
5G

Building communication infrastructure for universal access

The future of connectivity is not just about bandwidth and faster download speeds, but about universal coverage, better access, and higher performance

Harshal Bhalerao, Mahesh Kelkar, Duncan Stewart, and Karthik Ramachandran

KEY TAKEAWAYS

- **Internet penetration and coverage have improved over the past two decades.** The United States has made rapid strides in developing the communication infrastructure for the future by accelerating urban and rural broadband buildout and accelerating the coverage of wireless technologies like 5G fixed wireless access and low Earth orbit (LEO) satellite-based connectivity.
- **The sticky last-mile access and coverage problem still persists.** The government continues to chip away at the problem by providing federal funding and using the Federal Communications Commission's legacy equitable access programs.
- **Embrace cross-sector partnerships for infrastructure buildout.** Partnerships between the public and commercial sectors can help accelerate broadband infrastructure deployment, especially middle-mile infrastructure development, to benefit local businesses, communities, and governments.
- **Identify new ways to measure the maturity of the US communication infrastructure.** There's a need for a communication infrastructure index that can evaluate the maturity and progress of the US communication infrastructure. Such a tool can help governments make data-driven decisions on grants and identify areas to stimulate innovation and competition. Moreover, it could help commercial providers showcase their investments in advancing the US communication infrastructure.

The internet's origins trace back to the 1960s, emerging from a need for government researchers to share information efficiently. From early computer networks like Advanced Research Projects Agency Network to Transmission Control Protocol/Internet Protocol (TCP/IP) to wireless high-speed networks like 5G, the technology has come a long way, establishing its status as a modern-day fundamental need.

It has also facilitated global advancement, allowing developing countries to leapfrog years of growth and development. The United States has played a leading role in the initial development of the internet and other communication technologies. Furthermore, American technology companies had a significant role in creating hardware, software, and online experiences that enhanced their leadership in digital connectivity infrastructure and the digital economy.

With all the advances in the last few decades, there is a need to strengthen the communications infrastructure further. Federal investments could help stimulate innovations and accelerate the deployment of various connectivity technologies. As government leaders develop and execute their connectivity plans, they should focus on the communication infrastructure requirements of individuals and the broader market.

Individual connectivity needs: The United States has improved internet penetration measures, but the persistent last-mile connectivity issues remain.[1] Internet access isn't just about availability; more efforts are needed to improve affordability and adoption.

Hyperconnectivity needs: From smart factories to fast-moving drones, from connected agriculture to smart grids, the need for deeper and wider coverage will increase. We are entering a phase that demands a connectivity infrastructure that provides *everything everywhere, all at once*—wide and reliable coverage, security at scale, interoperability, energy efficiency, and sustainability.

Apart from these needs, governments often have distinct connectivity requirements to perform security, emergency management, and national defense tasks. So, what's the current state of communication infrastructure, and what role can the government and other ecosystem stakeholders play in developing it in the future?

What's now: America is on a strong footing to plug the digital access gap and get ready for a hyperconnected future

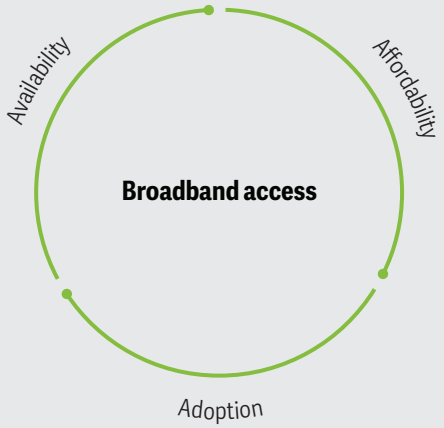
Broadband penetration is growing, and so are the options to access the internet, yet a sticky last-mile digital access divide persists

Most consumers in the United States today rely on cable- or fiber-based wired connections in the home. Similarly, there is growing coverage of 5G fixed-wireless access, which could offer comparable performance to some of the wired broadband connections we have today and provide connectivity to 10% to 12% of US households by 2027.[2] The Low earth orbit (LEO) satellite providers have also shown healthy growth in the United States, not just in hard-to-reach areas.[3]

The United States is also among the top countries with the most internet users in the world among large developed economies—about 96% of the US adults had access to the internet in 2024.[4] However, digital access is much more than internet use. Other factors that should be considered are whether the internet is readily available at home, at work, or in a geographic area, whether it is affordable, and whether residents are ready to adopt it (figure 1).

Figure 1

Broadband access is a function of availability, affordability, and adoption



Source: John Cassidy, Harshal Bhalerao, John O'Leary, Mahesh Kelkar, and Brad Hunt, "Closing the digital divide," *Deloitte Insights*, December 1, 2021.

The home broadband gap between rural, urban, and suburban households has narrowed considerably over the past decade (figure 2). The data also shows that rural home broadband usage has increased from 2018 onward, possibly due to targeted state and private sector investments in rural broadband infrastructure.[5] However, more work needs to be done to improve internet use and access across income and education levels.[6]

The third iteration of the Federal Communications Commission (FCC) National Broadband Map shows a decline in the number of unserved homes and businesses.[7] The new data from November 2023 shows that just over 7.3 million locations lack access to high-speed internet service, down from 8.3 million in May 2023.[8] The unserved locations are still significant, but the gap is narrowing.

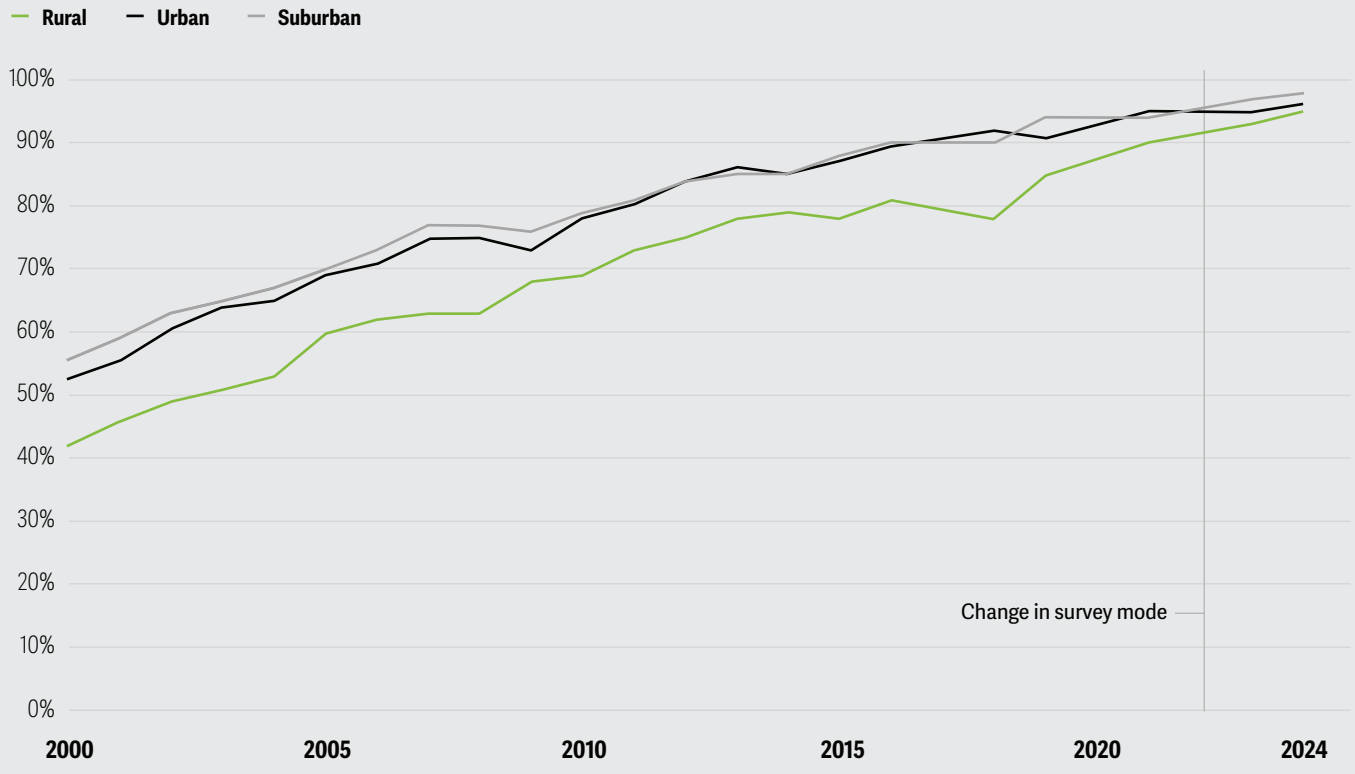
A changing market and regulatory demand for broadband speeds

For the past century, electrical power grids were built to supply power one way to consumers, but now they have changed to enable consumers to return extra power from off-grid power sources back to the grid. Likewise, the internet was also designed to optimize download speeds.

Figure 2

Rural internet access has improved consistently since 2018 and has caught up with urban and suburban areas

Percentage of US adults who say they subscribe to home broadband, by community type



Source: Pew Research Center.

The era of fast-growing bandwidth demand may be nearing an end (or at least slowing down) as changes in technology and consumer behavior indicate a near-term leveling off.[9] Research suggests this has partly been influenced by changing household composition and the corresponding needs of such households. In the United States, in 2022, the average size for family households (a third of the total) was 2.5, down from 2.6 in 2010. Of the rest, the average family size was only 1.25, with 37.9 million households (or 29% of the total) being single-person occupied. This affects the bandwidth demand in an average household.[10]

Governmental incentive programs and regulatory requirements have also sought to bridge the digital divide with minimum speed requirements. In March 2024, after almost eight years, the FCC increased the minimum broadband speed standards to 100/20 Mbps (download and upload speeds) from 25/3 Mbps.[11] It also raised the minimum speed criterion for 5G New Radio (5G-NR) to 35/3 Mbps. Based on this new criterion, about 45 million Americans today lack access to both 100/20 Mbps broadband services and 35/3 Mbps mobile 5G-NR service.[12]

This new benchmark is already having downstream effects on how digital access is measured and future funding for the connectivity infrastructure is allocated. To plug the rural 5G gap, the FCC has created the 5G Fund for Rural America (5G Fund) which will use a multi-round reverse auction to distribute about US$9 billion to bring voice and 5G mobile broadband service to rural areas. Moreover, the communication infrastructure in the future could offer more than just speed, such as more reliability, quality, improved sustainability, and lower latency.

5G evolution can be transformative and drive hyperconnectivity

5G looks to usher in an era of new, distinct use cases. Some of them will likely see the light of the day quicker than others, depending on the evolution of 5G's capabilities, adoption challenges, and economies of scale (figure 3). For example, enhanced mobile broadband, one of the first applications of 5G, has been improving mobile internet speeds in dense urban areas. This was an attractive starting point for service providers aiming to generate early revenue and for device manufacturers introducing 5G-enabled smartphones.[13] To do this, mobile network operators implemented 5G wireless networks on their existing 4G long-term evolution core networks, called non-standalone.

However, to fully utilize some of 5G's advanced features, a complete migration to standalone networks is necessary. These advanced networks, unlike the initial non-standalone setups, are built entirely on 5G technology and are crucial for enabling two significant applications: massive Internet of Things and ultra-reliable low-latency communication. The massive Internet of Things will enable a very high density of connected devices, and the ultra-reliable low-latency communication will support high network reliability and ultra-low latencies.[14] That said, many carriers, both in the United States and globally, have been slow to roll out 5G standalone networks, suggesting the demand for these two features is still nascent.

The next iteration of 5G technology—5G Advanced—is expected to be developed and released between 2024 to 2025. It offers a number of improvements over 5G (releases 15, 16, 17, and 3GPP), supporting much-improved network energy efficiency, artificial intelligence/machine learning radio access network (RAN) automation, extended reality (virtual reality, augmented reality, mixed reality, etc.), and more advanced multiple-in multiple-out (MIMO antenna technology that multiples the capacity of a radio link)—and may delay or even obviate a move to 6G in the next decade.[15] The evolution of 5G technology has the potential to drive advanced applications across a wide range of sectors, including health care, mobility, energy, smart cities, and much more (figure 3).

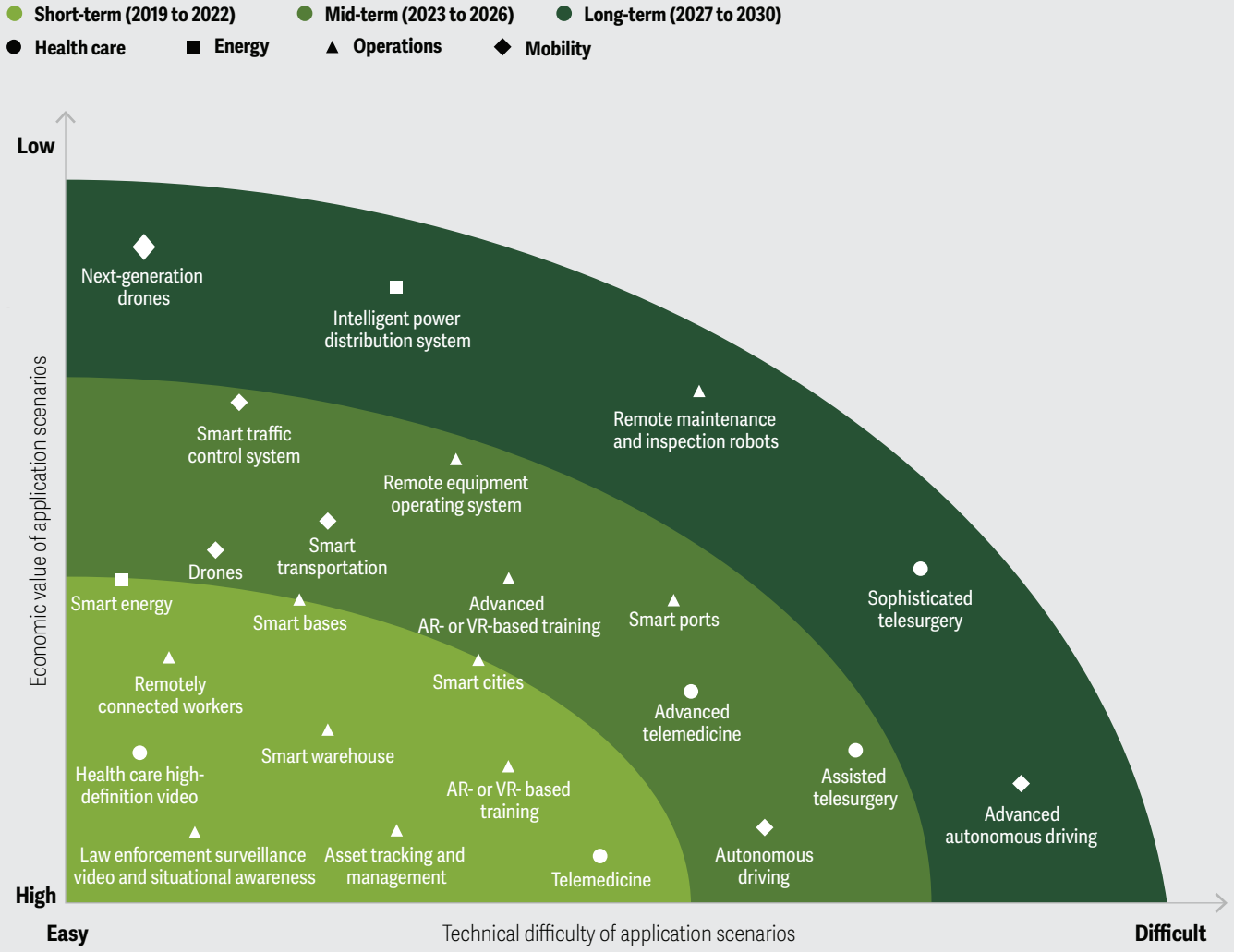
Focused investments can help strengthen supply chains and improve social outcomes

National Telecommunications and Information Administration funding can help strengthen supply chains and drive down costs of wireless connectivity

In the 1990s, there were more than a dozen large companies globally that made RAN gear. There are now only a handful that have more than 90% of the market.[16] Moreover, declining global spending on wireless infrastructure suggests that we may see even fewer suppliers

Figure 3

Some use cases will be deployed quicker than others depending on how 5G technology matures



Note: AR refers to augmented reality and VR refers to virtual reality.
Source: Deloitte analysis.

due to vendor consolidation.[17] To complicate matters further, most RANs are closed ecosystems. However, there is a slow but definitive shift toward multi-vendor open RAN architectures, which could help deepen supply chain alternatives in the RAN market.[18]

To encourage this trend, the federal government, through the CHIPS and Science Act, has established the Public Wireless Supply Chain (Innovation Fund), a $1.5 billion fund for ten years. The NTIA is responsible for using the fund to support wireless innovation, competition, and supply chain resilience by enabling smaller companies from the United States and partner countries to participate.[19]

The NTIA has awarded a series of grants totaling $140 million in its first round of projects under the Innovation Fund. The latest $42 million grant project funds a consortium of US carriers, foreign carriers, universities, and equipment suppliers to establish a testing, evaluation, and research and development center in the Dallas Technology Corridor and a second facility in Washington, DC.[20]

A robust connectivity infrastructure is needed to improve social outcomes and sustain digital acceleration

The COVID-19 pandemic made digital transformation a necessity, sparking large-scale innovations across education, health care, public services, and many other sectors. Sustaining digital acceleration will be important, as digital access has the potential to improve social outcomes for citizens.

Improving economic opportunities

The World Economic Forum's "Future of jobs report 2023" gives a glimpse into how better digital access can positively influence the job outlook for the coming years. It reports that expanding digital access can create a net positive impact (difference between jobs created and displaced) of 34% in the global job market—and an expected net positive impact of 42% in the United States.[21]

Numerous other studies around the world show how the internet or digital access increases economic opportunities. Research indicates that internet use and access affect employment, gross domestic product per capita, and total factor productivity. Moreover, digital access offers ways to keep up with current trends, learn and train on new skills, and help find new types of professions.[22]

Improving education attainment and outcomes

There are multiple studies and research that have shown a positive correlation between increased success rates in minorities in K-12 education when provided with digital access to computers, internet, mobiles, and social media.[23] Access to the internet can also help improve the quality of education by opening up access to a wealth of information, knowledge, and educational resources, as well as improved opportunities to learn beyond the classroom. Similarly, it can enable educators to use online resources to prepare lessons, explore interactive teaching methods, provide more attention to individual students, and support shared learning.[24]

Driving virtual health adoption in underserved populations

Virtual health (or telehealth) can help enable health access for consumers without having to travel, find someone to look after the kids, or take time off work. However, having dependable internet access is not always easy. Various studies have shown mixed results for underserved populations, some showing better access to virtual health and others showing a digital gap. Deloitte's survey of US health care consumers found a clear gap in virtual health access between consumers with good or reliable (46%) and poor or unreliable (31%) internet service.[25]

Health care organizations can work with local governments, utility providers, and businesses in their community (such as shopping centers, schools, shelters, libraries, and pharmacies) to offer free Wi-Fi and digital devices that can be used for virtual health services to reduce the digital gap. For example, the Texas A&M Health Science Center worked with OnMed to put kiosks in a rural Texas community to check patients' vital signs, dispense common medications and enable on-demand video visits with a nurse practitioner.[26]

Other federal programs aim to reduce the connectivity gap in rural and hard-to-reach areas. FCC's Rural Health Care Program, funded through the Universal Service Fund, focuses on funding voice and data services through the telecommunications program and broadband services using the Healthcare Connect Fund program.[27]

Government can explore a variety of ways to improve universal access and coverage

You can't manage what you don't measure: The need for a Communication Infrastructure Index

So how can we assess the development and advancement of a country's communication infrastructure?

Some parts of the ecosystem have been measured by the government in the past. As previously mentioned, the FCC's National Broadband Map provides granular details about unserved and underserved locations in the United States.

The broadband map is a useful starting point to know about the areas in the United States that have inadequate or no broadband services. But how can other vital parts of the ecosystem be measured, such as the impact of government grant programs, the level of competition and concentration in local and hyperlocal markets, internet performance and output, reliability, spectrum availability, consumer satisfaction, and many more?

There is a need for a *communication infrastructure index* that can evaluate the maturity and progress of US communication infrastructure.[28] It could be a valuable tool to measure different factors, such as the availability, affordability, reliability, and adoption of services. The tool can help governments make data-driven decisions on grants and identify areas to stimulate innovation and competition. Moreover, the index could provide commercial communication service providers a way to showcase their investments in advancing the US communication infrastructure.

Develop a portfolio of options to improve coverage and reliability

Governments have a critical role to play in catalyzing new wireless technologies such as LEO satellite-based internet for semi-urban and rural settings. While fiber-based internet seems to be the primary connectivity technology explored in multiple states, advances in technology will make high-speed wireless internet connections technically and economically viable across many areas in this decade.

LEO satellites, for instance, are creating new ways to connect. In 2024, more than 5,000 satellites were in LEO, and that number is expected to rise exponentially in the coming years.[29] Satellites can make high-speed connectivity in rural and mountainous regions feasible. In 2020, for instance, the Hoh tribe of western Washington lacked adequate internet.[30] The tribe reached out to the state, which connected them with SpaceX's Starlink team to discuss accessing its new LEO-based internet service. The timing was good since Starlink was planning beta trials for that region, so the company provided early access to the Hoh tribe.[31]

Satellite and mobile network operators should work through the appropriate agencies—for things like spectrum allocation, orbital slots, and landing rights (permission for satellite services in a country). For example, the FCC has worked to enable satellite and mobile network operators to collaborate more easily. It recently approved a regulatory framework to allow satellite operators to apply for access to excess spectrum controlled by mobile network operators.[32]

Partner to achieve connectivity infrastructure buildout

Private industry has an interest in infrastructure buildout, and this can set up a win-win scenario for broadband expansion, with local communities gaining benefits from private sector initiatives.

States can work with technology firms to expand their connectivity infrastructure. In West Virginia, Indiana, Ohio, Iowa, and Nebraska, for example, Meta's subsidiary Middle Mile Infrastructure is laying hundreds of miles of fiber-optic cables to connect the company's data centers. The company plans to lay approximately 275 miles of fiber-optic cable through West Virginia's western border and another 160 miles of fiber infrastructure in Indiana along the Interstate-70 corridor.[33] These buildouts have been possible through continual efforts and coordination between state agencies, state legislature, federal agencies, and Meta.[34] While Meta will use the infrastructure to connect its data centers, its excess capacity can be used by local and regional broadband providers to improve access in previously unserved areas. Similarly, in October 2023, the California Department of Technology announced a partnership with Lumen Technologies, Inc. to build 1,900 miles of network infrastructure by pulling new fiber using Lumen's existing conduit.[35]

States can accelerate broadband deployment by partnering with other industries. In 2020, for example, the New Mexico Department of Technology created a $5 million public-private partnership with ExxonMobil Corporation and a regional internet service provider to build a 107-mile fiber infrastructure connecting ExxonMobil's fields. As with the Meta buildout, this new infrastructure will help ExxonMobil improve its operations while providing high-speed internet to local businesses, governments, and residents.[36]

Achieving universal access

The pandemic increased the need to expand broadband access. Federal investments are expected to create many opportunities for state, local, and the private sector to work together and greatly increase broadband access in the future. However, a comprehensive approach toward broadband access should address all three As—availability, affordability, and adoption. Availability will get better with infrastructure development and wider coverage, and there is a need to shift focus toward affordability and adoption. The last-mile problem persists—it's usually the last house or the last neighborhood that's the hardest to reach—and it is important for broadband expansion to enhance connectivity in unserved and underserved areas.

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