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Tying Everything Together: Why AI Is Just One Thread in Network Transformation

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Adaptation and creative problem-solving have always driven network transformation. While transformation is unpredictable, we can ponder its potential trajectory by exploring previous trends. From the advent of specific legacy protocols to the proliferation of Dense Wavelength-Division Multiplexing (DWDM) and Ethernet, numerous innovations have persevered while others have fallen by the wayside.

In recent years, hyperscalers' cloud computing requirements redefined network design and operations as service providers invested in their infrastructure to maximize key connectivity qualities essential to these business needs. Artificial Intelligence and Machine Learning (AI/ML) applications will cause similar industry shifts, but they are only one thread in the larger picture of network transformation.

From Modest Beginnings to Modern Infrastructure

In building early infrastructure, many operators leveraged strategies that seem unconventional in hindsight. For example, some amplifier sites were placed in unlikely locations, such as gas station bathrooms. These sites functioned well despite their inauspicious appearance, ultimately showcasing network engineers' ingenuity as global connectivity infrastructure scaled up.

Aside from physical infrastructure, numerous legacy protocols were prevalent during telecom's nascent years. X.25 was an early packet-switched networking protocol designed to enhance reliability through error-checking mechanisms. However, these mechanisms also slowed performance and caused throughput inefficiencies. Frame relay sought to address these limitations, particularly in supporting Wide Area Networks (WANs). Despite its strengths, frame relay lacked scalability due to its reliance on fixed virtual circuits and struggled to support fluctuating traffic loads as network infrastructure expanded.

Then, multiprotocol label switching (MPLS) became popular in the late 1990s because it improved traffic management and scalability across increasingly complicated distributed networks. No matter what comes next, adapting to challenges through novel innovations or strengthening existing technologies remains the foundation of network transformation. So, it's no surprise that internet carriers will continue to apply these principles to support customers' evolving needs as AI applications present familiar (yet heightened) connectivity demands.

The Symbiosis Between AI, Optical Innovation, and Network Transformation

AI has captivated the world's minds and wallets as the technology sector's driving innovative force. It will transform networking similarly. As such a powerful and promising technology, its influence on telecommunications is two-pr onged. Telecom operators must ensure their networks can support AI's real-time data processing and transfer requirements, necessitating extensive investment in certain aspects of their operations. However, service providers can also leverage AI internally to improve customer experience and reduce human intervention in network management. Automated self-service platforms resolve customer issues quicker, while predictive analytics help operators identify and address potential bottlenecks before they cause outages.

However, AI's true utility depends on high-quality data. Therefore, telecom operators must unify disparate data sets to capitalize on AI's full potential. Internal silos often limit data accessibility, hindering service providers from establishing a unified source of truth. Dismantling these silos is critical in enabling AI-driven insights and network operations. After all, AI is only as good as the data you feed it.

Optical networking innovation is also vital in supporting data-hungry AI applications. DWDM technology is still a valuable tool for supporting the capacity requirements of emerging technologies. As bandwidth needs and operational costs escalate, many operators are also integrating IP over DWDM (IPoDWDM) in metro and long-haul networks. By eliminating the need for a separate transport layer, IPoDWDM can reduce costs while enhancing performance by reducing latency, helping network future proof their infrastructure for tomorrow's connectivity needs. Optical innovation is crucial because networks have already reached Shannon's Limit (the amount of data you can physically fit on a fiber-optic cable). As a result, operators are already integrating expanded frequency bands, such as the L-Band, to surmount these physical constraints by doubling the capacity of existing fiber pairs. Future network transformations spurred by optical innovation may also include increased deployment of hollow-core fiber. While we're still years from widespread implementation, this cabletype enables operators to shoot light through an air-filled core instead of glass fiber. This lowers latency significantly, even in long-haul applications, making it ideal for emerging applications that require fast, uninterrupted connectivity.

Better, Faster, Smarter: Enhanced Automation is Key

Historically, telecommunications operators have not prioritized sustainability. Service providers have primarily focused on improving traffic throughput and reducing capital expenditure (CAPEX) in their network operations. However, as climate change's effects escalate, sustainability is an increasingly vital consideration when designing and operating global networks. Still, the industry has plenty of work to do in this area. So, how can automation help?

Network automation was previously hindered by high costs and operational complexity. However, it's become increasingly viable due to recent progress in data analytics and intelligent traffic routing algorithms. These forms of automation help operators improve resource allocation and streamline their networks to boost efficiency while reducing power consumption. These advanced analytics tools can also provide real-time insights that enable proactive network management instead of reactive management, helping operators predict and prevent issues before they affect customers.

Network automation's ability to reduce energy consumption is a key consideration in the era of power-hungry AI applications. AI requires enormous computational power for data transfer and replication, resulting in strained network resources and heightened energy usage. By leveraging automation, operators can scale capacity according to real-time demands while minimizing energy waste. These benefits are crucial amid high energy costs throughout the telecommunications industry.

The Next Frontier: Quantum Computing and Digital Equity

Visions of technological progress have always driven telecommunications, and quantum computing is among the most promising possibilities. This novel technology may reshape networking even further by offering unprecedented security and efficiency. For example, quantum key distribution is already enhancing network security by enabling resilient encryption methods.

While widespread applications of quantum computing in telecommunications may take another decade or longer to reach fruition, numerous industry groups are making progress. However, quantum computing for routing traffic is currently theoretical and restricted to research environments. We may realize its utility in this area eventually, but that remains to be seen. Still, as space and power become increasingly constrained, quantum computing could help operators pack enormous capabilities into smaller, more energy-efficient systems.

On the other hand, the expansion of Fixed Wireless Access (FWA) to bridge the digital divide is a more realistic goal. Despite significant progress in global connectivity access, millions of people remain disconnected from the Internet, ultimately hindering economic development in underserved markets. FWA is a cost-effective alternative amid the high costs of fiber buildouts, making it an advantageous solution for enabling high-quality connectivity in rural regions and furthering digital equity on a global scale.

Weaving Together a Connected Future

Creative problem-solving has always underpinned network transformation. Over the past three decades, the telecommunications industry has repeatedly adapted to the business landscape's shifting demands. Despite this persistent transformation, some key connectivity qualities have remained constant. Internet carriers have always focused on maximizing scalability, reliability, cost efficiency, and performance when designing and building their infrastructure. Amid AI's heightened demands, they will continue to base their transformation strategies on these facets.

Similarly to cloud computing, AI will shape future network transformation trends as global business requirements accelerate according to technological innovations. Yet, for all of AI's hype, it is still only one part of the bigger picture. Network disaggregation, sustainability, automation, and emerging technologies such as quantum computing will also play major roles in shaping the future of global networking. While we must look ahead, operators will also pursue more immediate goals, such as expanding connectivity to underserved communities and supporting companies' escalating bandwidth requirements through optical innovation.

Network transformation is inherently unpredictable, but one thing is certain: it will continue to be a wild ride. As operators navigate the challenges and opportunities of the next few decades, they will leverage past lessons to build networks that are faster, smarter and more sustainable. While network transformation combines many disparate threads in hopes of weaving together a connected future, the picture it forms will reflect the Internet's original vision of unified communications.