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NETWORK SOLUTIONS™

Cloud Edge Computing with the Power of Fiber Optics

White Paper

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Contents

Figures

1. Introduction

Edge computing is becoming increasingly important as it enables low-latency, high-reliability processing for applications like autonomous vehicles and 5G industrial automation. To support these applications, data centers are moving closer to the edge of the network.

Unlike traditional long-haul networks that connect distant central data centers, edge cloud networks consist of many distributed data centers in the local areas. This architecture aims to meet the low-latency demands of edge computing services.

To effectively support edge cloud applications, optical networks need to be optimized. This includes reducing costs, minimizing size, and lowering power consumption. Traditional configurations designed for long-haul applications may not be ideal for edge computing.

Technological advancements have enabled network operators to achieve speeds of 400 Gbps over a single wavelength in their networks. Using wavelength division multiplexing (WDM) in the C-band, one fiber optic cable can transmit up to 18 Tbps. This approach requires significant demands on digital signal processing, power consumption, and WDM capabilities, resulting in higher costs. The adoption of coherent optics is better suited for long-haul and metro applications, not edge computing.

To meet the demands of edge computing applications, the industry needs to transmit fewer wavelengths over a single fiber while maximizing capacity for each channel. This requires simplified integrated transponders that support faster speeds over short distances.

The shift to edge cloud computing is driving changes in optical network design and technology. The focus is on optimizing networks for lower latency and reliability while minimizing costs and power consumption. Advancements in speed and wavelength division multiplexing are crucial, but tailored solutions are needed to meet the specific requirements of edge computing applications. Integrated transponders and other innovations will play a key role in achieving these goals.

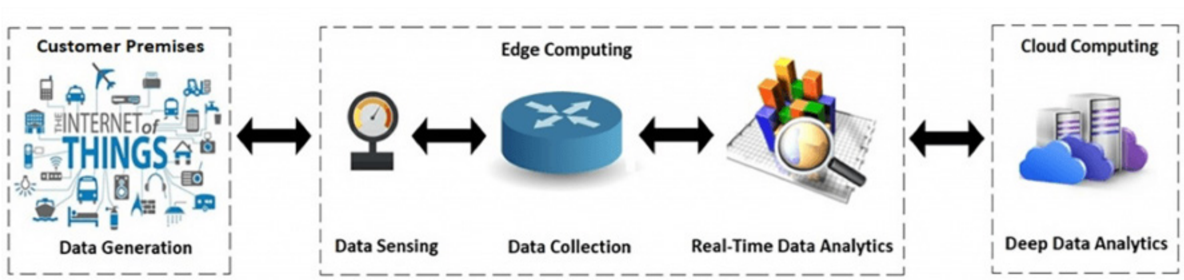


Fig. 1 What is Edge Computing [1]

2. The Impact on Edge Innovation with Fiber Optics

- Fiber optics is a critical enabler for edge innovation, empowering applications that require low latency, rapid data processing, and reliable connectivity. The combination of fiber optics and edge computing is transforming industries and paving the way for a more connected and responsive future. Below are the highlight areas with edge computing using fiber optics:

- Reduced Latency: Fiber optic technology significantly reduces latency, enabling real-time data processing and analytics. This is particularly important in applications such as autonomous vehicles, IoT, and robotics, where immediate responses are critical.

- Improved Cloud Services: Fiber optic connections enhance the efficiency of accessing cloud-based services. Low latency allows for faster data retrieval, which, in turn, enhances user experiences and productivity for businesses relying on cloud infrastructure.

- Enablement of 5G Networks: Fiber optic cables are essential for the successful deployment of 5G networks. They provide the necessary bandwidth and capacity to handle the substantial increase in data volume and bandwidth demands that come with 5G technology, ensuring a smooth rollout.

- Edge Computing Advancements: Fiber optic networks enable the deployment of edge computing resources, bringing advanced computing capabilities closer to the edge of the network. This not only accelerates real-time data processing but also reduces network congestion and enhances security.

- Augmented Reality (AR) & Virtual Reality (VR): High-speed fiber optic connectivity enhances immersive AR and VR experiences, with applications in gaming, healthcare, and education.

- Autonomous Vehicles: Fiber optics facilitate real-time communication between autonomous vehicles and their surroundings, improving safety and navigation systems for self-driving cars.

- Internet of Things (IoT): Fiber optics help address data congestion and latency challenges in the growing IoT landscape, enabling efficient communication between connected devices.

- These advantages demonstrate the pivotal role that fiber optics and edge computing play in shaping the future of technology. The seamless integration of these innovations holds the promise of unlocking new possibilities, redefining the digital world through speed and connectivity. Embracing these transformations can lead to a future where technology continues to evolve and create remarkable opportunities.

3. What Telecom and Data Center Operators are doing to support edge computing

As mentioned, fiber optic connections are essential for delivering on the promise of edge computing in applications like 5G and IoT. Edge data centers bring the internet's "edge" closer to less densely networked areas, storing frequently referenced content and applications to improve user experience for high-bandwidth applications like HD video, mobile computing, and cloud services.

Tech giants like Microsoft, Cisco, Google, AT&T, and Verizon are recognizing the significance of edge computing. They are partnering to develop infrastructure and solutions that can manage vast amounts of data near the edge, enhancing data workloads and keeping pace with business needs. These collaborations are essential to support the growth of edge computing and its applications. Google Cloud is working on a Global Mobile Edge Cloud (GMEC) strategy [3], aiming to collaborate closely with telecom operators. This strategy involves utilizing AI and analytics to provide advanced edge computing capabilities. Similar initiatives are seen with other major telecommunications and cloud providers, an example is Verizon will leverage AWS Wavelength, a new type of AWS infrastructure deployment that runs AWS compute and storage services at the edge of Verizon's 5G network [4].

Edge computing brings cloud capabilities closer to end-users, overcoming challenges associated with traditional cloud solutions such as high latency and security concerns. It enables faster data processing, lower latency, and better customer experiences, all of which are vital in the age of data-intensive applications and 5G networks.

Fig. 2 Edge computing is an emerging technology that enables the evolution to 5G by bringing cloud capabilities near to the end users to overcome the intrinsic problems of the traditional cloud, such as high latency and the lack of security. [2]

4. 5G, Fiber Optics & Multi-access Edge Computing

Multi-Access Edge Computing (MEC) moves the computing of traffic and services from a centralized cloud to the edge of the network and closer to the customer. Instead of sending all data to a cloud for processing, the network edge analyzes, processes, and stores the data. Collecting and processing data closer to the customer reduces latency and brings real-time performance to high-bandwidth applications. MEC requires high-speed, low-power, and scalable optical interconnects to connect the edge nodes with the core network, as well as within the edge nodes themselves.

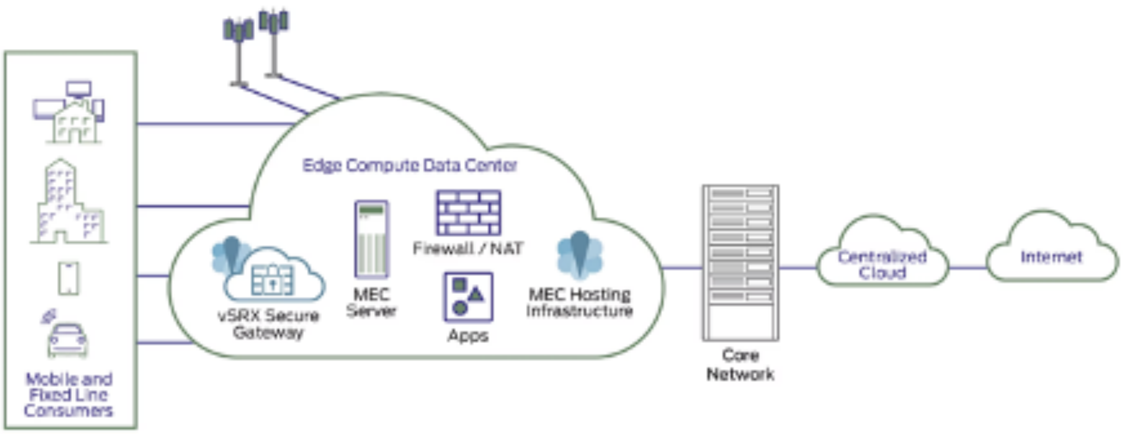


Fig. 3: Multi-access Edge Computing

5G and edge computing are closely intertwined, each complementing the other. 5G offers high speeds and bandwidth, while edge computing provides low-latency computing power closer to the point of data consumption. This combination enhances the network's capacity to accommodate a vast number of devices.

Fiber optic cabling plays a central role in supporting 5G and edge computing. The expansion of 5G networks relies on the growth of fiber optic infrastructure. These technologies evolve in tandem, addressing the demand for low-latency, always-on networks.

Businesses are increasingly recognizing the importance of automation and real-time data processing for decision-making. Industries like manufacturing benefit from edge computing and 5G for monitoring and managing data from various locations.

Embracing 5G, edge computing, and fiber optics is essential for businesses looking to stay competitive. It's not just about adopting these technologies but understanding their impact and adapting business models accordingly.

The integration of 5G, edge computing, and fiber optics is driving innovation and transforming the way businesses operate across various sectors.

As these technologies continue to evolve, they are set to create more agility and usher in significant changes in the digital landscape, with businesses needing to stay informed and adapt to leverage their potential fully.

In Amphenol Network Solutions [5], we're seeing a big impact of modular data centers development for edge computing where they can be deployed much quicker or cheaper than a brick-and-mortar facility. Products like our new LiNC panel [6], enable better use of what is sure to be a premium for space in edge computing environments. With its total front access (TFA) capability, LiNC can be deployed on or near a wall thus freeing up floor space for the production equipment like servers [7].

Fig.4 5G and edge computing are interlinked [8]

5. Edge Computing Use Cases with Fiber Optics

1. OSP Cabinets/Fixtures:

OSP cabinets are a compact form of data center infrastructure tailored for edge locations. They are smaller than traditional data centers and are designed to house a quarter-rack to two full racks of modern data center equipment. OSP cabinets are built to operate effectively in remote and harsh environments. They must withstand conditions that may be dusty, less well-maintained, and less temperature regulated compared to centralized data centers. This resilience is essential for edge locations that can be exposed to various weather and environmental challenges. OSP cabinets are strategically placed as close to end-users as possible. The goal is to minimize latency and achieve roundtrip times as low as 2-5 milliseconds. This proximity enhances the performance of applications that require low latency, such as real-time analytics, IoT, and edge computing services. OSP cabinets represent a critical component of edge computing infrastructure, providing the necessary computing power and data processing capabilities at the edge, where proximity to end-users and low latency are paramount. Their design and durability make them suitable for deployment in remote and challenging environments, helping to support a wide range of edge applications and services.

2. Macro Site, Small Cell, CRAN, and Private LTE Cell:

The integration of edge computing with cellular base stations and tower sites is a significant trend in the evolution of network infrastructure. In many edge computing models, cellular base stations play a pivotal role in connecting end-user devices to the core network. These base stations are considered key points for distributing edge computing capabilities.

Edge computing strategies often involve deploying data storage and compute capacity at tower sites, which are the locations of cellular and wireless infrastructure. These deployments may require specialized enclosures situated at the base of the tower.

Edge computing co-located with small cells, CRAN, and private LTE cell nodes offers several commercial and operational advantages in various industry segments. These include automation and Industry 4.0, worksites, mission-critical services, enterprises, and public safety.

Many of these industry segments operate in challenging environments where dense, high-performance computing outside of traditional data centers is necessary. These environments may have strict space constraints and operate under less controlled conditions, including dust and temperature variations.

The need for edge computing in such diverse and challenging environments requires infrastructure diversity. This diversity encompasses both hardware and enclosure designs that can operate effectively under the specific conditions of these use cases.

Integrating edge computing with cellular and tower-based infrastructure is crucial for meeting the needs of various industry segments, especially those operating in challenging environments. The ability to deploy high-performance computing resources in these locations is driving innovation in infrastructure design and technology to support diverse applications and services.

3. Metro Edge and Colocation Data Centers

Network traffic continues to increase, and a substantial portion of this traffic will be processed at regional and metro edge computing nodes. This shift is driven by the need for low latency and faster response times in various applications.

Cloud service providers, particularly large hyperscale companies, leverage existing Points of Presence (POP) and telecom installations to deploy edge data center facilities strategically. These locations are chosen to optimize the distribution of edge computing resources.

Regional and colocation data centers are becoming more attractive in the context of edge computing. Their locations in first- and second-tier markets make them convenient for delivering infrastructure incrementally to enterprises, especially in or near major cities, where they can serve a significant population.

These data centers require flexible, scalable, and high-performance fiber infrastructure to support the increasing demands of applications and customer requirements. This infrastructure is crucial for achieving the low latency and high performance necessary for edge computing.

4. Factory / Campus / Hospital

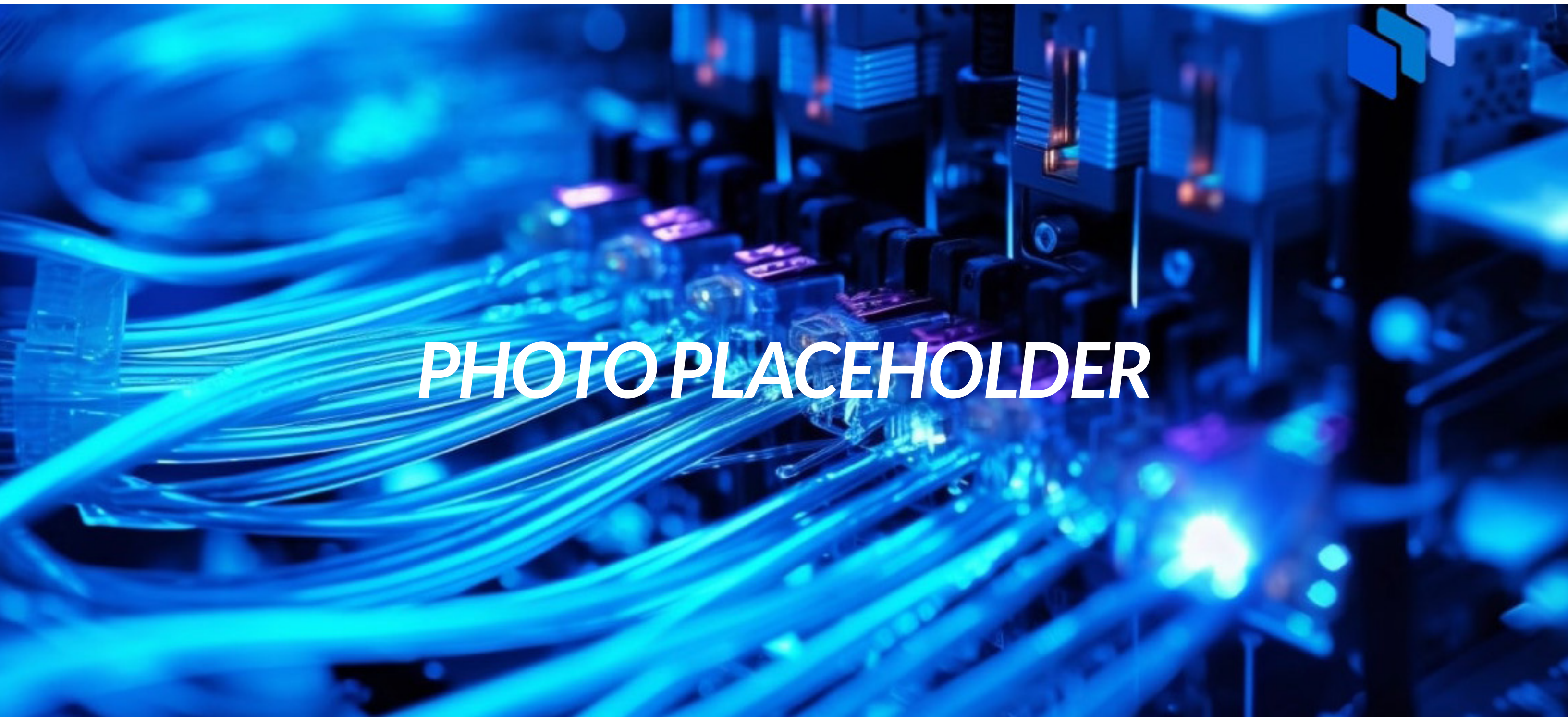
The expansion of edge computing to a broader range of locations, including office campuses, factories, warehouses, hospitals, and logistic centers, reflects the need to support data collection from IoT devices and sensors in various industries.

Edge computing is deployed in various forms, adapting to specific use cases and locations. This flexibility includes deploying one or two servers, co-locating a rack within an existing on-premises data center, or using a mini-data center enclosure that can be as large as a single rack.

These micro-data centers are designed to be compact and adaptable for atypical locations. They can fit into unconventional settings such as rooftops of commercial buildings, parking lots, business parks, university campuses, and near high-traffic areas like sports stadiums.

The primary purpose of these edge data centers is to facilitate data collection from IoT devices and sensors. By processing and analyzing data locally, near the source, they reduce latency and support real-time decision-making.

Edge data centers are often strategically distributed across geographic areas to support local data processing needs, ensuring that data doesn't need to be sent to a central data center, thus reducing network congestion and latency.



6. Summary

Edge computing is a pivotal technology that bridges the gap between cloud services and end-users, particularly in the context of 5G and IoT. Collaborations and strategies from industry leaders emphasize the importance of edge computing in delivering faster and more efficient services to users while supporting the evolving needs of businesses and applications.

Amphenol Network Solutions [9] are equipped with the expertise to ensure that our customers' networks are competitive and meet the demands of edge computing. We offer solutions from outside plant cables / cabinets to customized fiber optics interconnect to support the evolving requirements of the next generation edge computing for our customers.

7. References

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About the Author

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Charles Su, PhD, is a seasoned Senior Optical Engineer with over 20 years of experience in the telecom industry. Specializing in optical fiber components and systems, he has demonstrated strong leadership capabilities, successfully leading teams and delivering impactful solutions to address complex challenges. With a deep understanding of fiber optics technologies, Charles Su is renowned for his forward-thinking approach to next-generation product development. He has a passion for understanding and meeting customer needs, consistently developing innovative solutions that exceed expectations. Committed to driving customer success, Charles Su leverages his extensive industry knowledge and dedication to continuous improvement to deliver exceptional results.

About Amphenol

At Amphenol Network Solutions, we are driven by a passion for innovation and a relentless commitment to creating customized solutions that seamlessly integrate with your unique requirements. With our deep understanding of fiber optic technology, we specialize in creating tailored solutions that anticipate and adapt to the rapidly evolving demands of your network. Through our responsive support, unwavering commitment, and ongoing collaboration, we ensure that our solutions are ready to deliver superior performance and reliability.

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