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The Evolution Toward 5G-A and New Telco Business Models

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Summary

Mobile and fixed broadband networks are rapidly evolving to 5G-Advanced (5G-A) networks and gigabit services. Such networks are capable of multi-gigabit speeds, ultra-low latency and jitter, with deterministic reliability and consistency. These networks will also be fully autonomous with much higher connectivity and sensing capabilities.

The capabilities of 5G-A networks will enable a new generation of connected devices and Internet applications. They will transform how we, as consumers, live our daily lives, as well as how businesses function and operate. However, creating such networks requires significant investment on behalf of network operators, and operators will look for a return on that investment. This report explores how—by matching their strengths to customer buying priorities—5G-A network capabilities will lead to new successful telco business models.

Key messages

- Mobile 5G and fiber-to-the-home (FTTH) network deployments are now well underway in many countries, and the industry is actively working on further enhancements of such technologies. The 3GPP organization has officially adopted 5G-A, and the European Telecommunications Standards Institute (ETSI) is launching its own study on Fixed 5th Generation Advanced (F5G-A). The mobile and fixed broadband industries are, therefore, now on a converged journey toward 5G-A evolution. Such networks will be capable of:
  - Multi-gigabit speeds
  - Lower latency and jitter with much higher levels of reliability and consistency
  - Greater operational efficiency
  - Intelligent monitoring and decision-making autonomy
- In the consumer broadband space, networks have evolved massively since their first launches in the late 1990s and early 2000s. However, continued evolution is critical if these networks are to be able to support the devices and applications of the future. The following are three distinctive, but related, key trends that will drive greater demands on the network:
  - A rapid increase in the number, type, and capability of connected devices
  - A continued move to higher quality, immersive media experiences
  - The creation of the next generation of internet applications based on a cloud-first strategy
- Such technological advancements will enable new consumer use cases and experiences, such as fully immersive applications, glasses-free 3D video, and high-quality entertainment anywhere and everywhere.
- Enterprises have also quickly embraced digital technology and ways of working, and their capacity needs are expected to increase exponentially over the next five years.
- As businesses embrace digitalization, they generate, collect, store, and analyze much more data. They gain new insights that help them make faster and better decisions. Key technology and market forces for this digital revolution include:

  - IoT probes and smart devices that collect ever-larger amounts of data from sites and from the field
  - Network connectivity that is universal, cost-effective, and supports collection and transfer of large data loads
  - The cloud revolution, which has made storing, accessing, and processing large data loads efficient and cost-effective
  - Analytics and automation, backed by artificial intelligence (AI)/machine learning (ML) and natural language processing, which converts large volumes of data into useful information

- Technology-leading enterprises have a vision of continuous chains of automation. Whether workflows are handled automatically or with human intervention, AI working in real-time is driving better interactions and decision-making.

- Networks are key to this digital foundation. Rising client expectations put network providers under constant pressure to do better, requiring the service quality and value enabled by 5G-A.

- Network operators will need to choose their optimal market strategy and business models. Omdia has set out the following four trends we expect will be key provider strategic focus over areas the next five years:

  - Network as a service
  - Zero-touch customer lifecycles
  - Edge-driven ecosystems
  - Carriers as a commodity

The broadband roadmap to 5G-A

Since the massive rollout of 5G New Radio (NR) and Fixed 5G (F5G) technologies, the global telecom industry has started working on further enhancements of these technologies. In April 2021, 3GPP officially adopted 5G-A as the new marker for 5G evolution and formally kicked off Release 18 (the first release of 5G-A standards) at the end of 2021. In September 2022, ETSI released its F5G-Advanced and Beyond whitepaper to launch the study on F5G-A. This puts mobile broadband and fixed broadband industries on a converged journey toward 5G-A.

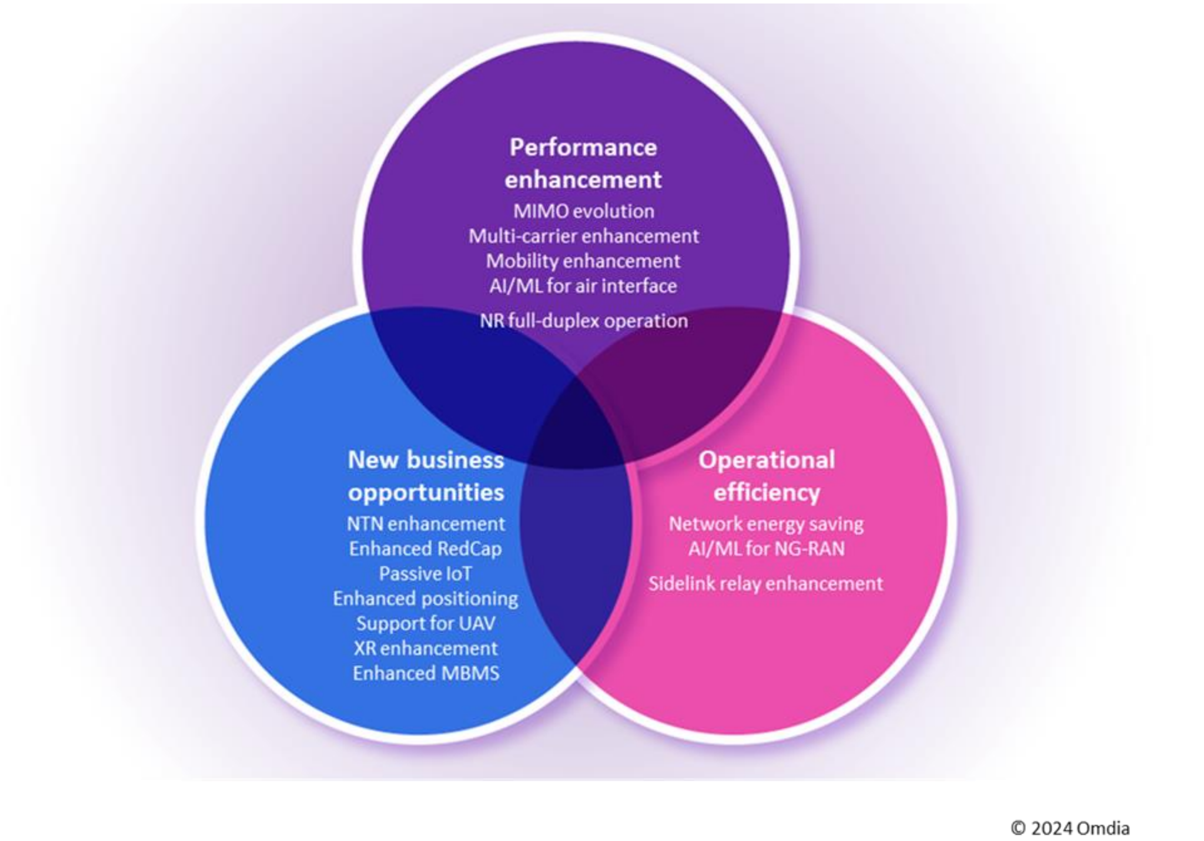
3GPP has completed three major releases for the 5G NR system. After the initial Release 15 standard, Release 16 and 17 continued to improve 5G system capabilities while expanding 5G into new devices, applications, and deployments. The 5G-A standardization will kick off another wave of 5G innovation. This effort will also include three releases, such as Release 18, 19, and 20. Release 18 standards will be completed by early 2024, and Release 19 will be launched at the beginning of 2024. Release 20 will be the last 5G-A standard and the first 6G release. 3GPP plans to kick off 6G studies in Release 20 in 2025–26.

5G-A standards will enhance 5G systems in multiple aspects, including:

- Improved capacity, coverage, and user experience, particularly improved uplink performance and reduced latency
- New services and support for new types of devices, such as extended reality (XR) applications, support for unmanned aerial vehicles (UAVs), enhanced positioning, and passive Internet of Things (IoT)
- Improved operational efficiency and lower operational costs through AI, ML, and new architecture options

Figure 1 shows the 5G-A features specified in Release 18. Because some of the 5G-A features will also be 6G candidate technologies, such as non-terrestrial networks (NTN), passive IoT, and precise positioning, the deployment and operation of 5G-A systems will also help mobile operators in the evolution to 6G rollouts.

Figure 1: 5G-A features in 3GPP Release 18



Source: 3GPP and Omdia

In the fixed broadband sector, ETSI established the F5G industry specification group in 2020 to promote "fiber to everywhere and everything" and enable the "twin digital and green transition." By 2022, the F5G group has formally released seven standard publications and two white papers. It is now moving to a new phase of F5G-A.

In its F5G-Advanced and Beyond white paper, the ETSI F5G group gave objectives of the F5G evolution:

- Faster: Increasing bandwidth
- Quicker: Reducing latency
- Wider: Increasing the network scope and number of endpoints
- Greener: Enhancing energy efficiency

- Smarter: Integrating computing
- More Aware: Improving network operations, leveraging new services
- More Trustworthy: Addressing network and data security and privacy

To meet these objectives, various technologies from broad perspectives have been studied in the F5G-A framework, including 800G+ OTN, 50G-PON, fiber-to-the-room (FTTR), fiber-to-the-machine (FTTM), end-to-end slicing, and network-based sensing.

The evolution of fixed broadband technologies is echoed by the World Broadband Association (WBBA). The WBBA is a multilateral, industry-led association that provides leadership for digital broadband across the next decade. **Table 1** shows the broadband generation characteristics and roadmap defined by WBBA in its *Next Generation Broadband Roadmap* white paper.

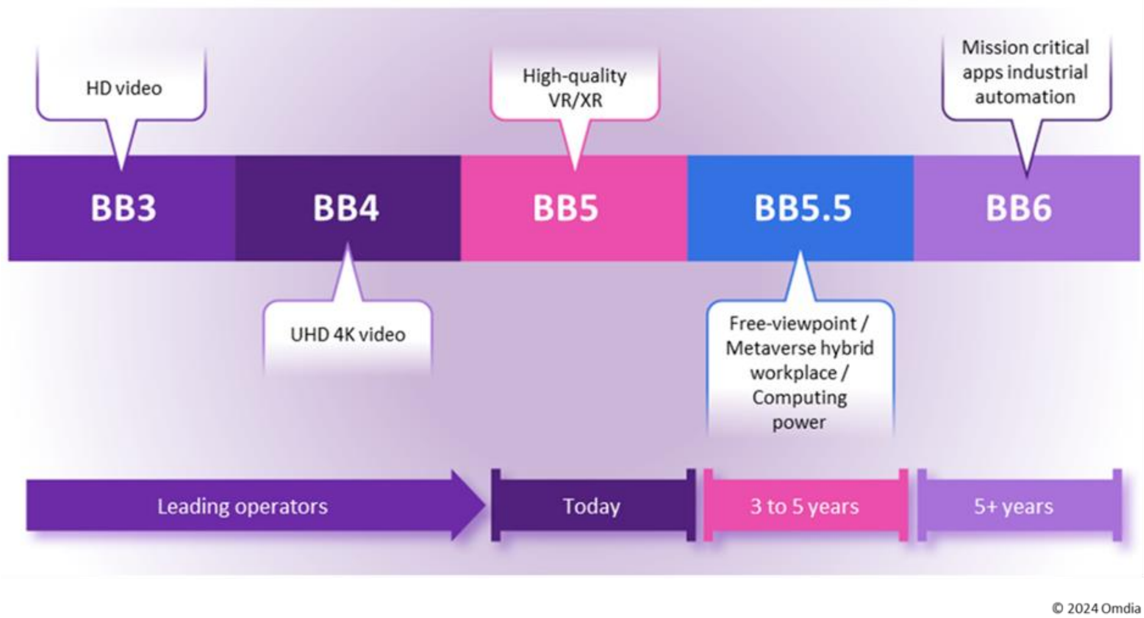
Table 1: Broadband generation network characteristics

	BB3	BB4	BB5	BB5.5	BB6
Residential speed	Up to 30Mbps	Up to 100Mbps	Up to 1Gbps	Up to 10Gbps	Up to 50Gbps
Enterprise speed	Up to 1Gbps	Up to 10Gbps	Up to 100Gbps	Up to 400 – 800Gbps	Up to 1.6 – 3.2Tbps
Intelligence	No automation	Partially autonomous (L2)	Conditionally autonomous (L3)	Highly autonomous (L4), fast provisioning times	Fully autonomous
Reliability & latency	99.9% / n/a	99.99% / 10ms	99.999% / 5ms consistent latency / low jitter	99.999% / 1ms latency (hard guarantee) / very low jitter	Deterministic reliability / <1ms latency (hard guarantee) / very low jitter
Trustworthy & green	n/a	2× better per bit energy efficient	5× better per bit energy efficient	10× better per bit energy efficient, fast problem detection and response (minutes)	10×-plus better per bit energy efficient, very fast problem detection and response (seconds)
Connectivity	Copper to the home	Fiber to the home	Fiber to the room/desk, slicing in Gbps granularity	Fiber to the machine, fine granular (Mbps level) slices, 10 times IoT connections	Fiber sensors, 10 times more IoT terminals
Sensing capabilities	n/a	n/a	n/a	Sensing for optimized O&M, application and computing awareness, AI	Fiber sensing for applications, application and computing awareness, AI

Source: WBBA

The evolution of mobile and fixed broadband technologies enables communications service providers (CSPs) to meet growing traffic demands and support new types of applications, from video to the Metaverse and beyond (**Figure 2**).

Figure 2: Broadband generation roadmap with reference applications



Source: WBBA and Omdia

Future application demand

Consumer technology and application lifecycle

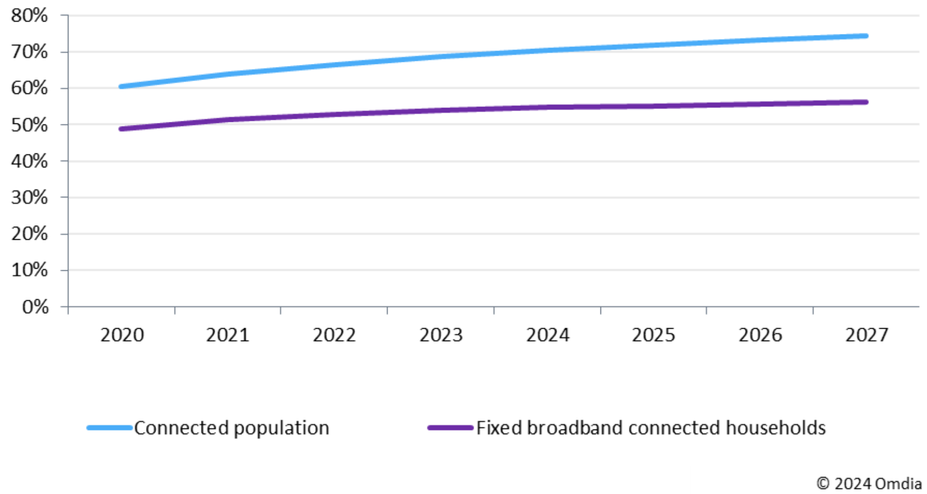
Consumer demand for broadband networks will continue to increase exponentially as we head toward 2030 and beyond. The demand will be largely driven by the following three key distinctive, but related, trends:

- A rapid increase in the number and type of connected devices
- Continued move to higher quality, immersive media experiences
- A next-generation of internet applications based on a cloud-first strategy

Rapid increase in connected devices

As a population, we are becoming increasingly connected. By 2027, 74% of the global population will be connected, and 56% of residential households also enjoy high-speed fixed broadband connectivity (**Figure 3**). In highly developed nations such as China, the broadband penetration of the population over the age of 4 years old will be quickly heading toward 100%.

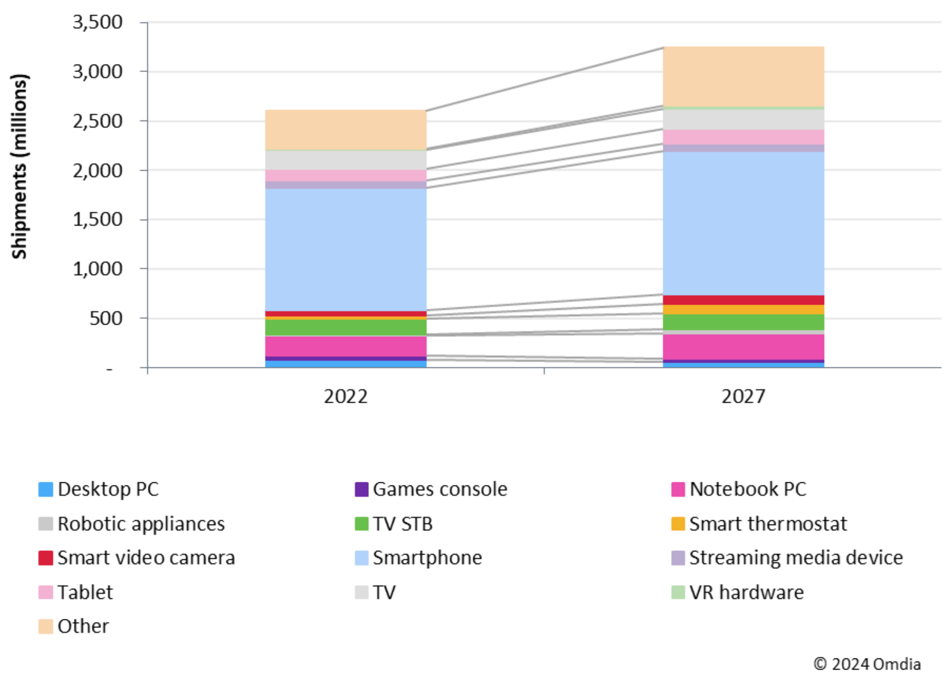
Figure 3: Global connected population



Source: Omdia

However, it is not just people but also things that are becoming connected. There will be an increasing number of connected consumer electronic devices, appliances, sensors, and other items entering our workplaces and homes. By 2027, the total number of connected devices being shipped on a global basis will increase by 25%, with smart home devices and virtual reality (VR) hardware seeing the highest percentage rates of growth (**Figure 4**).

Figure 4: Global connected device shipments, 2022 vs 2027



Source: Omdia

Cars will become entertainment hubs

The home and office are not the only places where people will be connected. Mobile devices, such as smartphones, tablet PCs, wearables, and laptops, keep us connected while on the go. Connected cars are also becoming increasingly common. More than 500 million connected vehicles are expected to be on our roads by 2025. Such vehicles support different types of screens. The following three core categories are designed for, or enable, media consumption:

- Center stack display (CSD): The primary interface for the in-car entertainment system
- Instrument cluster display (ICD): Mainly used for vehicle telemetry, which also can support media information

- Rear seat entertainment (RSE) systems: Media entertainment for rear passengers

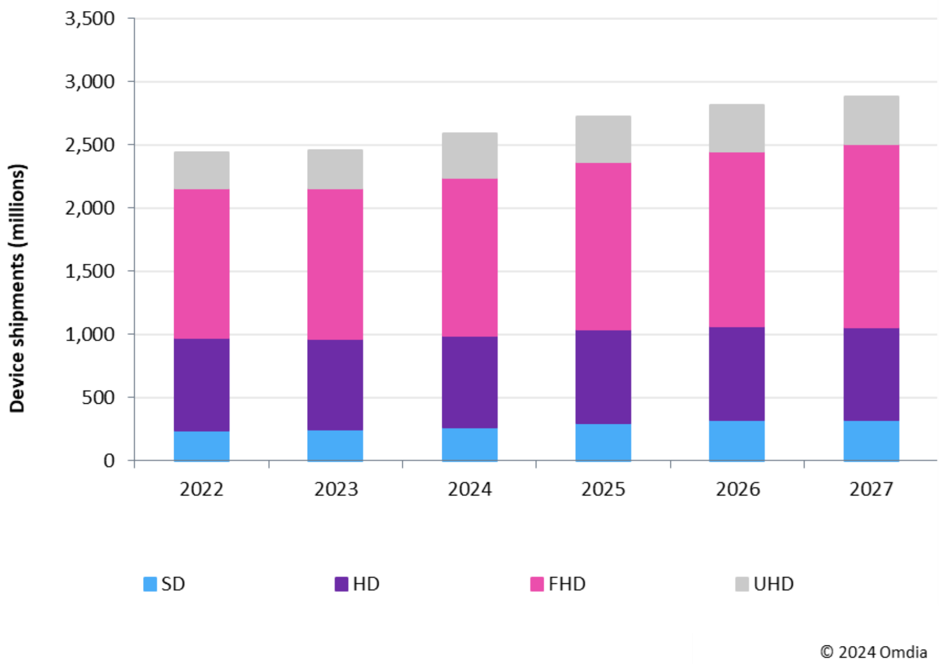
Even in non-connected cars, the use of media screens is common. Smartphone tethered ICDs are used for navigation, communications, and music applications. There are many third-party, after-market entertainment devices to entertain rear passengers. Premium car manufacturers are also adopting in-built connected media screens and entertainment devices. For example, Tesla has installed 17-inch touch panels that support video streaming, internet browsing, and karaoke. Both the number of CSDs and in-built RSE systems shipments (plus 15% and 100%, respectively), as well as their average sizes (plus 15% and 10%, respectively), will continue to grow in 2022–27.

The shift to larger screens and higher quality video

The evolution of the video screen

The number of video-enabled connected devices is increasing, the screens on those devices are getting larger, and they offer higher and higher levels of video quality. By 2027, 61% of all devices shipped will have a screen, and 63% of those screens will be full high definition (FHD) or ultra-high definition (UHD) (**Figure 5**).

Figure 5: Shipments of devices with a screen by resolution



Source: Omdia

The TV remains an important screen in the home and will remain so for the foreseeable future. The modern TV has evolved beyond a simple receiver for linear broadcast video, to a full home entertainment system. In some cases, the TV is even a control hub for the smart home. By 2027, 93% of all TVs shipped will be smart. They will also continue to increase in size and resolution. By 2027 30% of TVs shipped will have screens that measure 60 inches or more, and 76% will have 4K or higher resolution (**Figure 6**).

Figure 6: TV sets will become bigger and support higher resolution

Source: Omdia

Although the TV will remain an important screen in the household, the smartphone is by far the most common. Based on Omdia’s data, the global average number of connected devices per broadband household as of the end of 2022 was 17 (the average broadband home has 3.7 smartphones). Since the launch of the first iPhone in 2007, screens have become a key selling feature for mobile phones. At the end of 2022, 44% of all smartphones shipped had FHD capability, and 2% were based on new foldable technology, increasing the potential display size to as much as 8 inches or more. By 2025, Omdia projects that 11% of smartphones shipped will have foldable capability, and 48% will be FHD.

Coming of age for AR/VR

Today, augmented reality (AR) glasses and mixed reality (MR) headsets are still relatively rare. However, VR headsets are becoming more common, largely driven by the increased investment from organizations, such as Facebook (Meta) and Qualcomm. Apple recently made its first step into MR devices with the launch of its Vision Pro AR/VR headset. With Apple's branding and marketing power—together with its tightly integrated hardware and software—Vision Pro's users will be greeted by familiar user interfaces, apps, and personal content. If the company successfully bridges existing consumer experiences into new immersive environments, it will give fresh impetus to the MR market. The VR/MR headsets utilize multiple FHD video streams per session and rely heavily on cloud-based content and applications. The technology will place heavy demand on broadband networks regarding bandwidth and latency, with high levels of reliability and consistency.

The next wave of 3D video

3D video has seen waves of interest. The most recent was in 2009–12, with the popularity of blockbuster 3D films, such as Avatar, and new 3D enabled TV sets from brands, such as Samsung. The interest has always been relatively short lived, owing to the inconvenience of having to wear special glasses and the depth of perception.

As more VR/MR headsets enter the consumer mass market, they will support 3D experiences for use cases such as gaming. However, there are also other new technologies that will provide a non-glasses-based experiences. Such devices can switch between 2D and 3D, enabling the user to only utilize 3D viewing when they wish. Removing the need for special glasses is another potential step toward enabling mainstream popularity for 3D video.

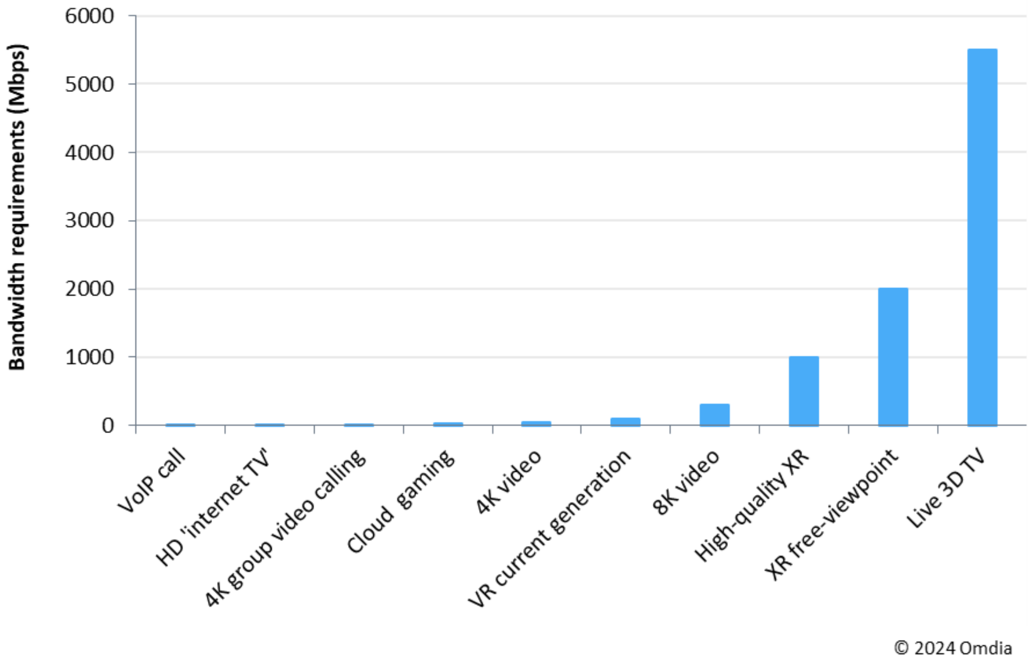
The first generation of glasses-free 3D screen technology, known as glasses-free 3D 'binocular', is relatively mature. Tablets from makers such as BOE and Leia support the technology, and it is expected that BOE will also release a 3D-capable smartphone in 2024. The second generation of glasses-free devices using 'light field' technology is also well under development. Leia has launched its Lume Pad 2, and other companies, such as Google, are launching trial products (Project Starline).

From SD to HD to UHD to 3D

This drive to increased quality video experiences will place higher and higher demand on the network. Today's video streaming services can offer HD video using less than 5Mbps through compression techniques. However, high-quality 4K video streams can require speeds of up to 50Mbps, and 8K video streams require up to 300Mbps.

Advanced services such as VR and 3D TV will see a further step change in terms of network demand. High-quality VR applications can require speeds of up to 1 to 2Gbps per session, and live 3D TV can require up to 5Gbps per stream (**Figure 7**).

Figure 7: Bandwidth requirements for various advanced video applications

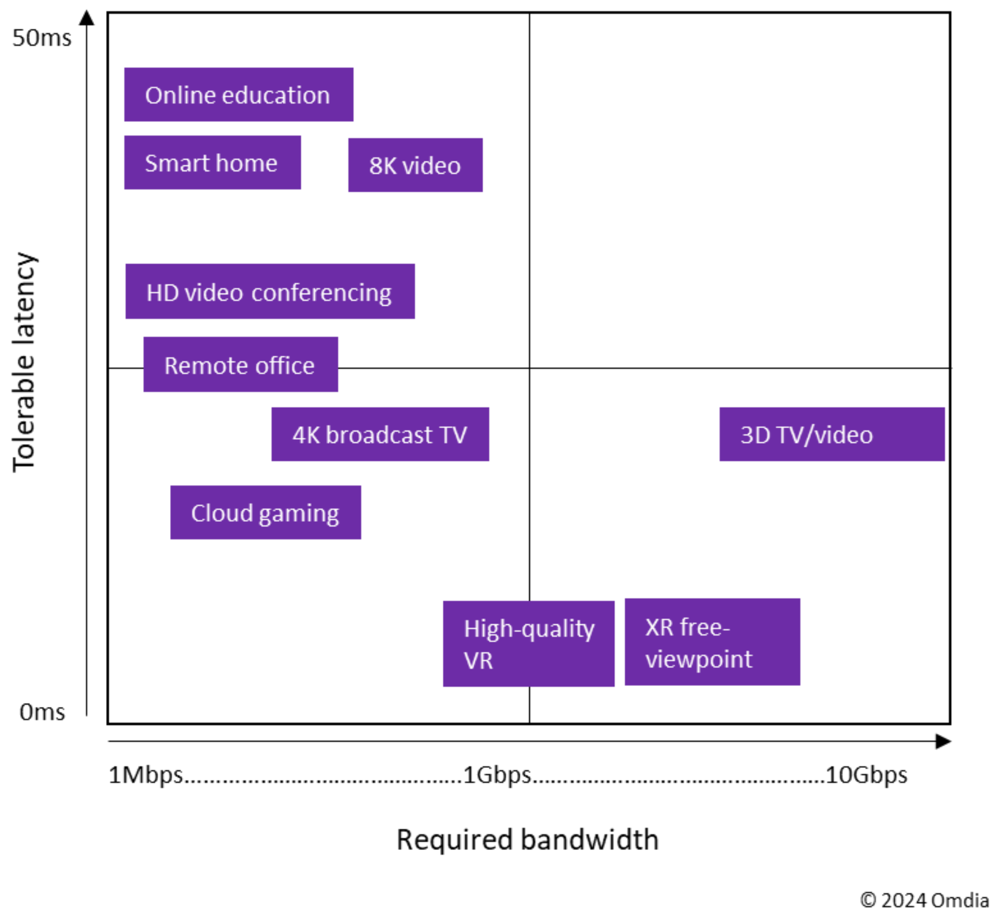


Source: Omdia

Greater reliance on the cloud

Over the years, there has been a push for hosting greater intelligence in the cloud. This has several advantages, including reducing the cost, internal computing power, and battery size of devices. It also allows for the consistent use of the latest software version, and supports advanced technologies, such as big data analytics and new cloud-based applications or use cases. Examples of these applications include cloud gaming, autonomous vehicles, and the metaverse. However, as applications become more interactive and rely heavily on real-time communication, bandwidth and latency and service reliability and consistency, become an increasing priority (**Figure 8**).

Figure 8: Advanced cloud-based applications will place significant demands on the network



Source: Omdia

The trend for global enterprises toward multi-cloud transformation is also increasing significantly. According to the WBBA, the proportion of multi-cloud utilization is expected to reach over 80% by the end of 2023. Furthermore, the computing power of AI is set to expand, making up 46% of total computing capacity by 2025.

The network plays a crucial role in enabling this evolution. In future distributed data center architectures, even small variations in network performance can lead to significant losses in computing power. The future network, therefore, must be capable of application and computing awareness, with deterministic latency and higher reliability.

Enterprise technology and application lifecycle

As enterprises turn to digital technologies and ways of working, their capacity needs will increase exponentially over the next five to seven years. Digital technology is relevant to all businesses. The goal is to collect, store, and analyze data, generating valuable information for the organization to make faster, better decisions.

Technology and market forces have converged to make this digital revolution possible for businesses:

- IoT probes and smart devices collect vast amounts of data from sites and from the field
- Network connectivity is universal, cost-effective, and supports the collection and transfer of large data loads
- The cloud revolution has made storing, accessing, and processing large data loads efficient and cost-effective
- Analytics and automation, backed by AI/ML and natural language processing, organize these large volumes of data into useful information.

The market in low-, medium-, and high-performance IoT applications

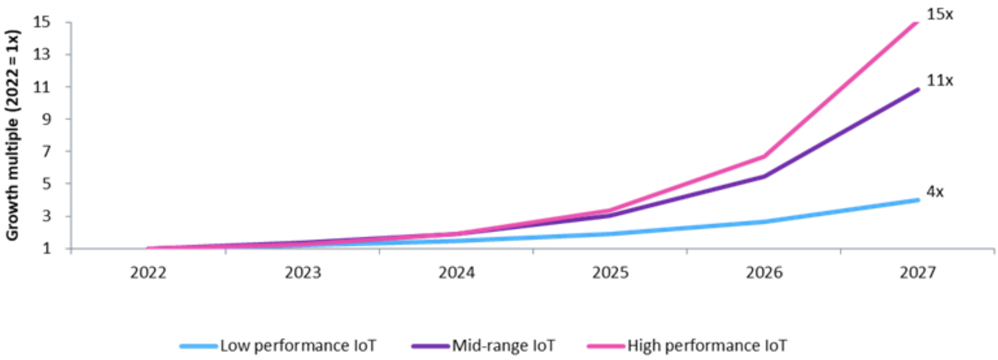
When it comes to connected devices, the simplest remain by far the most common. Simple sensors, meters, and controllers send small amounts of data intermittently. The data itself may be high-value and sensitive, for instance, kiosks that process financial payments, motion detectors that trigger security alerts, and appliance sensors that request technician service. These devices that generate small amounts of traffic are proliferating. A single warehouse may install hundreds of smart lights and a vendor may ship tens of thousands of connected devices across different office buildings worldwide.

Medium-performance connected devices support larger transfers of unstructured data, such as images, low-resolution video, or streaming wave data (acoustic, liquid, seismic, and electromagnetic). This category includes controllers that handle complicated tasks. Mid-range IoT devices power workhorse applications, such as barcode and license plate reading, facial recognition, IP voice, and basic streaming video from security cameras.

High-performance connected devices support the most demanding requirements, starting with HD video, extended reality (XR), and connected autonomous vehicles. This category includes over-provisioned capacity for complex controllers, to guarantee that critical actions happen in real-time. Most of this category is currently real-time HD video streams for cognitive analytics, for example, quality control in manufacturing or monitoring patient brain activity in healthcare.

Figure 9 forecasts the growth in bandwidth demand for IoT devices by their level of performance. The number of low-performance connected devices will grow at the fastest rate. However, low-end devices have less influence on net new bandwidth demand compared with the growth of mid-range and new high-performance IoT applications.

Figure 9: Projected IoT bandwidth growth for low-, medium-, and high-performance applications



Low-performance IoT	Mid-range IoT	High-performance IoT
(~1 Mbps per 10 devices)	**(~1 Mbps per device)**	**(10-100+ Mbps per device)**
Meter (temp, pressure, volume)	Video clips, image capture	Hi-res video
Location tracking, inventory	Biometrics	New media (3D, holo, XR)
Non-real time device control	Real-time controllers	Multiple video streams
Non-critical alarm monitors	Low-res video	Critical controllers
Transactions	Streaming waveform	Autonomous vehicles

Source: Omdia

New adoption plus operational scaling multiply traffic growth

Many new digital technologies are in play, and enterprises are prioritizing based on benefits and their requirements. Some technology adoption is moving fast, some is more gradual. For example, visual processing and cognitive analytics are popular and growing quickly. An image or video stream has much more information than data, and networked cameras have become inexpensive to deploy or embed in gear. Visual processing has proven versatile. It is effective for uses such as worker safety and compliance, site security, people and inventory identification, and quality control. By contrast, operational technology (OT) has been slower to migrate to digital. Areas such as AR/MR show great promise. But in 2023, headsets and their useful business applications are still mostly under development. Other digital applications adoption falls somewhere in between.

One factor that contributes to business growth is the adoption of new technology. Another growth factor is technology expansion and upgrades inside organizations. A business that has experience with visual processing in the business will be comfortable adding more cameras, or swapping out to newer cameras that support higher-resolution video, or that transmit more images per minute.

Four digital technologies stand out for their potential to grow exponentially over the next five years: visual processing and cognitive analytics, and data collection from networked IoT devices and probes, are projected to grow traffic up to 20-fold. Immersive AR/VR/XR and location tracking are projected to grow traffic 10- to 11-fold over the next five years (**Figure 10**).

Figure 10: Forecast network traffic growth for key types of digital applications, 2023-27

Source: Omdia

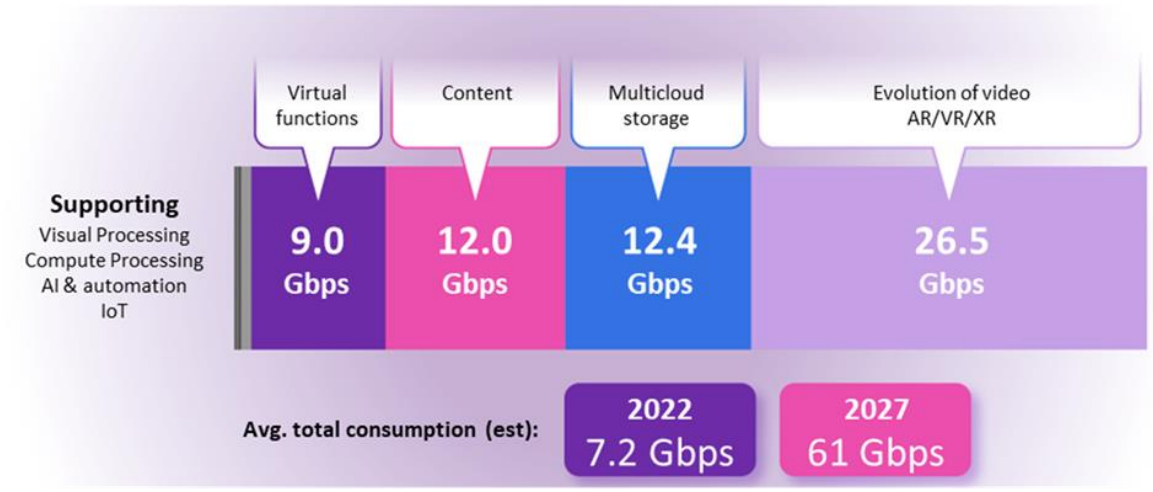
Network managers know that their established IT platforms and applications—rather than new ones—tend to consume large amounts of bandwidth in organizations. Visual processing, cognitive analytics, and IoT are all projected to grow rapidly through 2027. However, these newer technologies will still collectively generate just 250Mbps—less than 1%—of an average large enterprise's total traffic in 2027.

The big four digital IT solutions that will represent the bulk of the average large enterprise's traffic load in 2027 are:

- **New video and immersive experiences**: Although the use of some next-generation technologies will still be limited, new video and immersive experiences need large amounts of real-time bandwidth to support high-value, interactive applications.
- **Distributed storage**: Digital applications can generate very large amounts of data, especially if they transfer video or images. Many of these data sources will be mirrored off-site. Stored data will also be shifted around for re-use, such as running additional waves of analytics.
- **Content aggregation, distribution, and consumption**: Content continues to become richer media, whether using higher resolution, multiple streams, or cross-tagging across many different data sources. Knowledge workers will need to continue to step up their pace of content consumption, which will increase incoming and outgoing data flows.
- **Virtual functions**: Virtual networking and communications help manage how the business connects and operates, drawing on cloud-hosted resources to process secure connectivity and collaboration.

Omdia estimates that on average, a very large enterprise uses about 7.2Gbps of capacity throughout its operations. In 2027, bandwidth consumption is expected to grow to 61Gbps, with the bulk of traffic coming from new immersive formats, storage, media and content, and virtual functions (**Figure 11**).

Figure 11: Estimated bandwidth consumption for the average large enterprise, 2027



Parts of enterprise network consumption are hidden

Enterprises tend to underestimate their total bandwidth consumption. This is because executives tend only to count the capacity they buy directly from network providers, which misses hidden capacity consumption.

For example, hybrid and remote workers use their own wireline and wireless broadband services and internet access to connect to corporate resources. Additionally, there is a background network connectivity that connects cloud resources. This network consumption is billed to the enterprise as cloud services.

Connecting applications and the critical role of AI

Technology-leading enterprises aim for continuous improvements in automation. They want to collect and use data to generate information that can be analyzed and acted upon in real-time. Making the right decisions relies on having quality, timely, and comprehensive data. When done correctly, businesses can operate with greater speed and accuracy, reducing the likelihood of human error.

Automation is not new to businesses. The latest wave of change, Industry 4.0, was first introduced in 2016. The new wave is characterized by crossing physical, digital, and biological worlds. Industry 4.0 is a high-level concept originally tied to industrialization and manufacturing. However, businesses have deeply invested in practical ways to tie applications—and worlds—together, for uses that range far beyond manufacturing. The following are examples of the world's evolution of Industry 4.0, which are in wide use today:

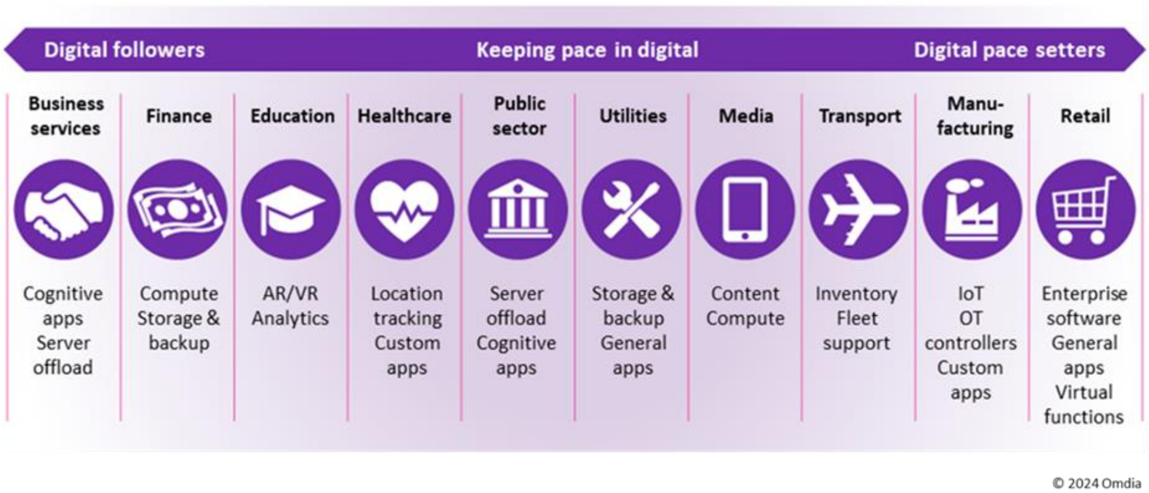
- **Automated supply chains**: Track in-house resources and the expected pace of consumption. They generate orders to preferred suppliers based on tracked key performance indicators (KPIs) such as cost, quality, timeliness, and compliance). In turn, each supplier has its own systems connected to downstream sources to source goods and materials. Each maintains its own sets of KPIs with partners.

- **Inventory tracking**: Track the location and status of resources across the organization, whether in a warehouse or on site. Retailers can assemble complex orders by searching and retrieving available items. Enterprises and services partners can locate and track specialty gear and software, to help use resources efficiently relative to availability and licenses. Similar concepts apply in other sectors. The 'inventory' could be manufacturers' digital twins or healthcare patients who are associated with their electronic medical records as they move through the system.

- **Closed-loop response**: Monitor alarms in physical or digital systems. Distributed probes collect data on the performance metrics of systems. The data are analyzed to detect issues and take appropriate actions. Responses can be complex, triggering additional tests and troubleshooting. Whether the issue is addressed by machines or humans, the interactions between machines lead to faster assessment and problem resolution.

The examples mentioned above often start in an organization as a standalone application. Over time, applications evolve to connect to each other. Different industries have different digital priorities. For instance, visual processing and cognitive analytics are important to all industries. However, visual processing and cognitive analytics are especially relevant to public sector (which is tasked with issuing and maintaining licenses and IDs for people and assets), and to business services (which helps build and operate these technologies for its B2B clients). XR is another example that is important across industries. In B2B, this technology is still seeing the most activity from research in universities—the education sector. Banking, financial services and insurance (BFSI), retail, and energy/utilities tend to focus their digital priorities on upgrading their existing business software and applications (**Figure 12**).

Figure 12: All industries embrace digital, but some have wider and others more focused goals



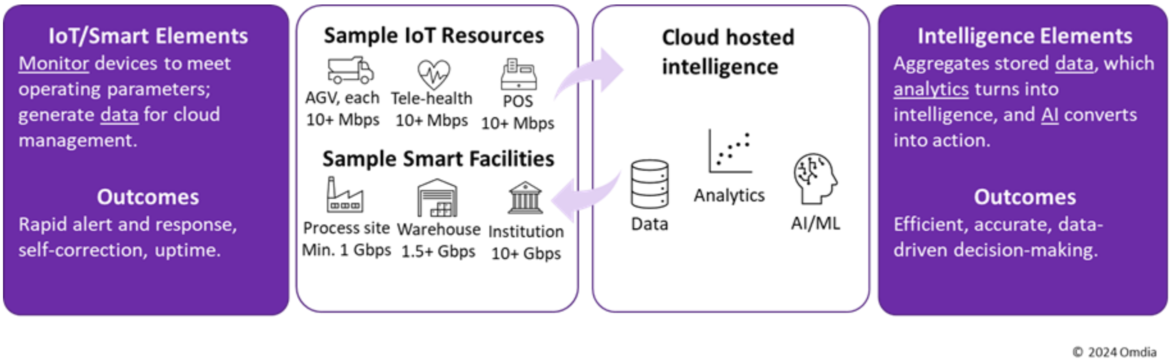
Notes: n=310
Source: Omdia

Information shared across applications is becoming richer and time intervals are shrinking. Both factors drive intra- and inter-business applications traffic. Businesses also are working with ways to automate mediation between connected applications. The following are some examples:

- What is an acceptable alert threshold?
- How does one guarantee an automated assessment and response are correct?
- How should the process differ if an automated instruction incurs a cost, such as a product or services order?

Whether workflows are handled automatically or mediated by human intervention, decisions must be well-informed. This is enabled by the rapid proliferation of AI, which makes decisions based on the analysis of data collected through IoT resources and smart assets (**Figure 13**).

Figure 13: The relationship between IoT/smart data aggregation and intelligent decisions



Source: Omdia

AI holds great promises for enterprises and service providers. Predictive AI can learn and adapt through observation. Predictive AI in operations (AIOps) can decide—or help a human decide—where, when, and how to respond through reactive, proactive, or prescriptive actions. In the form of generative AI (GenAI), it can help present information in a natural language context that is easily understood by humans. GenAI can work interactively with people through natural language instructions, making large volumes of data much easier to manipulate and extract value.

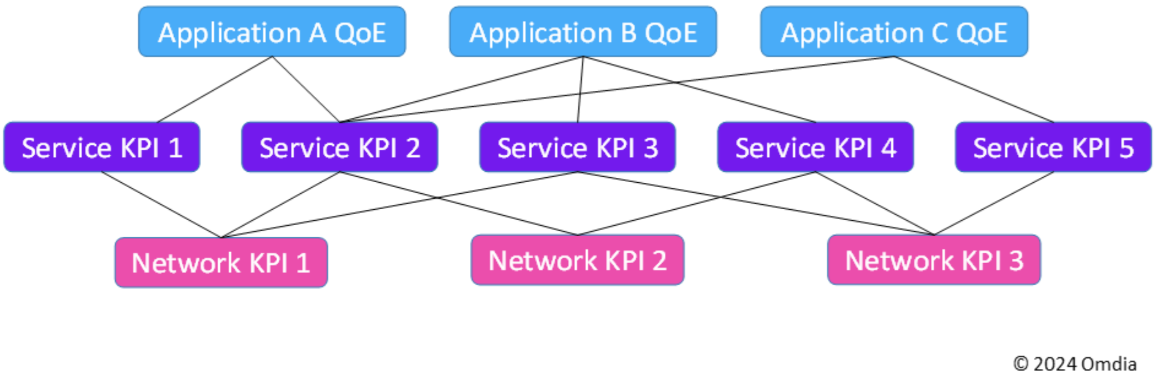
Both predictive AI and GenAI have found traction in organizations. Its initial entry points have included customer service and support, IT operations tasks, network services troubleshooting, and cyber security threat analysis. The technologies rely on larger and richer datasets to inform queries, analysis, and decision-making.

Ultimately, AI ties data sources together and works with other applications. Although AI is computing-heavy, it relies on ingestion and processing of data. The capabilities unlocked by AI drive large increases in enterprise bandwidth. This goes back to the digital platforms and solutions that will present the bulk of bandwidth demand for enterprises over the next five years. New immersive technologies, such as high-capacity and high-performance storage, content aggregation and distribution, and virtual functions hosted in cloud environments, are merging realities across the physical, digital, and biological realm of Industry 4.0. Artificial intelligence enables and supports the merger of these worlds.

How will QoE for advanced applications affect the KPIs of future networks?

There is a direct link between end-user applications quality of experience (QoE) and the performance of the network. End-user experience is subjective, and the communications industry has used the QoE methods, such as mean opinion score (MOS), for many years. The results of MOS can then be related to specific service KPIs to meet that experience, which in turn, can be related back to network performance KPIs (**Figure 14).** For example, to receive a MOS rating of 5 (Very Good), a streaming video application must meet certain service KPIs. One of these KPIs might be an initial buffering time of less than 100ms. Achieving this service KPI requires network KPIs, such as a minimum bandwidth requirement to meet the buffering time limit.

Figure 14: Sample relationships between QoE, service KPIs, and network KPIs



Source: Omdia

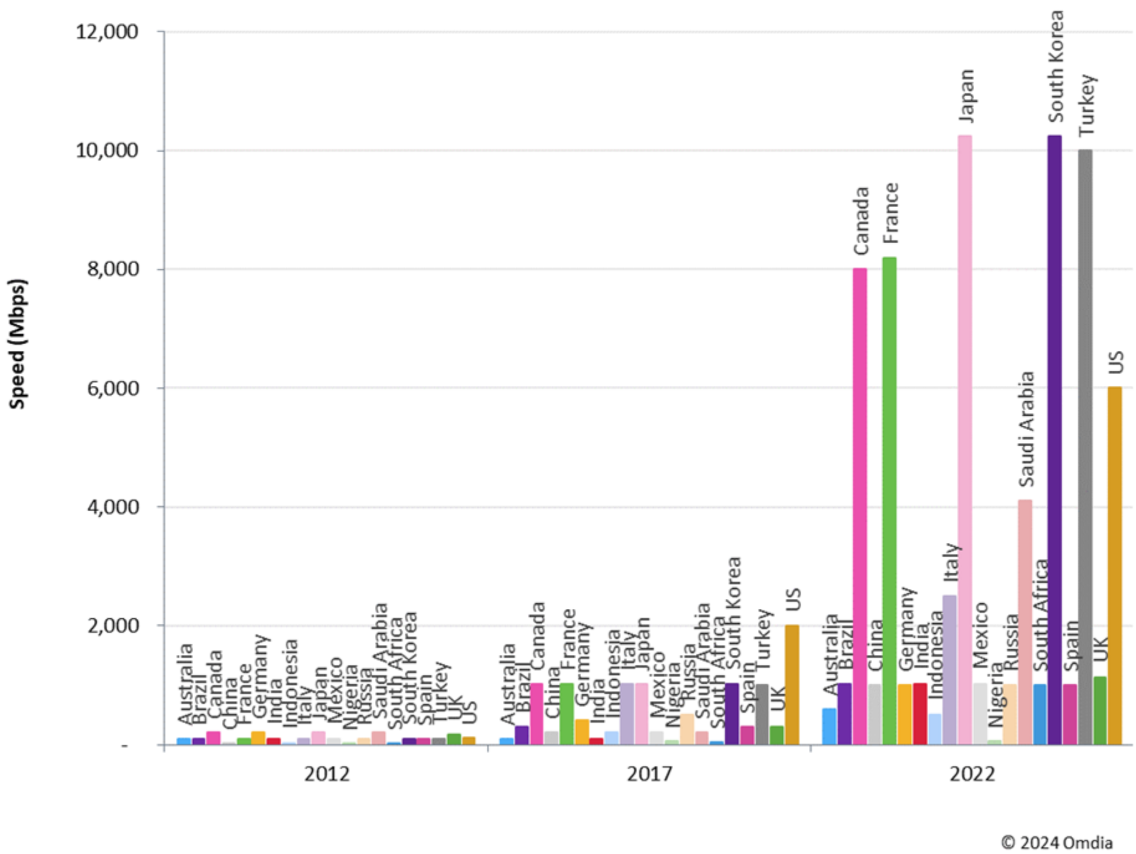
Consumers, households, and enterprises do not use just a single application at a time. Even a single device might perform multiple functions at once, and this is then multiplied for the members of a household or workers in an enterprise. Therefore, the modern broadband network must be capable of handling the demand of concurrent running applications, all with different quality of service characteristics that must be met for end applications to meet users' experience expectations.

Meeting the demand of application concurrency

Based on Omdia's forecasts, by the end of 2022, the global average number of connected devices per broadband household was 17. This number includes an average of 3.7 smartphones, 1.7 computers, 0.8 set top boxes or dedicated media streamers, and 0.9 smart TVs. In highly developed countries or high-end households, the average number will be higher, and the devices will be more advanced. Therefore, in developed markets, households frequently have HD video streams, online gaming sessions, and video conferencing calls happening concurrently. As the number of connected devices in households increases, so does the demand for network resources.

This concurrent application demand has helped to drive a rapid increase in broadband network capability. Gigabit speeds are now available in many markets, and some top markets are offering 10Gbps services (**Figure 15**).

Figure 15: Maximum broadband speeds offered worldwide

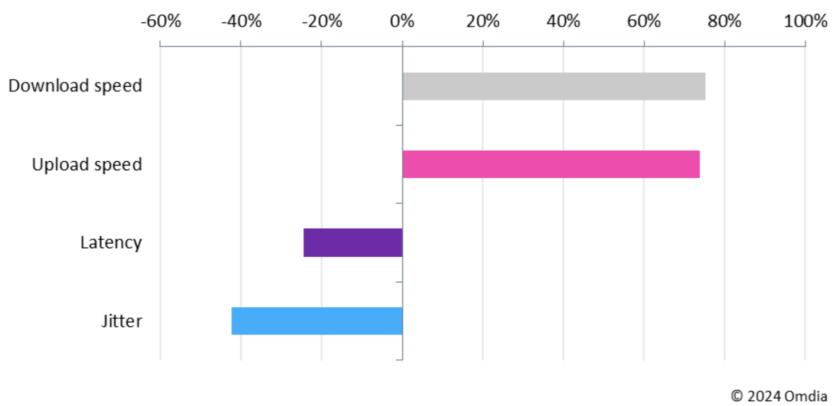


Source: Omdia

This increase in broadband network capability is driven by the move to next-generation access technologies, such as FTTH and data over cable service interface specification (DOCSIS) 3.1 cable. At the end of 2022, 67% of global consumer broadband connections used FTTH. Omdia projects that by 2030, the proportion of fiber-based access for households will increase to 77%.

The move to more advanced broadband technologies has not just pushed maximum speeds, but also the overall average bandwidth of broadband services. It has also improved other metrics such as latency and jitter. Based on Omdia's Fiber Development Index, which measures the development and associated broadband experiences across 90 countries, the median download speed increased by 75% and the median upload speed by 74%—on average—in just two years between 2020–22. The lags incurred by average latency and jitter decreased by 24% and 42%, respectively (**Figure 16**).

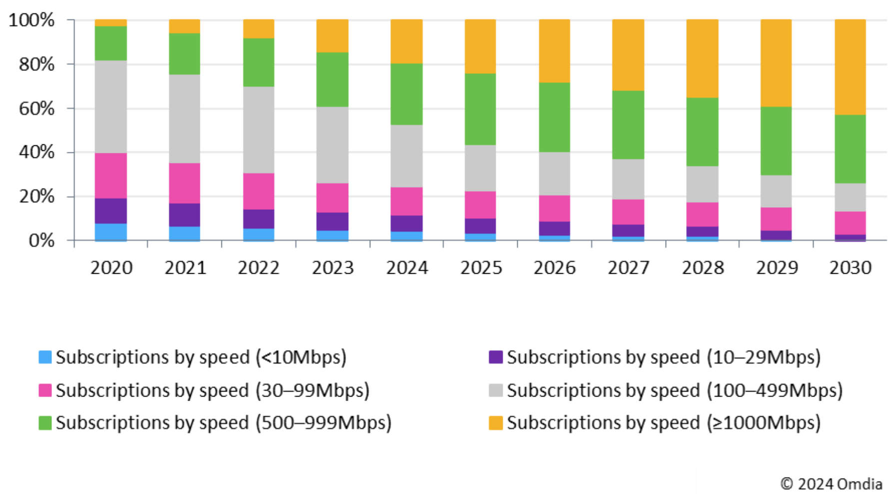
Figure 16: Changes in broadband metrics (2020–22)



Source: Omdia

The uptake of gigabit services will continue to grow. By the year 2030, Omdia forecasts that 43% of all broadband subscription services at a global level will offer downstream speeds of 1Gbps or more. Only 27% of all broadband subscription services will subscribe to services with downstream speeds of less than 500Mps.

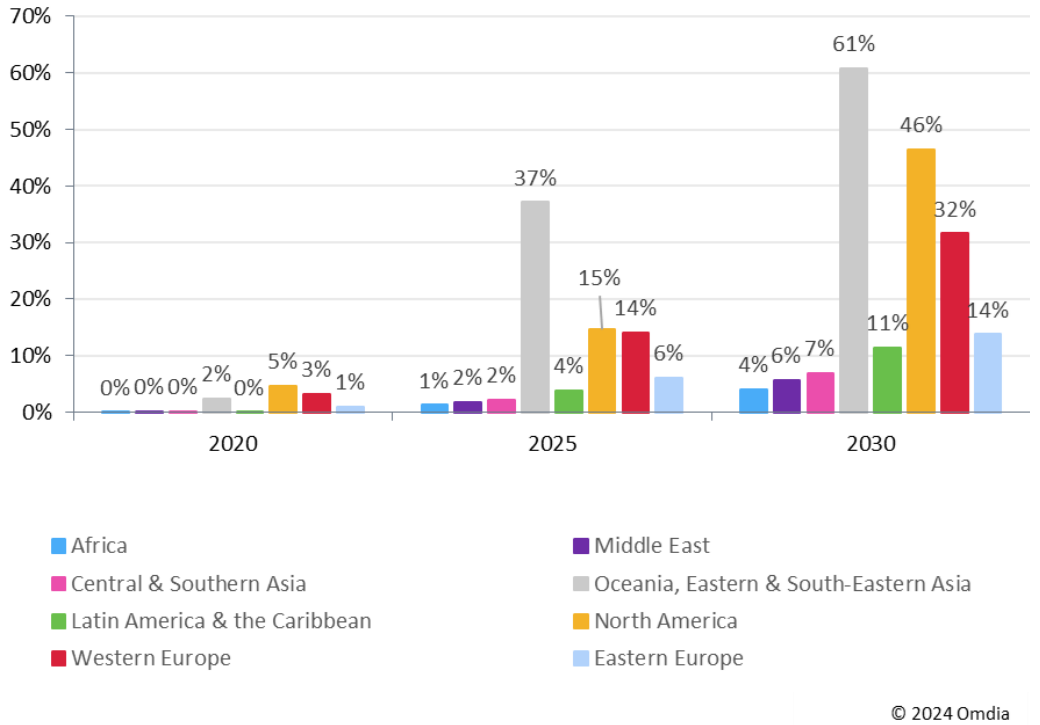
Figure 17: Global broadband subscriptions by speed



Source: Omdia

It is important to note that the availability of ultra-high-speed services internet services is not evenly distributed across the world. Developed markets have a higher availability and subscription of these services, compared with emerging markets. By 2030, Omdia forecasts that only 4% of broadband connections in Africa will be gigabit services, as compared with 61% of connections in Oceania, Eastern & South-Eastern Asia, and 46% in North America (**Figure 18**).

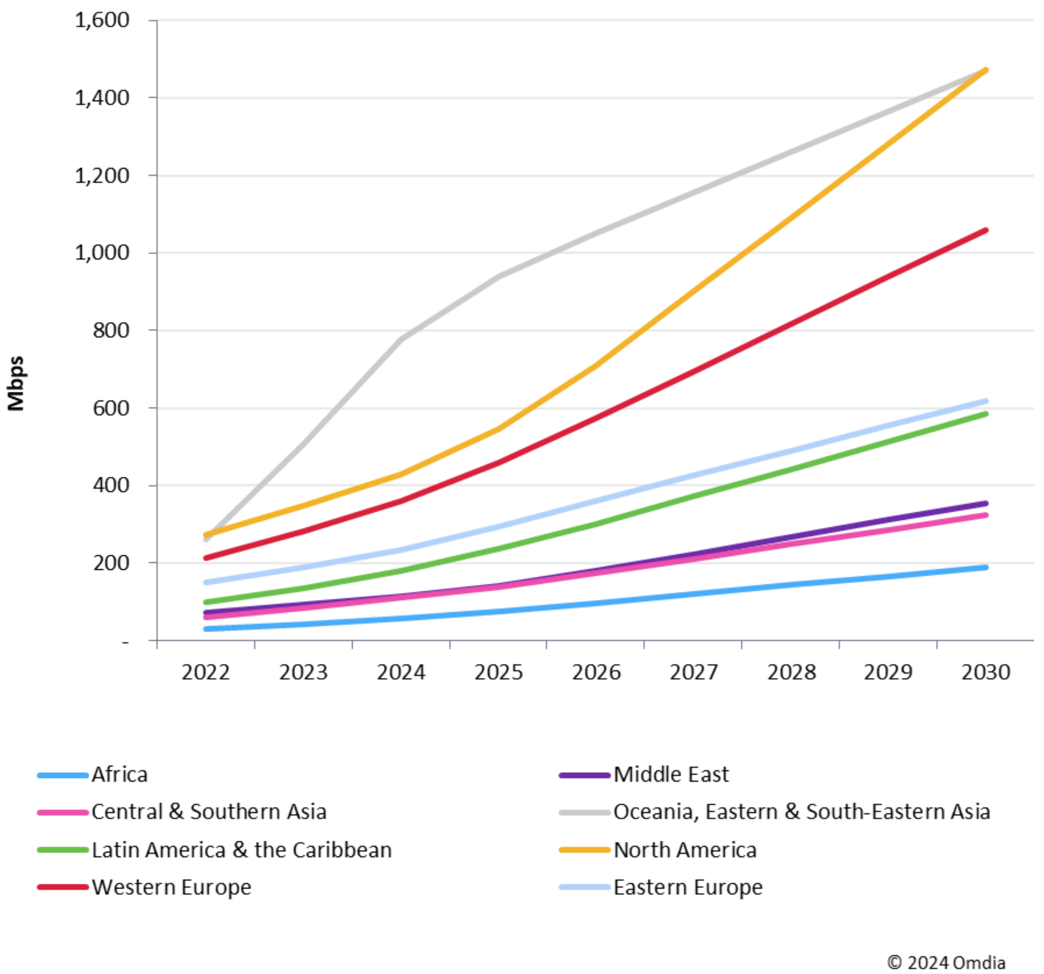
Figure 18: Percentage of consumer broadband subscriptions with speeds of 1Gbps or more



Source: Omdia

Similarly, there are also discrepancies in average speeds, which are expected to exceed 1.4Gbps in in Oceania, Eastern & South-Eastern Asia and North America, compared with only 200Mbps in Africa (**Figure 19**).

Figure 19: Average broadband speed by region



Source: Omdia

To maximize the socioeconomic benefits of high-speed broadband services and the next-generation Web 3.0 applications in all countries, it is vital that countries set out ambitious national broadband plans with required regulations and legislation to encourage investment in all-optical broadband networks.

Technology enablers of 5G-A to support future applications

New features have been introduced in 5G-A and F5G-A to meet the increasing demand for data traffic and to support new applications.

One of the key technologies in 5G systems is multiple input, multiple output (MIMO) antennas. In Release 15/16/17, most MIMO features were designed for downlink MIMO operation. However, the growth of mobile data traffic, particularly the increasing demand for uplink bandwidth, has generated further requirements for network capacity and data rate. Release 18 will specify necessary enhancements for uplink MIMO, such as improvements to multiple transmission and reception points (multi-TRPs) use cases and support for advanced UEs (e.g., FWA CPE) with >4 transmission (Tx) and high Tx power. Release 18 will also introduce necessary enhancements for downlink MIMO that facilitate the use of a large antenna array.

The 5G-A system will also enhance the support for XR devices. Many XR use cases are characterized by quasi-periodic traffic (with possible jitter) with a high data rate and a relatively strict packet delay budget (PDB). The multiple periodic data streams with variable packet sizes are especially challenging for 5G new radio (NR) resource scheduling and power-saving mechanisms. Because many end-user XR devices are expected to be mobile and small-scale, they have limited battery power. Therefore, DL semi-persistent scheduling (SPS) and UL configured grant (CG) operations will be introduced in 5G-A systems to meet XR's traffic characteristics. Discontinuous reception (DRX) support of XR devices will be enhanced to lower the power consumption of XR devices. Cross-layer coordination between RAN and application can also optimize and improve capacity and power.

Other features of 5G-A systems, such as the sub-band full duplex (SBFD), ambient IoT, and integrated sensing and communication (ISAC), will be specified either in Release 18 or in following releases, to support industrial applications that require ultra-low latency and to help mobile operators address new market segments.

In the fixed broadband sector, service providers in China, the Middle East, and elsewhere have started deploying FTTR solutions for households and businesses. Together, FTTR optical and Wi-Fi convergence, multi-user intelligent scheduling, and anti-interference algorithms can enable seamless handover between 5Gbps and 10Gbps speeds, and over 512 concurrent connections with milliseconds-level service latency. FTTR solutions can effectively meet the growing demand of diverse bandwidth-hungry applications, such as XR and glasses-free 3D video.

In 2023, China Mobile announced that it would launch a new tender for 400Gbps fiber backbone systems. The new solution will significantly boost backbone network capacity and meet long-term demand for traffic growth. Meanwhile, the industry is also moving to beyond-400G (B400G) technologies, including 800G+ transmission. Equipment vendors are introducing new, advanced transport capabilities, such as flexible modulation rate and format, constellation shaping, and advanced error correction, to achieve the best data rate for any optical channel condition.

The F5G-A system will also improve the flexibility and agility of transport networks. In F5G-A, the optical transport network (OTN) is enhanced to provide higher capability and greater flexibility for a larger number of services. It also supports a wide range of data rates, from a few Mbps to over 100Gbps. New optical cross-connects (OXCs) will achieve reconfigurable optical add/drop multiplexing, which enables more flexible and dynamic metro networking.

Other technologies, such as end-to-end slicing, elastic resource scaling, joint optimization of optical networks and cloud computing resources, can also significantly improve the flexibility and agility of the transport and backbone networks.

All these 5G-A and F5G-A features can bring the network capability to a new level to meet the needs of consumers and enterprises by 2030.

Potential new business models for broadband service providers

Over the next five years, network providers must continue to scale their capacity steadily. This is a basic requirement because consumers and businesses are increasingly relying on digital channels for their home and work lives. They expect consistently high levels of application availability and performance, and they want to buy services that are flexible and can adapt to their changing needs. Additionally, they prefer to do businesses with services partners that make it easy to access the content and applications they need. Finally, consumers and businesses both expect value for money.

These rising client expectations put network providers under constant pressure to do better. To deliver, network operators must adopt excellence in operations. They can achieve that excellence through greater service intelligence and automation.

Consumers are increasingly connected in everything they do. They rely on cloud to deliver complex applications to an ever-wider range of devices, with the experience optimized for the device and interaction. For enterprise, the shift to digital technologies enabled migrating from data centres to cloud services. They are moving to cloud-hubbed networks, interconnected clouds, and a distributed edge. Enterprises are also changing the way they consume networks, and service providers must be prepared for the changes. These changes include the following moves:

- From private WAN to public internet VPNs
- From dedicated capacity to broadband access
- From concentrated, in-office staff to a distributed, hybrid workforce
- From firewall-based perimeter security to zero trust, perimeter-less cyber security
- From static service delivery to “as-a-Service” dynamic billing models

With all these changes happening simultaneously, few network providers can do all things for all audiences. Therefore, providers must pick and choose where to invest strategically. Providers who align their service models with the buying priorities of businesses have a higher probability of succeeding. In the next five years, we predict that providers’ business models will evolve in four main directions.

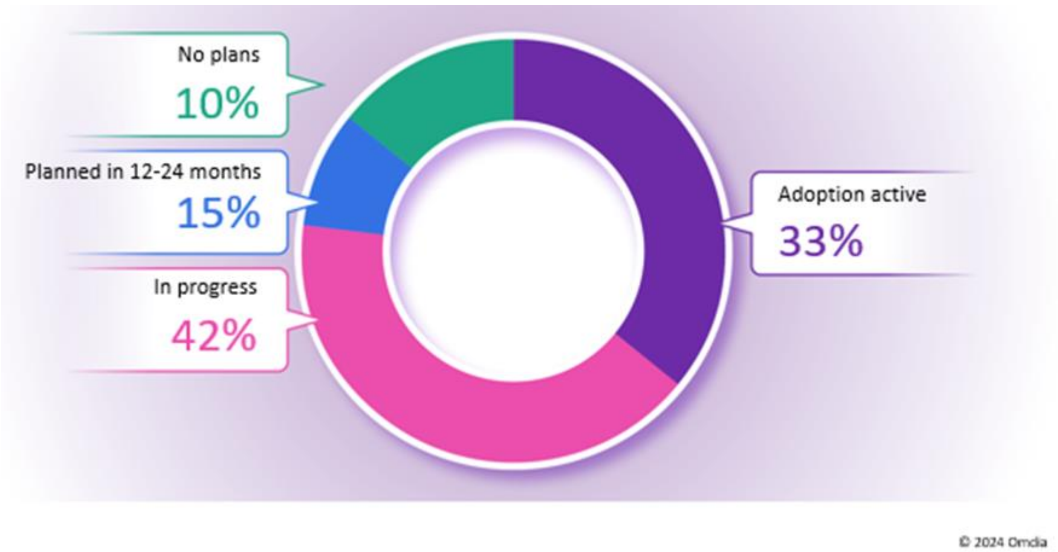
Network as a service

Network as a Service (NaaS) simplifies how enterprises consume network services. NaaS hides underlying complexity from the enterprise, exposing details only where the enterprise buyer wishes to dig into them. NaaS is an umbrella term with many components to the experience. These include:

- Network and service components that are pre-integrated and work together seamlessly
- Intelligent tools choose service packages in ways that meet enterprise requirements
- Dynamic usage-based billing, bandwidth-on-demand for services
- Simple, easy to understand contracts that can swap out components as needed

About one-third of large enterprises are using some aspects of NaaS. Another 42% have some aspects of NaaS in progress (**Figure 20**).

Figure 20: One-third of large enterprises have adopted NaaS elements in their networks



Notes: n=404
Source: Omdia

Why it is significant: Enterprises want simpler, more cloud-like experiences for the ordering and delivery of their network services. They are interested in business outcomes—price, performance, uptime, compliance—and not the fine-grained details of underlying services and supplier ecosystem. Service contracts should be brief and easy to understand. They should ensure that the enterprise is in control of network changes, and that there is flexibility that allows for changes as business needs change.

Provider requirements: Operators can adopt some elements of NaaS by making small changes. These changes may include offering flexible billing plans and decision-making tools that group and tier services utilize by quality and cost. Simpler, more flexible contract legal language can help enterprises to reconfigure services without penalty. Sales training and support will help account managers become more consultative and less transaction based. More sophisticated NaaS features need internal systems development. The carrier may prebuild digital service packages with a range of configuration options. It can add monitoring or control tools and AIOps to its portal, so enterprise IT receives intelligence on how the network is performing and how it may be improved.

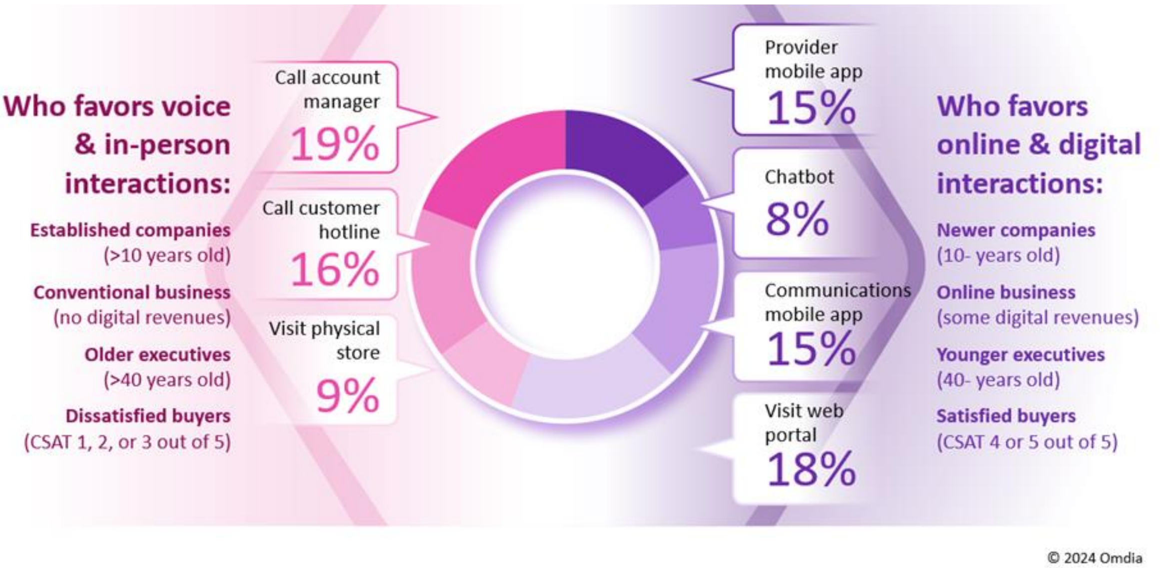
Zero-touch customer lifecycles

The zero-touch customer lifecycle enables consumers and businesses to navigate through any or all aspects of their providers' relationship using digital interfaces. There are many customer touchpoints that can be upgraded to digital transactions, including:

- Explore available services
- Select services and receive quote
- Negotiate and sign contract
- Install, configure, activate
- Receive bills, resolve differences, payment
- Expand, upgrade, and reconfigure
- Receive support and resolve trouble
- Renew contract or churn out

For example, more than half of SMEs favor online and digital interactions with service providers, while established companies and older executives prefer voice and in-person transactions. Newer companies and younger executives also prefer digital interactions (**Figure 21**).

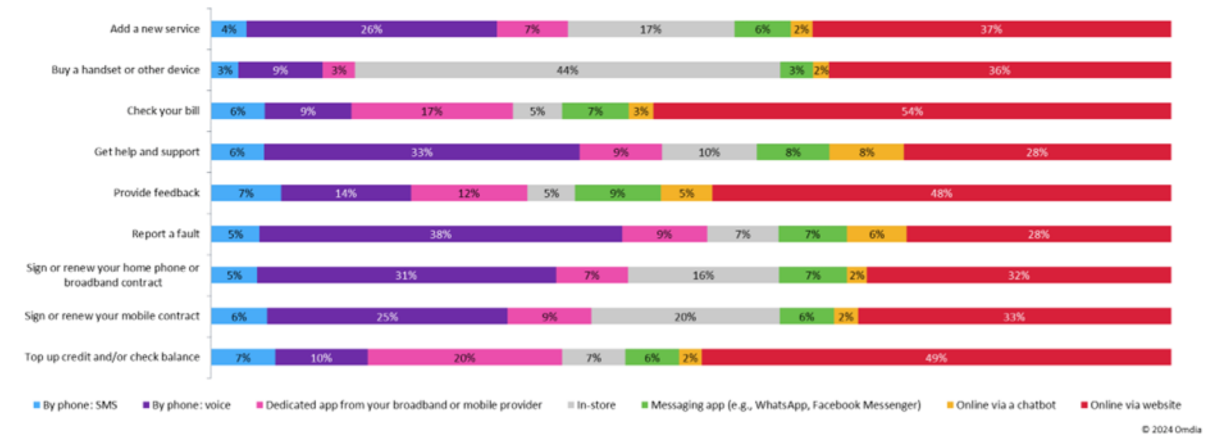
Figure 21: Preferred ways SME executives interact with service provider partners



Notes: n=946
Source: Omdia

Consumers are increasingly favoring digital channels to interact with their service provider. However, there are a few exceptions where they prefer the in-store experience for choosing a mobile handset, and prefer the telephone for reporting faults and getting support. As operators move toward offering 'everything as a service' business models through a single comprehensive mobile app, even these functions will shift to digital channels. In addition, the use of AI for data analytics and chatbots is starting to increase efficiency and improve the in-store and voice channel experiences.

Figure 22: Consumers' preferred interaction channel with their service providers



Source: Omdia

Why it is significant: Buyers want to interact with providers through their preferred medium. Some executives and company cultures strongly prefer to do business online. Some consumers, especially the younger generations, are digital natives. In the consumer space, more and more digital-only brands are targeting younger consumers. Some business executives take to cloud experiences that allow them to self-order, set up and configure their own accounts, and pay by credit card or bank transfer. Why, then, is the network provider experience so complicated? Network providers must offer all aspects of the customer lifecycle available as online options.

Provider requirements: Operators can invest in portal development to support digital transactions through their sites. Almost all network providers have online catalogues of services. They support message notifications (e.g., via text or email) for service order requests, alarms, and billing statements. There has been hesitancy to move service quoting and contracting online through automated interfaces. Over time, the network provider can implement more back-end customer journey analytics, which will help understand and improve how customers interact with their systems. The provider can identify negative patterns and try to turn them into positive outcomes. The zero-touch customer is also the target audience for GenAI chatbots in customer service and support. This can save the service provider on labor costs, while giving preferred ways of interacting to digital-native consumers and digital-forward businesses.

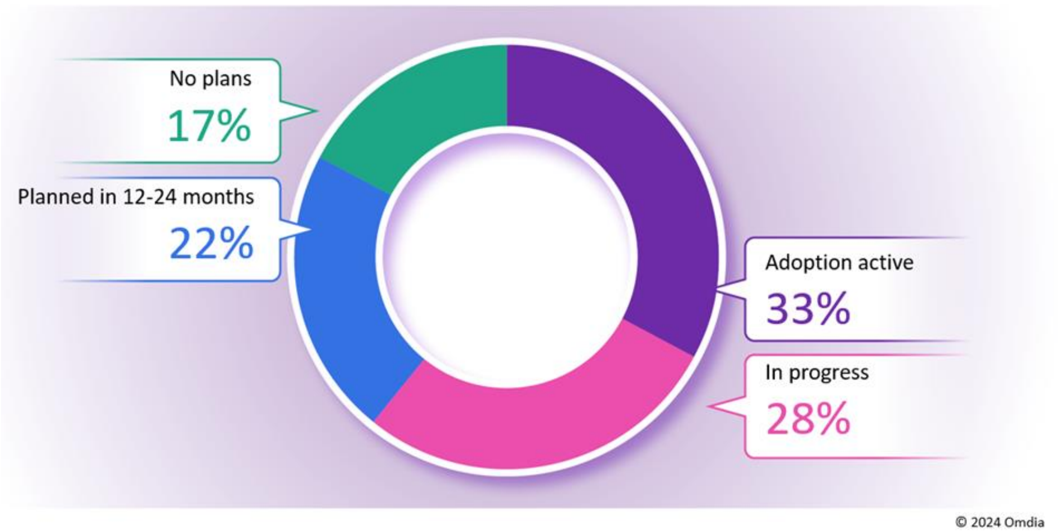
Edge-driven ecosystems

Network providers own distributed physical real estate; they are skilled at building network platforms and assembling ecosystems of network partners. That contrasts with cloud providers which are sited more centrally, are good at hosting computing infrastructure and assembling applications ecosystems. If network providers make their distributed facilities available, cloud providers could use them to host high-performance/low-latency environments in proximity customer sites. From a network provider point of view, the elements of an edge-driven ecosystem include:

- Physical real estate such as network nodes, distributed central offices or head-ends
- Direct connectivity to wired and/or wireless access network(s) such as 5G and fibre, possibly wired broadband, and third-party network provider presence
- Possible cage or rack colocation options at larger edge sites
- Bare metal and basic virtualization environments hosted by the network provider for its cloud partners and some large enterprise buyers
- Smart cloud orchestration across for the distributed edge (still a work in progress)
- The buy-in of one or more cloud providers participating in the network provider's edge, drawing their ecosystem of partners and customers

About one-third of large enterprises have some sort of active edge deployment (**Figure 23**). Of these, most enterprises have deployed site edge. Many enterprises with site edge also try out proximity-hosted edge clouds. Fewer businesses rely purely on network-hosted edge clouds.

Figure 23: One-third of large enterprises have begun testing edge cloud deployments



Notes: n=359
Source: Omdia

Why it is significant: Performance between enterprise sites and cloud locations becomes less predictable if traffic has to traverse more network hops. Cloud at the edge minimizes the number of network hops, which reduces latency and makes performance more predictable. Some buyers need consistent high performance and high availability, and they are willing to pay a premium to get it. When the network provider is part of the edge cloud ecosystem, it can tie its access networks with cloud, for a better chance to capture and keep customers.

Provider requirements: Operators have widely invested in edge computing infrastructure to support internal IT and virtual networking. Adding extra racks of compute and storage to host third-party edge services is a modest investment bump. Network operators should not expect a big financial windfall from cloud provider partnerships. These deals will resemble wholesale arrangements, with thin margins that help defray operating costs. Edge is attracting enterprise interest. However, an edge can be hosted on an enterprise site or in its data center, in an operator environment, or even in one of the cloud provider's own facilities. To date, the edge-driven ecosystem hosted inside telco-owned facilities has grown slowly compared with mainstream cloud.

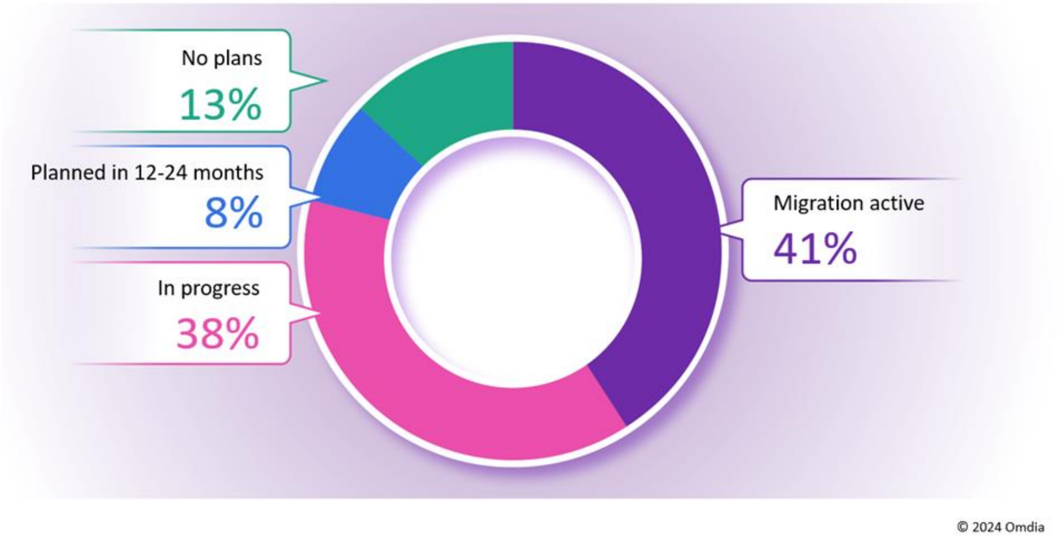
Carriers as commodity

The range of core enterprise network services is flattening and simplifying. Some network providers specialize in offering only a few core services and plans, which they offer on a wholesale-like basis. The future essential B2B carrier services are as follows:

- Switched Ethernet, which replaces dedicated transport and private WAN
- Dedicated internet, which replaces private IP with internet VPN
- Wireline and wireless broadband internet, which serves SME and larger enterprise branch offices
- On-site equipment is a separate managed service, which provides routing intelligence and applications/bandwidth management
- Voice/UC and collaboration are separate managed services, delivered from the cloud like other categories of applications
- Security is a separate managed service, delivered via the cloud

More than 40% of large enterprises have migrated parts of their network off private WAN in favor of public internet VPNs (**Figure 24**).

Figure 24: More than 40% of large enterprises have begun WAN migration to public internet VPN



Source: Omdia

Separately, 37% of enterprises have re-hubbed parts of their network around cloud services. These efforts simplify the network architecture and flatten the portfolio of B2B consumed services.

Why it is significant: By taking out operational complexity, for instance, moving to a simplified services portfolio, a provider loses revenue opportunities. However, it also greatly lowers operating costs. The network provider can separate its core operations from managed and professional services. The network part of operations emerges from this effort smaller and simpler, with a reduced headcount and sustainable margins. The managed services part can draw from many networks and clouds to compete on its own services merits.

Provider requirements: Many operators are already separating their businesses into different branches, with one handling the network operations and engineering, and the other managing the customer-facing retail aspects of the business. While it is technically achievable to pull apart network and managed services, large, established operators may find it challenging to implement this change owing to their business structure and investor. Such companies will likely see a split into core network and managed services to be unappealing, similar to wholesale/retail structural separation. However, in markets with ongoing hyper-competition, smaller competitors may consider this business model to become more streamlined, nimble, and cost-efficient. If AI and automation further drive up competition and force down pricing for managed services, at some point providers may turn the network into a simple, commoditized service layer that provides a slimmed-down portfolio of connectivity services to all managed services providers.

Business model transformation leads the technology evolution

As previously mentioned, new business models are emerging in the mobile and fixed broadband markets. Meanwhile, modern communication technologies are approaching the Shannon boundary, which is the performance limit according to information theory. The telecom industry is transforming its traditional technology-driven evolution model into a business-driven one. Therefore, it is crucial to fully consider and evaluate market demand and business models at the beginning of a study cycle for next-generation technologies.

In their transformation, industry players must find a balance between business demand and improving technical efficiency. For example, the rising energy costs and the need to comply with climate change regulations force CSPs to consider solutions that improve network energy efficiency. However, most of these solutions will affect network capacity or coverage. Therefore, CSPs must make a trade-off between meeting network performance demand and reducing energy consumption.

Cross-sector collaboration is critical for transformation. Deep collaboration with vertical industries can help telecom players obtain enough understanding of industrial requirements and enable the next-generation technology to support diverse industrial applications. Even in the consumer market, collaboration with over-the-top (OTT) providers is crucial for telecom companies to understand consumer demand and changing behavior patterns.

In summary, the need for business model transformation is expected to become a primary driving force for technology evolution. When studying next-generation technology, CSPs must strengthen their business demand analysis and engagement with content providers, industrial solution specialists, cloud platforms, and so on.

Appendix

Further reading

"Blockchain is good for more than just Bitcoin" (September 2019)

Blockchain Technology and Adoption Trends (December 2019)

"CenturyLink goes 'colorless' and takes on the edge cloud" (February 2020)

Service Provider Routers & Switches Market Tracker - Q4 2019 (February 2020)

Li You, "Tech-savvy Hangzhou tries out new 'City Brain'," *China Daily* (retrieved February 8, 2024)

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