latest monitoring techniques is imperative for operators that want to avoid reputational and costly damage as a result of unexpected outages. Additionally, fiber monitoring has next-generation uses that go beyond just protecting cables—the sensors themselves can actually enable new technologies, such as:

Autonomous vehicles

Transportation is becoming increasingly connected—whether that's running the navigation systems of an autonomous vehicle or enhancing the driving experience with data and content. The trucking logistics industry is also becoming reliant on sensors, robotics, vehicle maintenance monitors, and more.

The massive volumes of data passing to and from connected vehicles—particularly AVs and unmanned aerial vehicles (UAVs) that rely on real-time data to stay safe and location-aware—will demand resilient high-bandwidth connectivity, everywhere, and fiber sensors can provide the critical real-time data that can make that possible.

Smart cities

Smart cities are becoming closer to reality, but will require video, safety monitoring, and real-time street information about objects and people—all things enabled by fiber and in part, fiber sensors.

The future of fiber monitoring

As we continue to build out networks that are capable of delivering the technology of tomorrow, like autonomous vehicles and smart cities, continuing to build sophisticated monitoring systems in tandem is equally as important as building the networks themselves.

The miles of fiber cable buried underground and underseas serve as the information superhighways that propel our increasingly digitized world forward. Fiber sensing will not only protect them, but also act as the service that makes autonomous vehicles, smart cities, and safer streets a reality.

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