Middle Mile Networks

THE BACKBONE AND HIGHWAY TO AFFORDABLE BROADBAND INNOVATION

JUNE 2025

Fiber Broadband ASSOCIATION

When fiber leads, the future follows.

EXECUTIVE SUMMARY

Middle-mile networks form the essential link between local broadband services and the global internet. A middle mile network is defined as a network that connects two or more networks together. They are critical to delivering high-speed, reliable connections. Yet, many middle-mile networks today are built using outdated assumptions about household bandwidth needs. While public reports suggest peak-hour usage of 15–20 Mbps, real-world observations show active households often exceeding 100 Mbps. This discrepancy underscores the need to design middle-mile infrastructure based on real-world concurrency trends rather than diluted averages.

This paper highlights the growing mismatch between reported averages and real usage patterns. It presents insights from service providers, examines current trends, and outlines clear recommendations for designing middle-mile infrastructure that can meet today's—and tomorrow's—demands.

JUNE 2025

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INTRODUCTION

What Is Middle-Mile Infrastructure and Why It Matters

The combination of increased consumer bandwidth demand and the emergence of government and private sector funding availability has fueled a marked increase in the deployment of broadband access infrastructure, particularly Fiber-to-the-Home (FTTH). This broadband access infrastructure aggregates all traffic from end-users in the access area and delivers the traffic to (and/or distributes digital content from) a central office. However, broadband traffic does not terminate at the central office; it must be connected to the internet, which is accessed at peering points (sometimes called internet exchanges) that are often remote to these central offices, particularly in the case of rural central offices. Similarly, Broadband Network Gateways (BNGs), which terminate the Passive Optical Network (PON) systems that provide FTTH, must be traversed by all PON traffic, and they are also often remote to these central offices.

A middle-mile network, sometimes called the second-mile network, provides the link between the broadband access infrastructure (accessed at the central office) and the internet peering point (and the access network's BNG). It acts as the critical bridge between the "last mile" and major internet hubs or data centers. All last mile networks, including satellite and fixed wireless, require middle mile network connections.

Without strong middle-mile networks, even the best last-mile connections struggle to deliver consistent, high-speed internet. Middle-mile infrastructure directly affects how fast, reliable, and affordable broadband service is for end users. It also shapes how easily providers can scale networks to meet future demand. In simple terms: **A weak or inadequate middle-mile network limits the entire system.**

PURPOSE OF THIS WHITE PAPER

The goal of this white paper is to challenge outdated assumptions about middle-mile design and capacity planning. Many current funding programs and infrastructure projects still rely on old models of user behavior and demand forecasts, too often based on existing traffic demand over a copper pair network. Yet today's broadband environment—and tomorrow's—looks very different.

This paper will show why middle-mile networks must be designed, not around yesterday's average usage, but around real-world broadband application demands and those that are only now emerging, such as:

- *Growing numbers of devices per home*
- *Heavy streaming and gaming use*
- *New applications like augmented/virtual reality (AR/VR) and telehealth*

Each of these examples are driving higher peak-hour usage across all demographics. By accounting for these trends and suggesting practical network planning choices, this paper will offer clear, actionable recommendations for building middle-mile networks that are **affordable, scalable, and future-proof.**

Current Broadband Landscape: The Urban vs. Rural Divide

Broadband availability has improved significantly in many cities and suburbs. Gigabit speeds and fiber connections are becoming more common there. Additionally, ring or mesh fiber networks already interconnect urban and suburban central offices. Further, operators of urban and suburban access networks often site BNGs and even internet peering points in their end offices, eliminating the need for separate middle-mile networks in these cases.

But large gaps remain — especially in rural, remote, and underserved communities.

- Many rural network operators have yet to deploy, or fully deploy, FTTH in their serving areas because:
- Their business models do not require high-capacity broadband services, and
- They face higher per-subscriber costs for building last-mile infrastructure (i.e., deploying fiber to each residence) because their population density is low.
- Even in rural areas served by early PON systems, basic broadband can be slow, unreliable, and/or expensive.

An important distinction seen in rural networks is that their middle-mile capacity requirement, prior to deployment of a current-generation PON system, is relatively modest. Voice services generate little traffic, and Digital Subscriber Line (DSL) systems deliver only a small fraction of the capacity of current PON systems. However, when these operators begin offering the high-speed connections supported by current PON systems, their central offices will aggregate a surge of new traffic that will overwhelm their existing middle-mile infrastructure. Without a significant improvement in their middle-mile connections, rural ISPs will face higher costs to move data to internet exchanges, leading to slower speeds, higher prices and limited service choices for end users.

Closing the digital divide requires more than just last-mile expansion. It demands a strong, affordable, and resilient middle-mile foundation that can grow as usage patterns evolve. Investing in scalable middle-mile infrastructure will lower costs, expand service coverage, and create a true path to digital equity for all communities.

Broadband access network termination sites are referred to differently by operators. Multiple System Operators (MSOs) use "headends;" Internet Service Providers (ISPs) use "Points of Presence (POPs);" fixed wireless operators use "antenna tower sites;" and direct launches from data centers are called "data centers" (or POPs). For simplicity, this paper will continue to use the term “central office” unless the other term is explicitly called for.

FIBER BROADBAND ASSOCIATION’S MIDDLE MILE SURVEY

The survey compiled by the Fiber Broadband Association included a wide range of responses, with input provided by 38 network operators across 25 states. These network operators provided a great deal of information and valuable guidance about the condition and future of middle mile networks across America. The survey results can be broken into several categories that covering contextual data, transit architecture, and traffic and cost data.

The survey respondents are a cross-section of the small businesses across America that operate internet subscription services. There are about 1500 such service providers serving their communities by maintaining and building the internet backbone for their local community. These operators account for more than 12 million subscribers, or more than 20% of the rural population of the United States if we make the reasonable assumption that most of these networks are based in rural America.

Those who responded to the survey have an average of 12,000 subscribers each and expect to triple their subscriber base over the next 5 years. If that average growth expectation extends across the rest of the service provider market, this group of service providers could bring broadband coverage to 60% of rural America, a massive accomplishment given that this covers 97% of the land area of the United States. Whether structured as a cooperative, municipal-owned network, private business, or utility, these businesses are increasingly critical for serving the broadband connectivity needs and growth of rural America.

These service providers depend on middle mile transit networks to connect their communities to the internet.

The survey respondents ranged in distance from the nearest internet exchange point from as close as being collocated at the internet exchange (about 12% of respondents) to depending upon a middle mile network to connect them as far as 275 miles. This distance is, of course, driven by the distance between the community central office(s) and the nearest Internet Exchange (IX) points, which should not exceed 400 miles within the continental United States.

Surprisingly, almost 70% of these ISPs own and operate their middle mile between the central office and IX, while 30% lease fiber capacity from a transit provider. Most of these middle mile networks also were operated with redundancy in mind, offering not only redundant fibers but also redundant geographic routes to the IX. It's important to note is that owning and operating the middle mile provides a clear advantage for the Internet provider. Providing a middle-mile solution opens new commercial opportunities and can strengthen community ties, allowing providers new revenue opportunities. Of the service providers that served more than 50 large anchor institutions, all of them operated their own middle mile network.

The service providers also gave an indication of the bandwidth available and bandwidth used by their network. Most of the providers expected that they could scale their middle mile capacity beyond 400 Gbps as demand grew. Current peak traffic on the networks stayed below 100 Gbps for 65% of service providers. However, the future expectation of these service providers was that peak traffic would grow substantially, with only 22% of providers believing their peak traffic would remain below 100 Gbps by 2030.

One factor likely reducing peak traffic demand was the Content Delivery Networks (CDN) nodes hosted at service provider locations. Half of the service providers use a combination of up to 7 CDN providers such as those offered by Netflix, Amazon, Google, Apple, Microsoft, Qwilt and others. These providers help offload peak traffic by caching content with high probability of usage, to reduce repeated download of content. It should be noted that those using CDN already had significantly higher peak traffic than those without. Of those using CDN, 62% had peak traffic higher than 100 Gbps, while of those not using CDN only 10% had peak traffic higher than 100 Gbps.

Information was also requested regarding backhaul traffic expenses, which account for both the cost to transfer the data to the IX – transit costs – as well as the cost to exchange traffic with other internet providers – peering costs. Based on the survey results, most providers have backhaul costs below 10% of their monthly operating expenses, but 36% of service providers reported backhaul costs that exceeded 10% of their operating expenses.

INSIGHTS FROM MIDDLE-MILE ISP SURVEY: REAL-WORLD UTILIZATION TRENDS

To better understand the challenges internet service providers (ISPs) face with middle-mile networks, the Fiber Broadband Association's Middle Mile Working Group conducted a national survey during 2024–2025. The survey included responses from nearly four dozen ISPs working in rural, suburban, and regional areas. The goal was to collect direct input on how ISPs design, operate, and plan their middle-mile infrastructure.

The responses revealed several consistent themes. Most ISPs reported that their middle-mile segments typically span between 20 and 80 miles. This highlights the need for reliable long-distance connectivity and cost-effective routes to upstream networks or exchange points.

A major issue raised by respondents was the high cost of connecting to internet exchanges. ISPs—especially those in rural areas—often face steep prices and limited options when trying to reach major peering points. These challenges increase operating costs and limit flexibility.

Scalability also emerged as a concern. Many ISPs shared how hard it is to predict future traffic demand with confidence. Without better forecasting tools and scalable designs, networks can quickly become overloaded—requiring upgrades sooner than expected.

Funding is another common obstacle. While many ISPs want to expand or improve their middle-mile infrastructure, existing grants and programs often don't cover enough of the total cost. This makes it difficult to invest in needed upgrades like added capacity, route redundancy, or improved exchange access.

In short, ISPs are committed to building strong networks, but middle-mile costs, capacity planning, and funding limitations remain key barriers. Solving these issues is essential to delivering high-quality broadband and supporting schools, hospitals, and other anchor institutions.

Three Key barriers ISPs Encounter When Building Networks:

1. Middle Mile Costs

2. Capacity Planning

3. Funding Limitations

Planning Implications for Middle-Mile Networks

The old approach of designing middle-mile networks around low average household usage no longer reflects how people use broadband today. Modern network planning must account for more simultaneous activity, higher peak-hour demand, and continuous background usage from connected devices.

Planners should expect:

- **Multiple high-demand applications running at the same time** in a typical home
- **Sustained high utilization during peak hours,** not just short traffic bursts
- **Rising overall traffic,** driven by both user activity and always-on smart devices
- **Continued customer growth,** especially in areas receiving new broadband investment

Building middle-mile networks for these realities is critical. Designing for traffic concurrency, rather than outdated averages — helps prevent congestion, service degradation, and the need for premature upgrades. To ensure long-term performance and customer satisfaction, planning for real-world demand is no longer optional. It's essential.

Current Bandwidth Utilization Trends

What Public Data Says About Peak-Hour Usage

Most industry reports, including those from Cisco and OpenVault, estimate that the average U.S. household uses between **15 and 20 Mbps** during peak evening hours. These figures are based on large datasets that include a wide range of users—from heavy streamers to casual internet users who might only check email or browse lightly.

While useful, these averages **hide a lot of important differences.** They blend together homes with almost no internet activity and households with multiple people actively streaming, gaming, and working online at the same time.

What Real-World Data Tells Us

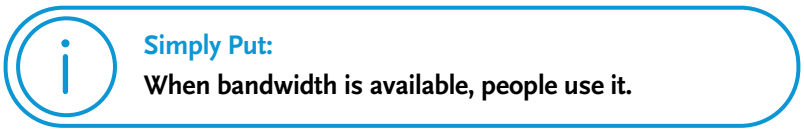
Field reports and recent data, including findings from the Preseem ISP Network Report 2025, show a different story.

- **Active households** — especially those with fiber, cable, or advanced wireless service — often use much more bandwidth during busy hours.
- In many cases, homes with multiple devices and users are already consuming over **100 Mbps during peak periods.**
- Preseem's network-wide averages show around **3–4 Mbps per subscriber,** but this number again includes many homes with little or no activity at any given moment. Among active users, bandwidth usage is **much higher.**

Why There's a Gap Between Public Averages and Real Usage

The main reason for the gap is **averaging.** Public reports measure overall traffic divided across all subscribers — even those who aren't online. That pulls the "average" down and doesn't reflect what's happening in busy, high-use homes.

At the same time, access to faster networks — fiber, DOCSIS 3.1 cable, and fixed wireless upgrades — **is changing how people use the internet.** With more bandwidth available, households naturally shift to richer applications: multiple 4K streams, video calls, cloud gaming, VR/AR sessions, and constant smart home device traffic.



Practical Implications for Middle-Mile Planning

If middle-mile networks are sized based only on historic averages, they will quickly become overwhelmed. The reality is that peak-hour demand per household is rising much faster than traditional models suggest — and in active service areas, in many households it's often pushing over **100 Mbps** today.

Middle-mile planning needs to be based on **peak concurrency** — not overall averages — to avoid congestion, service degradation, and costly rebuilds later. Designing for sustained peak-hour loads of **100–200 Mbps per home** is the practical approach to ensure future scalability and cost efficiency.

Broadband usage patterns have evolved. Today's homes often support a wide mix of Wi-Fi-enabled devices—appliances, smartphones, laptops, smart TVs, gaming consoles, voice assistants, and home security systems. According to data from sources like Plume IQ and Parks Associates, the average broadband household now manages **20 to 25 connected devices**.

This increase in connected devices leads to heavier and more continuous network usage. Streaming video, online gaming, remote work, virtual meetings, and smart home applications frequently run at the same time. The result is high concurrency, where multiple users and devices compete for bandwidth during peak hours. These patterns demand not just faster broadband—but more robust and scalable infrastructure across the entire network, especially in the middle mile.

Emerging Applications Driving Bandwidth Needs

Alongside device growth, newer applications are driving far greater bandwidth requirements than earlier network models anticipated:

- **4K and 8K Video Streaming:** A single 4K stream typically requires 20–25 Mbps, while 8K streaming can demand 50 Mbps or more.
- **Cloud Gaming:** Services like GeForce Now or Xbox Cloud Gaming recommend 35–50 Mbps for smooth, low-latency play. Add voice chat or multiple users and demands grow rapidly.
- **Virtual and Augmented Reality (VR/AR):** Multiplayer and high-resolution VR experiences can require 50–100 Mbps, particularly for interactive or immersive applications.
- **Smart Home Devices:** Always-on devices such as security cameras, smart thermostats, and sensors contribute steady background traffic, adding up to 5–15 Mbps even during idle periods.
- **Smart Agriculture and Connected Infrastructure:** In rural areas, precision agriculture tools—such as drone surveillance, irrigation controls, and soil sensors—are generating new types of bandwidth demand. These systems rely on real-time data transfer and are increasingly dependent on middle-mile reliability.

> "a single plant in a field can generate 18GB of data."
>
> — FCC Commissioner Brendan Carr

Together, these activities don't just increase average usage — they amplify peak-hour demand. Multiple users and devices running concurrently are now the norm, not the exception. This makes it critical for middle-mile networks to be designed with higher capacity, lower latency, and the flexibility to support future applications that are already starting to take hold.

Owning Middle-Mile: Financial, Operational, and Community Impact

A clear theme emerging from the survey is that many ISPs are choosing to build and operate their own middle-mile infrastructure. While this requires a significant upfront investment, the long-term benefits extend far beyond balance sheets.

Owning middle-mile routes allows ISPs to reduce recurring backhaul costs and improve EBITDA margins, which directly enhances company valuation. These assets also increase operational control, enabling providers to scale capacity, improve redundancy, and negotiate better transit terms. But the advantages go further.

Middle-mile ownership also improves the end-user experience. With fewer third-party dependencies, ISPs can deliver faster speeds, lower latency, and more reliable service—especially in rural and underserved regions. It also allows them to respond quickly to outages or performance issues, increasing customer satisfaction.

Equally important, owning infrastructure gives ISPs a stronger role in the communities they serve. It makes it easier to connect anchor institutions like schools, hospitals, and libraries—delivering the bandwidth these facilities need while strengthening public trust. Some ISPs also use their middle-mile assets to participate in open-access partnerships and broadband access programs, reinforcing their role as both a service provider and a civic partner.

In this way, middle-mile ownership is not just a technical decision—it's a strategic one. It positions ISPs for financial resilience, operational flexibility, and deeper community engagement.

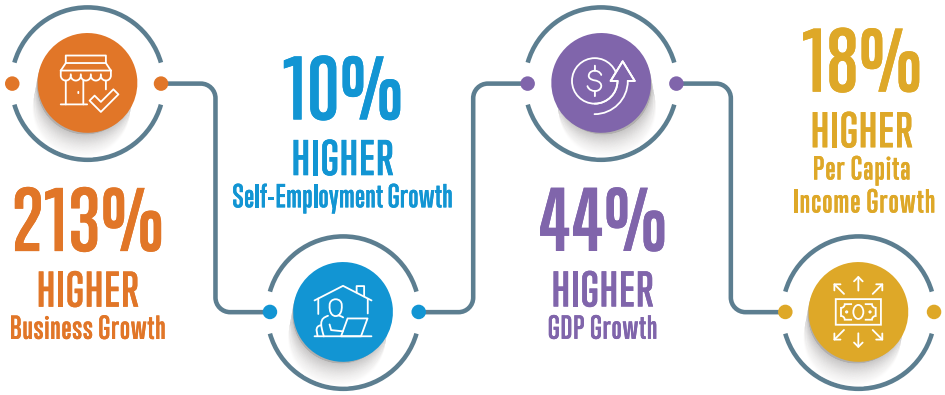


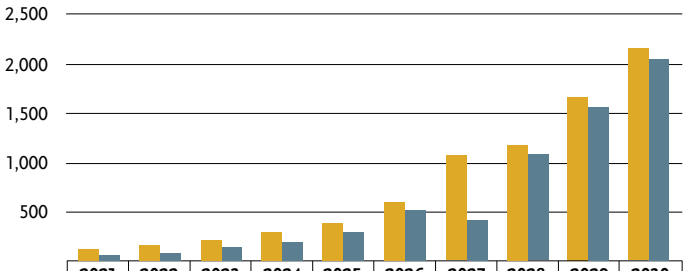
Figure 1:
Fiber Helps Economic Development in Rural Communities

SOURCE: Weinstein, A., Erouart, M., & Dewbury, A. (2024). Beyond Connectivity: The Role of Broadband in Rural Economic Growth and Resilience.

RECOMMENDATIONS & CONCLUSIONS FOR SERVICE PROVIDERS

Build Your Business Plan for Middle Mile Growth

To attract both public and private investment, a well-structured business plan is indispensable. Building a strong business plan for middle mile growth involves several strategic considerations that position service providers for long-term success. Controlling middle mile infrastructure can significantly enhance revenue growth by enabling providers to deliver higher speeds and more reliable services, which in turn attracts more customers and strengthens competitive advantage. Future-proofing the network is also critical; by enhancing speed and reliability now, providers can lay the groundwork for future Fiber to the Home (FTTH) expansion projects, ensuring sustained profitability. Additionally, preparing the network to handle peak demands of 400 Gbps or more helps avoid future costs associated with bandwidth shortages, making the investment more cost-effective over time. Strategic growth opportunities also emerge through positioning for collocation and edge deployment of AI technologies. As AI and edge computing continue to rise, having a scalable, high-capacity middle mile network will enable providers to offer advanced services and tap into new and lucrative revenue streams.



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
DOWNLOAD Mbps	131	158	222	293	396	601	709	1,182	1,658	2,141
UPLOAD Mbps	73	98	160	203	302	529	633	1,100	1,570	2,044

• Does not include Robotics
• Early adopters, Radiologists, Power Users/Gamers, others may require much more

Figure 2:
Projected Peak Bandwidth Requirements — Household of 4

SOURCE: Fiber Broadband Association Technology Committee
The Rural Digital Divide: Fiber Broadband Can Eliminate the North American Rural Digital Divide

Grow Your Horizon on Options For Expanding Middle Mile

Expanding middle mile infrastructure requires broadening the strategic horizon and exploring a variety of collaborative and design-focused approaches. One effective strategy is to partner with surrounding service providers to enhance route redundancy and participate in joint middle mile initiatives. These partnerships help build more resilient networks with multiple pathways, reducing the risk of outages and improving overall service reliability. Leveraging state resources is another valuable tactic; for instance, working with state agencies such as Departments of Transportation (DOT) can provide access to existing infrastructure and rights-of-way. A notable example is Utah's partnership with UDOT, which has successfully expanded middle mile networks by sharing fiber optic lines along interstate highways—maximizing resource utilization and reducing deployment costs. Additionally, designing networks based on real-world demand rather than historical averages ensures that infrastructure is built to meet actual usage patterns. Analyzing current data allows for more accurate planning to accommodate peak demand. Scalability is also essential; investing in infrastructure capable of supporting 400G to Terabit-level networks ensures that the system can grow with future bandwidth needs without requiring major overhauls. Finally, adopting middle mile open-access frameworks promotes the development of multi-use infrastructure, allowing multiple service providers to share the same network. This approach fosters innovation, encourages competition, and reduces overall costs.

A compelling example of innovative middle mile strategy is highlighted in the model proposed for rural operators, which emphasizes the value of shared infrastructure and cooperative investment. As discussed in *Broadband Communities Magazine*, rural service providers can benefit significantly from forming regional consortia or cooperatives to jointly invest in and manage middle mile networks. This model not only reduces individual capital burdens but also enhances network reach, redundancy, and service quality. By pooling resources and aligning deployment strategies, rural operators can overcome geographic and financial barriers, ensuring that even the most remote communities are connected to high-capacity, future-ready broadband infrastructure.

Funding Needs for Middle Mile Infrastructure

Securing adequate funding is essential for the development and expansion of middle mile infrastructure. These networks serve as the critical link between the internet backbone and last-mile connections, enabling high-speed broadband access in both urban and rural areas. Investing in middle mile infrastructure not only addresses immediate connectivity gaps but also lays the foundation for future technological advancements. Robust middle mile networks are vital for supporting increasing bandwidth demands and enabling emerging technologies such as artificial intelligence, edge computing, and smart infrastructure.

Public Funding Sources

To further support middle mile development, stakeholders should explore federal, state and local programs designed to support middle mile and broadband needs. The following are examples of some such public funding programs:

PROGRAM	SUMMARY
NTIA – Enabling Middle Mile Broadband Infrastructure Program	Provides nearly **$1 billion** in federal funding to support the construction, improvement, and acquisition of middle mile networks across the U.S., aimed at reducing the cost of connecting underserved areas.
Broadband Equity, Access, and Deployment (BEAD) Program	Administered by the NTIA, this **$42.45 billion** program primarily targets last-mile broadband expansion, but states can allocate funds to middle mile projects that are essential to achieving last-mile connectivity.
USDA Re-Connect Program	Offers **grants and loans** for broadband deployment in rural areas. Middle mile infrastructure that supports rural connectivity—especially for farms, schools, and healthcare facilities—may qualify.
Appalachian Regional Commission (ARC) & Delta Regional Authority (DRA)	These regional agencies fund infrastructure in economically distressed areas. Middle mile projects that promote digital inclusion and economic development are eligible.
Economic Development Administration (EDA) Public Works Program	Supports infrastructure projects that drive **job creation and economic growth**. Middle mile networks that enable remote work, business development, or digital entrepreneurship align well with this program.
State-Level Broadband Offices & Infrastructure Banks	Many states operate their own **grant and loan programs** through broadband offices or infrastructure banks. These often prioritize middle mile investments aligned with state digital equity and broadband strategies.
Tribal Broadband Connectivity Program	Administered by the NTIA, this program funds broadband infrastructure on **tribal lands**, including both middle and last-mile components, supporting tribal sovereignty and digital access.

Private Funding Opportunities

While federal and state grants provide foundational support, **private investment** plays a critical role in scaling middle mile infrastructure. Potential sources include:

PROGRAM	SUMMARY
Infrastructure Investment Funds	These funds seek long-term, stable returns and are well-suited for financing large-scale, capital-intensive infrastructure like middle mile networks.
Public-Private Partnerships (PPPs)	Combine public sector support with private sector efficiency and capital, enabling shared risk and accelerated deployment of broadband infrastructure.
Telecom and Tech Companies	Invest in middle mile infrastructure to enhance their own service delivery, support edge computing, and maintain competitive advantage in high-speed connectivity.
Community Development Financial Institutions (CDFIs) & Impact Investors	Focus on digital equity and inclusive growth, often funding projects that serve underserved communities or promote social impact alongside financial returns.

Private funding not only supplements public grants but also brings innovation, speed, and accountability to infrastructure projects. Encouraging private sector participation through tax incentives, streamlined permitting, and co-investment models can significantly accelerate deployment timelines.

Call to Action

Policymakers, industry stakeholders, and communities must collaborate to build robust, scalable middle-mile infrastructure. This involves prioritizing high-capacity networks, fostering partnerships, and encouraging open-access middle mile frameworks to ensure equitable access to high-speed internet. Specific actions include:

PROGRAM	SUMMARY
Investing in Scalable Infrastructure	Allocate resources to build middle mile networks that can meet current needs and scale to support future bandwidth demands, including 400G–Terabit capacities.
Promoting Partnerships	Foster collaboration among service providers to develop redundant and resilient networks, improving reliability and reducing deployment costs.
Supporting Middle Mile Open-Access Models	Advocate for open-access policies that allow multiple providers to share infrastructure, encouraging competition, innovation, and cost-efficiency.
Enhancing Funding Programs	Strengthen and expand funding mechanisms to support the deployment and upgrade of middle mile infrastructure, particularly in underserved and rural areas.

CONCLUSION

Our vision is a future where middle mile networks not only meet today's connectivity demands but are also built to scale with the technologies of tomorrow. By grounding our strategies in real-world demand and drawing on insights from service provider surveys and case studies, we can more effectively fund, design, and deploy infrastructure that is resilient, future-ready, and capable of supporting the next generation of digital innovation.

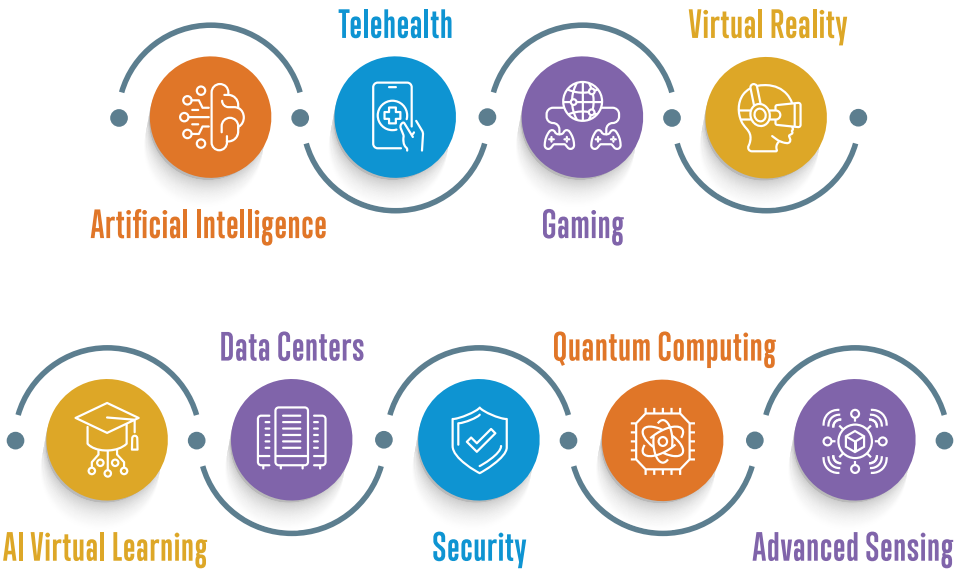


Figure 3:
Emerging Technologies and AI into the Future.

APPENDIX

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