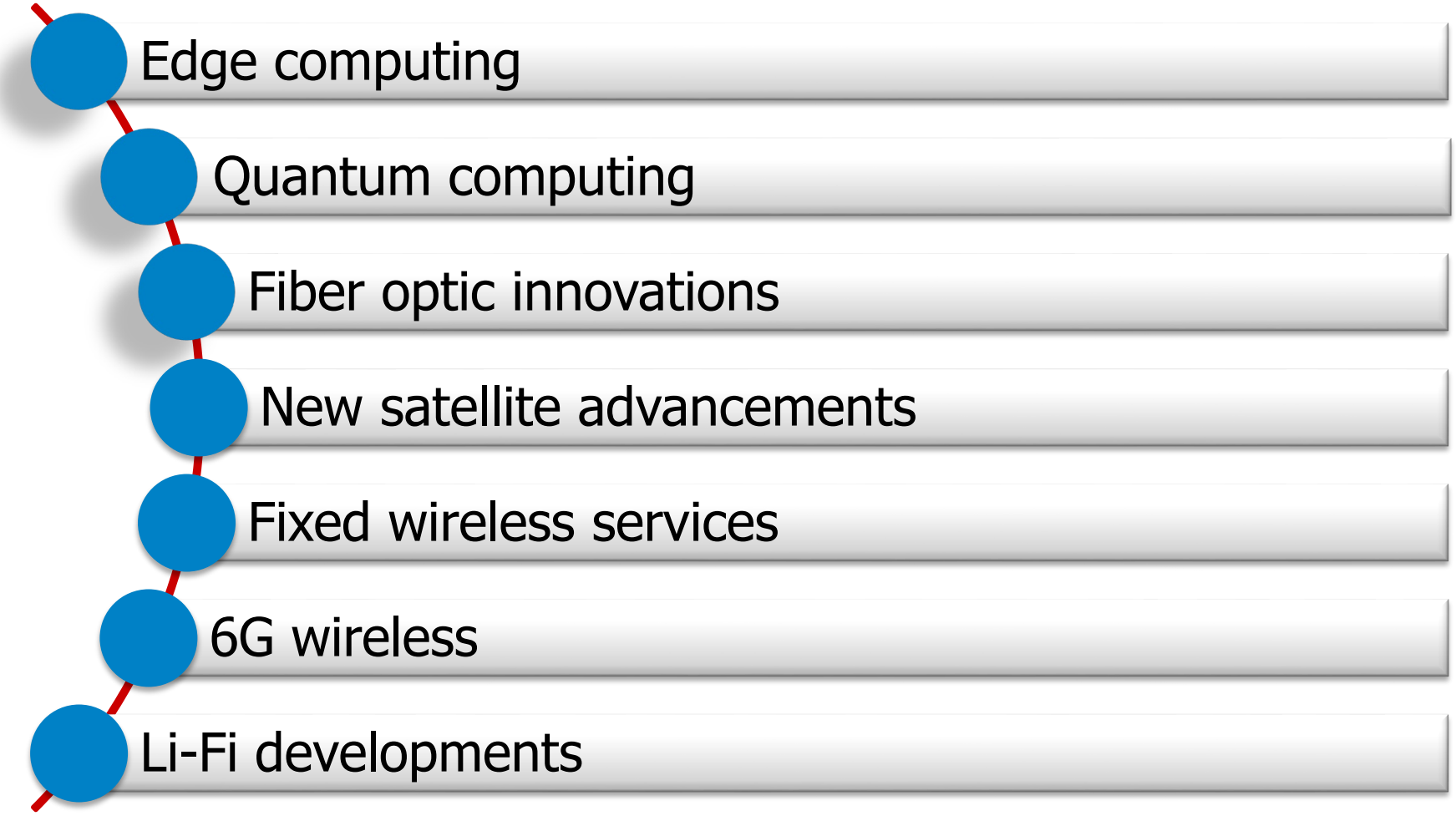
Future of Broadband Technologies

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Agenda



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Edge computing



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Edge computing

- Decentralization is the key
- Biggest advantage – reduced latency
- What about cloud computing and data center pros and cons?
- Can edge computing and cloud computing work together?
- Gartner research states as of 2025, 75% of enterprise-generated data was created and processed outside traditional centralized data centers or cloud environments
- Global edge computing market projected to reach $45.5 billion by 2028 with a current compound annual growth rate of 25%

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Edge computing
Components



Cloud computing

Edge servers, routers and gateways

Edge devices

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Edge computing
Common applications

- **IoT devices** – processing data generated by IoT devices
- **Smart manufacturing** – predictive maintenance and quality control
- **Smart cities** – traffic management and public safety
- **Healthcare** – remote patient monitoring and telemedicine
- **Autonomous vehicles** – real-time navigation and object detection
- **Content delivery** – caching content (e.g., music and video)
- **Gaming, virtual reality and augmented reality** – reduce latency
- **Artificial intelligence at the edge** – allows for real-time data analysis

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Edge computing
Effect on rural LECs

- **Pros**
  - Improved service delivery
  - Efficient network management
  - Data privacy and security
  - Offline operation
  - Cost efficiency

- **Cons**
  - Complexities
  - Investment challenges



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Edge computing
Opportunities

- Identify use cases – providers should identify specific use cases where edge computing can provide the most value
  - Including reducing latency for real-time applications, optimizing bandwidth usage, supporting IoT deployments or offering value-added services like edge analytics
- Content delivery networks – telcos can deploy edge servers at their network edges to cache popular content locally
- Network security – edge computing enables telcos to implement security mechanisms to detect and mitigate threats closer to the source
- Develop edge applications – telecommunication providers could develop or partner with third-party developers to create edge applications

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Quantum computing and communications



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Quantum computing

- Quantum computing – a new way of processing information using the principles of quantum mechanics, which is the science that explains how atoms behave



Source: Microsoft 365 CoPilot

- Unlike regular computers that use bits (which can be either 0 or 1), quantum computers use qubits, which can be both 0 and 1 at the same time due to a property called superposition
- Using a phenomenon known as quantum entanglement, qubits can also be linked together, even across distances, allowing them to solve certain problems much faster than regular computers



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Quantum communications
Potential benefits

- Quantum communications – a method of sending information using qubits, instead of classical bits
  - Faster, lower latency and more efficient use of bandwidth
  - Offers unbreakable security and tamper detection, ensuring any interception or interference with the communication is immediately detectable
- Quantum teleportation – a process by which the quantum state of a particle is transferred from one location to another without moving the particle itself using quantum entanglement and classical communications
  - Quantum communications could, in theory, enable faster communication by bypassing the physical limitations of signal transmission, but current quantum systems are not yet capable of matching the data throughput of fiber optics

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Quantum communications
Anticipated timeframe

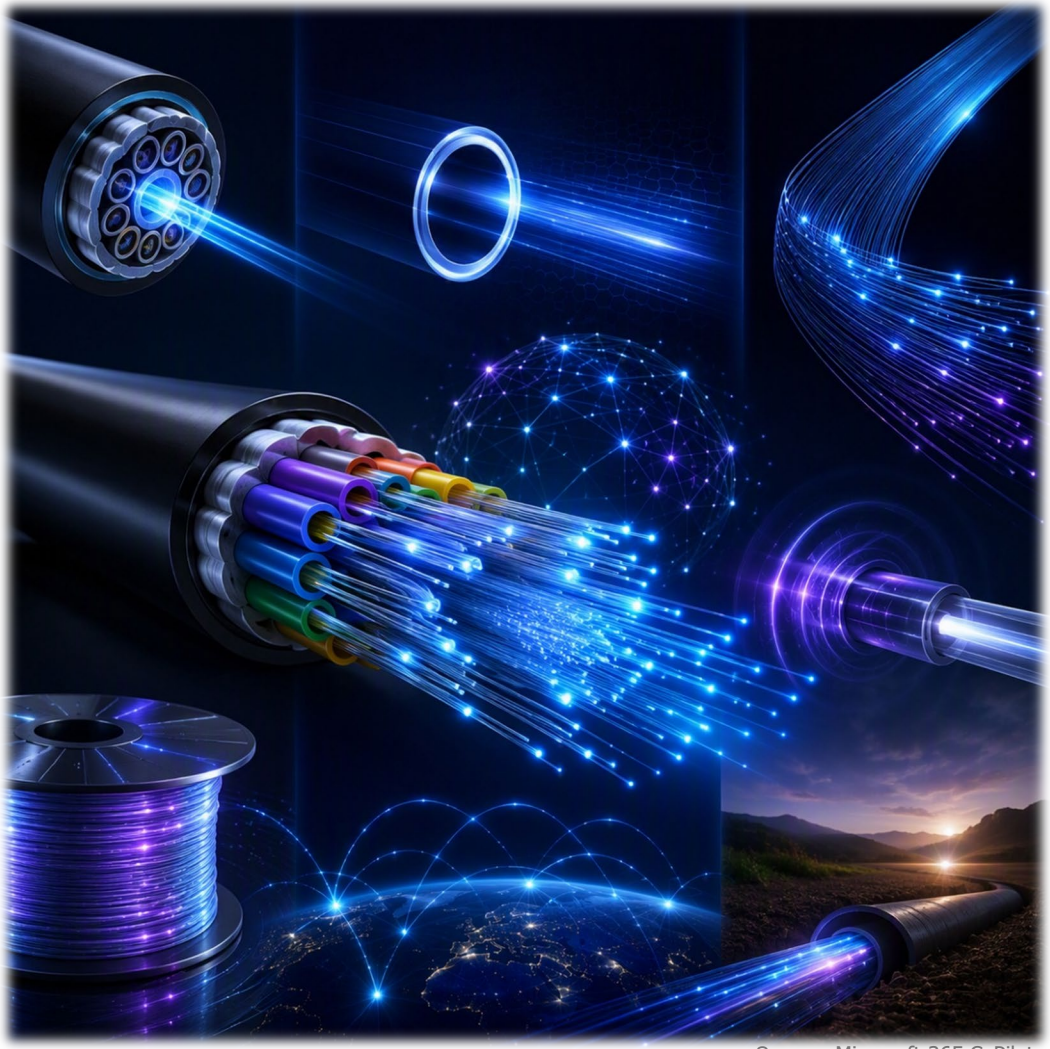
- Quantum teleportation has been successfully demonstrated over distances of hundreds of kilometers using optical fibers and satellite links
- Data centers are integral for providing power, cooling, capacity and electromagnetic shielding for quantum entanglement to occur
- Efforts are underway to build quantum communication networks
  - Prototype quantum networks, such as between government and research institutions for secure communication, are expected in the next five to 10 years
  - Regional quantum networks for data transfer over metropolitan or regional scales in next 10-15 years
  - Global quantum networks, for example the quantum internet, expected in 15+ years



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Fiber optic innovations



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Fiber optic innovations
Multicore fiber and space division multiplexing

- Multicore fiber – incorporates multiple cores within a single fiber strand, allowing simultaneous data transmission over parallel cores
  - Significantly increases data capacity without requiring more physical fibers
  - A single MCF can replace multiple single-core fibers, reducing space requirements in cables and conduits
  - Ideal for dense urban environments, data centers and submarine cable systems
  - Requires advanced space division multiplexing equipment to handle data from multiple cores
  - Widespread commercial adoption is expected in the next five to 10 years

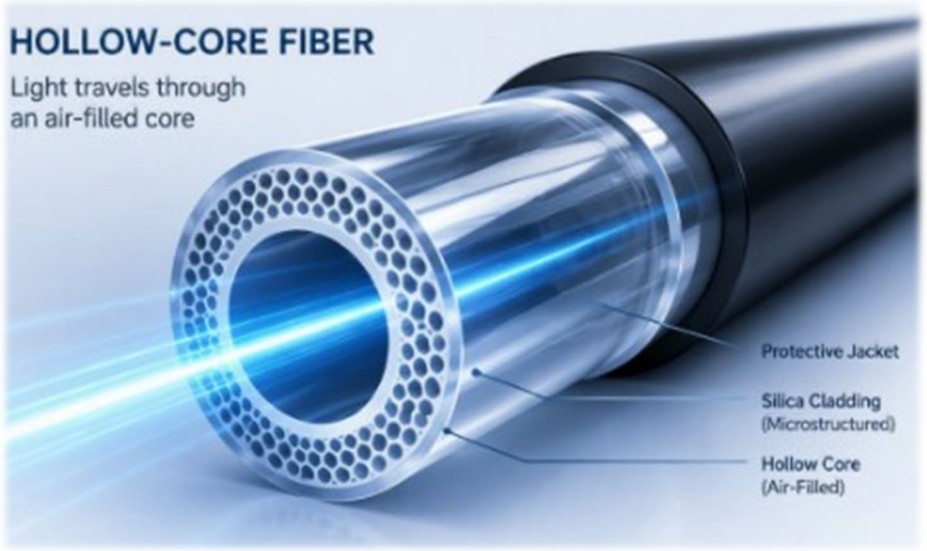


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Fiber optic innovations
Hollow-core fiber

- Hollow-core fiber – Evolving fiber technology that uses a hollow core instead of solid glass to transmit light, significantly reducing latency and signal loss
  - Ideal for ultralow latency applications and long-distance communications
  - More challenging to manufacture and currently more expensive
  - While the use of hollow-core fiber is not yet widespread, it is gaining traction in specific high-performance applications, such as aerospace, defense and research labs



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Fiber optic innovations
Artificial intelligence integration

- The integration of artificial intelligence with fiber optic transmissions is an emerging trend that aims to optimize the performance, efficiency and management of optical networks
  - AI algorithms can analyze network traffic patterns and predict periods of high demand
  - Dynamic bandwidth allocation – AI can adjust bandwidth allocation in real time based on traffic conditions
  - Self-healing networks – AI enables the development of self-healing networks, where the system can autonomously detect and recover from faults without human intervention

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New satellite advancements



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New satellite advancements

- Combining satellite and mobile wireless service
  - In October 2021, Verizon said they would work to combine its 5G wireless network with Amazon's Kuiper and AT&T agreed to work with OneWeb
  - SpaceX began testing its Starlink satellite-to-cell service with T-Mobile in 2023, vowing to end mobile dead zones. Beta testing was open to anyone through July 2025, and now T-Satellite is available on compatible, existing smartphones
  - AST SpaceMobile is contracting with most cellular phone makers and service providers to make a space-based cellular broadband network. First test mobile video call with standard smartphone made in January 2025. On Jan. 16, 2026, AST SpaceMobile won contract for U.S. Missile Defense Agency's SHIELD program
  - Preparation for 6G wireless commercial deployment by 2030

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New satellite advancements

- Terrestrial data center connectivity
  - Data center backup in space where fiber is unavailable or prohibitively expensive to deploy
  - Wireless backhaul



Source: Microsoft 365 CoPilot

- Orbital data centers and AI clusters
  - Pros – abundant unfiltered solar energy, bypass local zoning regulations and completely unaffected by Earth's weather
  - Cons – cooling will require huge radiators instead of fans, and AI chips need shielding from cosmic radiation
  - SpaceX, Google and Lonestar have plans for orbital data center initiatives

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Fixed wireless services



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Fixed wireless services
Introduction

- Fixed wireless services – wireless communication devices or systems used to connect two fixed locations with a wireless link
- Until recently, fixed wireless was used primarily to provide services in rural and other difficult-to-serve areas
- In some cases, a wireless connection could be the only option for high-speed communications
- Can be used to provide special access, local exchange voice service, interconnected VoIP service and broadband transmission service
- But what about now?

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Fixed wireless services
Merging with 5G technology

- Industry shift from a temporary service to a legitimate broadband alternative, making 5G fixed wireless mainstream
  - Speeds of 300 to 500+ Mbps are becoming common in well-engineered deployments
  - Carriers are using midband spectrum (2.5 GHz, 3.5 GHz, C-band) for a balance of coverage and capacity
  - Premium fixed wireless tiers are emerging, offering higher performance and business class options

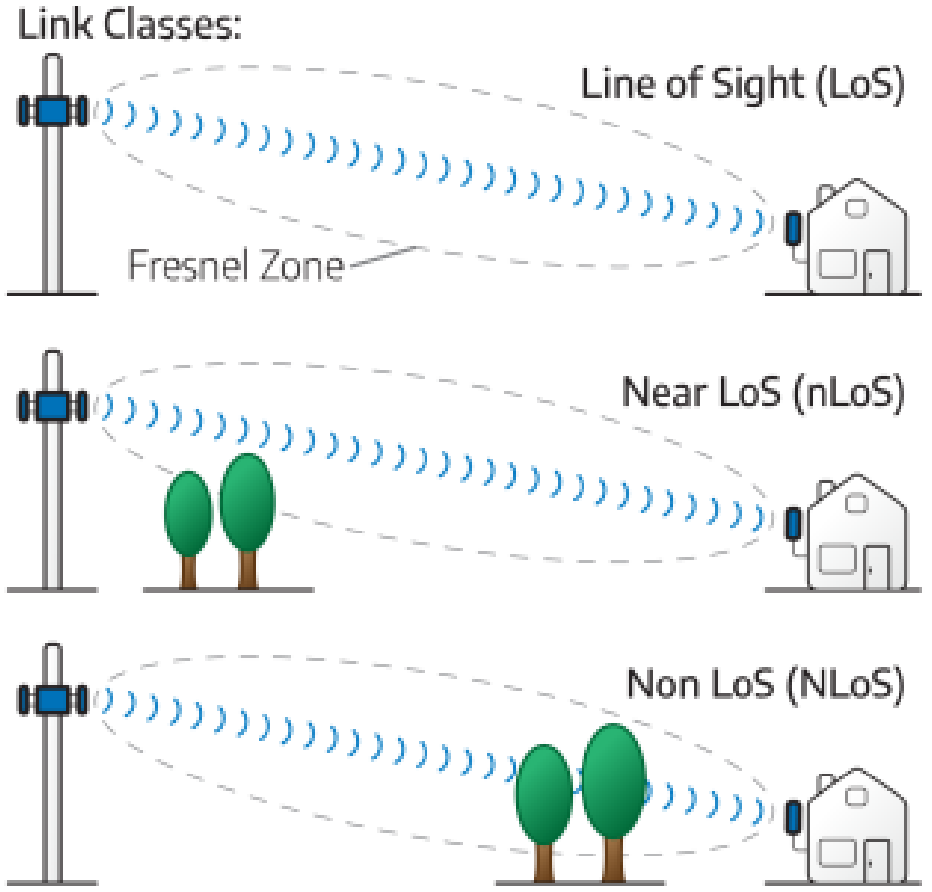


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Fixed wireless services
Not your old line-of-sight technology

- Near line-of-sight systems are breaking into rural coverage
  - Use advanced beamforming
  - Employ better antenna designs
  - Improve signal recovery and interference mitigation
  - Reduce the impact of trees and terrain

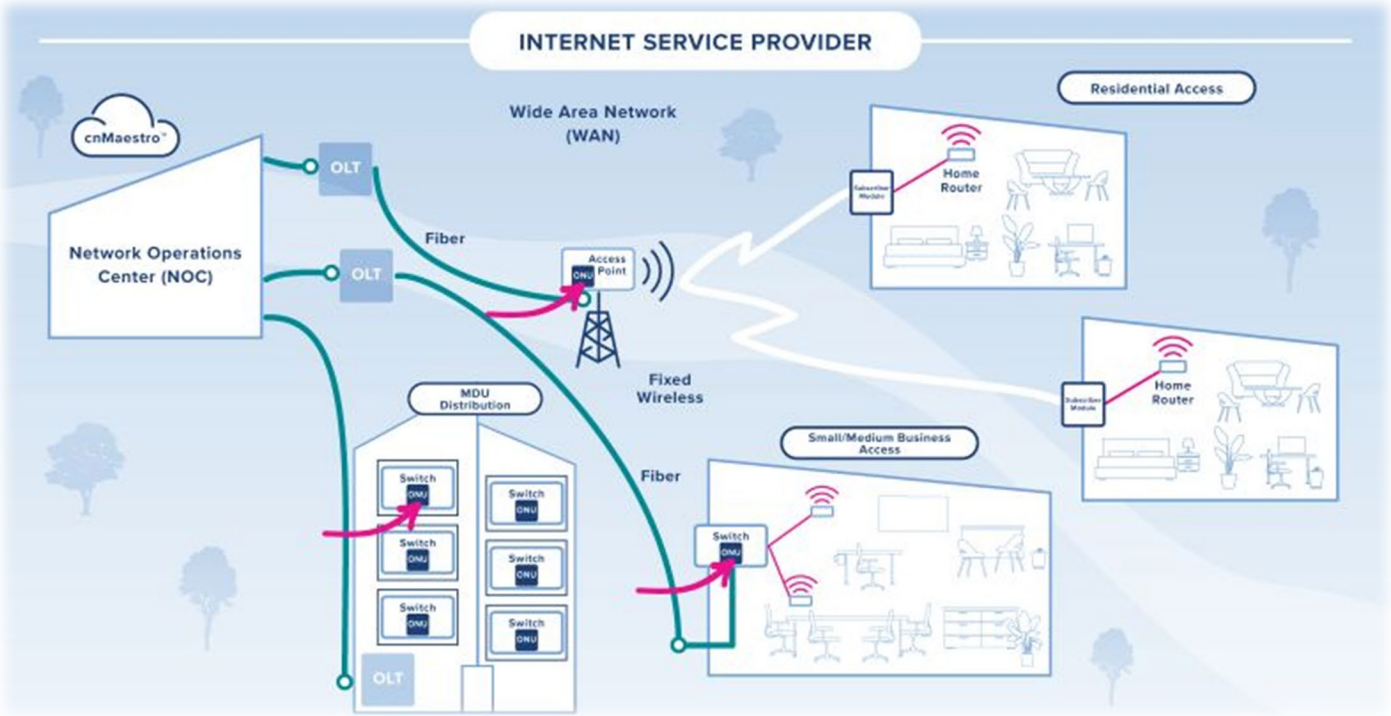


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Fixed wireless services
Hybrid networks mesh technology

- Wireless and fiber hybrid working together
  - No longer one or the other
  - Use fixed wireless for rapid expansion
  - Use fiber where density supports it
  - Leverage fixed wireless as an interim solution before deploying fiber to the home



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Fixed wireless services
Creating a well-rounded customer experience

- Wi-Fi 7 changing the customer experience with:
  - Multilink operation
  - Lower latency
  - Better multidevice performance
  - Channel widths up to 320 MHz
  - Speeds approaching 46 Gbps in ideal conditions
- Wi-Fi 8 expected to be finalized by 2028
  - Peak rate of 23 Gbps
  - Ultrahigh reliability



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6G wireless

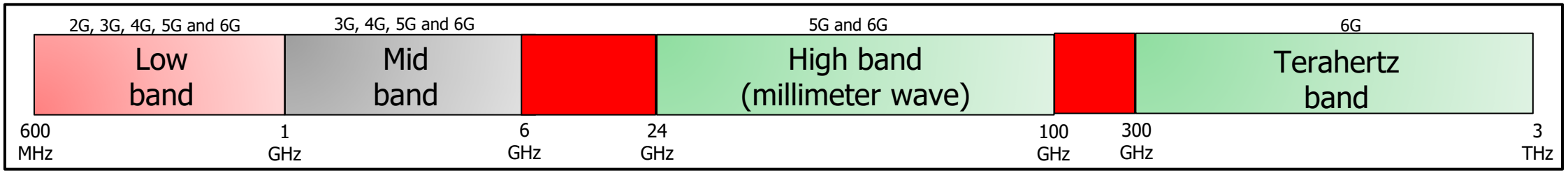


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6G wireless

- 6G, referring to sixth generation, is the next evolution of fixed and mobile wireless communication technology, anticipated to succeed 5G
- Anticipated speeds exceeding 1 terabit per second
- Extremely low latency
- Massive connectivity
- Will utilize terahertz frequency bands, providing huge data carrying capacity



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6G wireless
Challenges

- THz band may only be suitable for very short distances
  - Signal attenuation in the THz band is extremely high
  - Will likely require densely deployed small cells – MIMO
- Will likely require very high energy usage to boost signal strength
- Hardware limitations – designing efficient transceivers, antennas and amplifiers capable of operating at THz frequencies is a significant challenge
  - New, more complex handsets will be needed to use 6G



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6G wireless
When?

- The United States, China, European Union, South Korea and Japan all have government-led programs working on the development of 6G
- Technology giants like Samsung, Nokia and Apple are all researching aspects of 6G deployment
- Anticipated timeframes
  - Research and standardization efforts continue through 2027
  - Early deployment and commercial rollout during 2028-2030
  - Widespread commercial deployment begins 2030
  - Large scale deployment in a global quantum internet begins 2040

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Li-Fi developments



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Li-Fi developments



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Li-Fi developments

- Light fidelity – a wireless communication technology that uses light waves, typically from LEDs to transmit data
- Li-Fi operates similarly to Wi-Fi but with light instead of radio waves
- Li-Fi enables fast data transfer by using visible light communication, providing significantly higher speeds compared to traditional Wi-Fi
- Li-Fi can be used to deliver broadband internet access by expanding wireless communication into various areas where Wi-Fi might struggle
- Compared to Wi-Fi, Li-Fi is faster, more secure and creates no interference
- Implementing Li-Fi necessitates the installation of compatible LED lighting systems equipped with data transmission capabilities and LoS requirements

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Summary

- The future of computing and technology show major signs of continuing to grow and advance
- The next few years should prove to be interesting, with several of these technologies in the testing stages now
- Opportunities are available for rural telecommunications providers
- Like everything, there are some pros and cons, but knowledge is the key to seeing how this works with your networks

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Acronyms

AI	Artificial Intelligence
FCC	Federal Communications Commission
Gbps	Gigabits per Second
GHz	Gigahertz
IoT	Internet of Things
LEC	Local Exchange Carrier
LED	Light-emitting Diode
LEO	Low Earth Orbit
Li-Fi	Light Fidelity
LoS	Line of Sight
MCF	Multicore fiber
nLoS	Near Line of Sight
NLoS	Non Line of Sight
NECA	National Exchange Carrier Association
Wi-Fi	Wireless Fidelity

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