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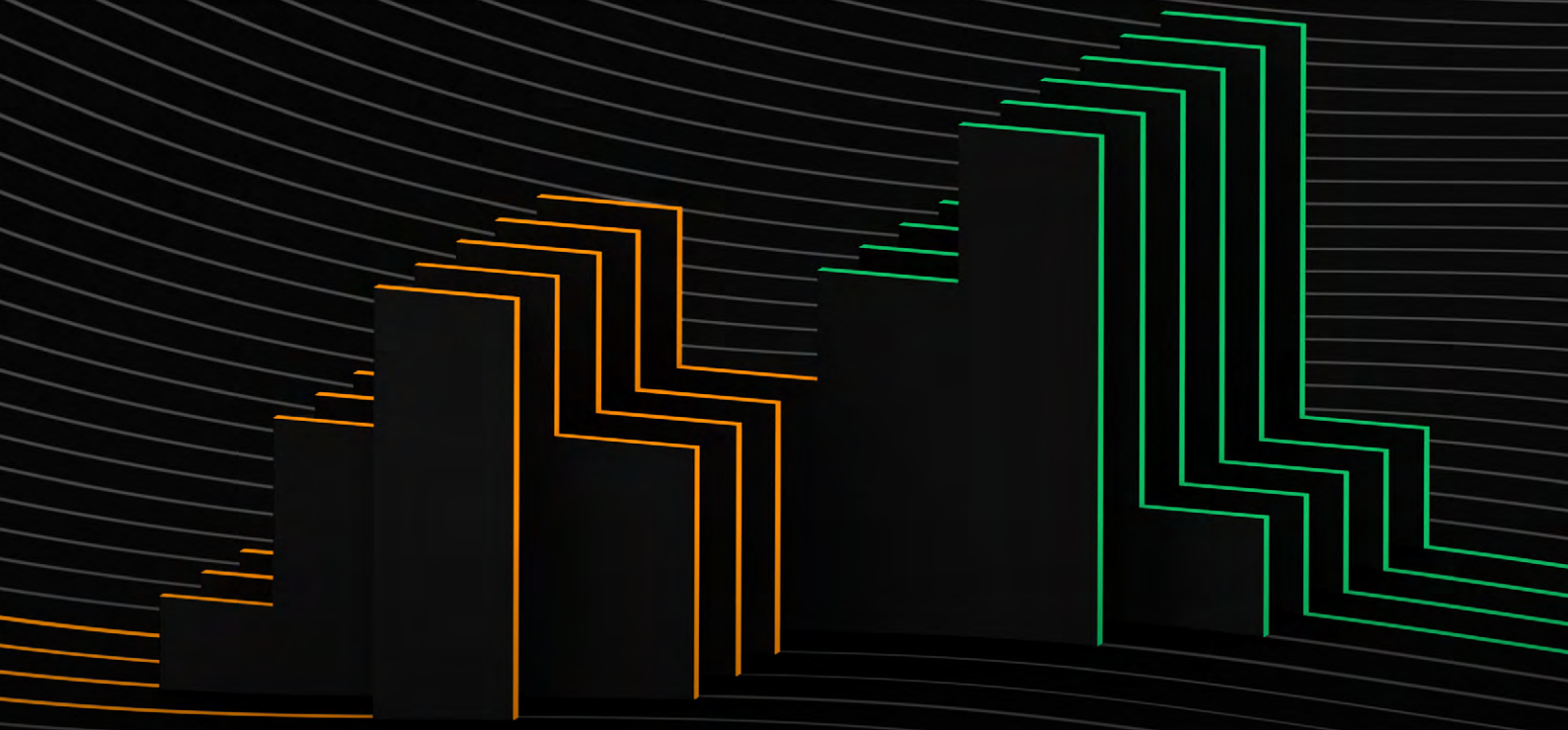
Ericsson Mobility Report



November 2020

Subscriptions
In 2026, 3.5 billion 5G subscriptions are forecast, accounting for 40 percent of all mobile subscriptions

Critical IoT
Time-critical services for consumers, as well as enterprises, will be enabled when Critical IoT is introduced with 5G networks

Co-written article with AT&T
The challenges of 2020 have put FirstNet, the US's dedicated first responder network built and managed by AT&T, to the test

Letter from the publisher

5G is here and happening

This year will go down in history as one which saw widespread global disruption, caused by a pandemic that has shaken every economy and significantly impacted everyday life. It has been a big strain on everyone, no matter where in the world you live.

While countries may have differed in their approaches to containing the virus, all face a future with irreversible changes in the ways that we live and work. In retrospect, 2020 will probably also be known as the year when society as a whole took a giant leap forward in our digitalization journey.

The fundamental need for good connectivity is a cornerstone for this change, clearly visible in this edition of the Ericsson Mobility Report as the demand for capacity and coverage of cellular networks continues to grow. 5G is no longer just a novelty. Instead it is entering the next phase, when many new devices and end-user applications make the most out of the technological benefits it provides, while communications service providers worldwide continue the build-out of 5G. By the end of this year over 1 billion people, or 15 percent of the world's population, will live in 5G coverage areas.

2020 has also proven to be an exceptional year for cellular networks used for public safety applications. Together with AT&T, we have looked into how FirstNet – the nationwide network deployed to serve first responders in the US – stood up to the test of this year's emergencies related to the pandemic, one of the most active hurricane seasons on record, and severe wildfires.

As society rapidly changes, it is clear that cellular networks are a critical infrastructure that will continue to support many aspects of our everyday life.

We hope you find the report engaging and useful!

Publisher
Fredrik Jejdling
Executive Vice President and Head of Business Area Networks

Contents

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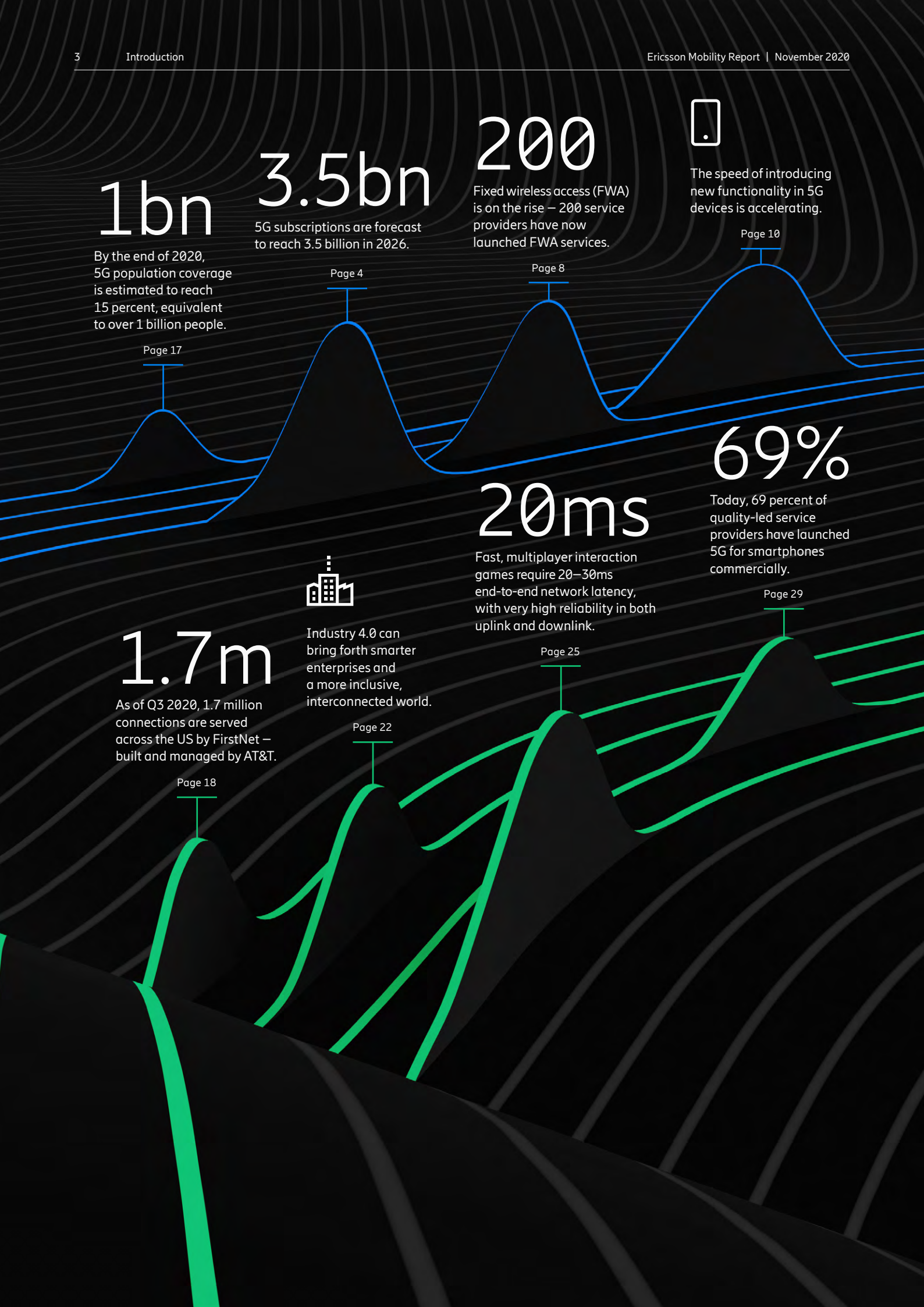

1bn

By the end of 2020, 5G population coverage is estimated to reach 15 percent, equivalent to over 1 billion people.

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3.5bn

5G subscriptions are forecast to reach 3.5 billion in 2026.

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200

Fixed wireless access (FWA) is on the rise – 200 service providers have now launched FWA services.

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The speed of introducing new functionality in 5G devices is accelerating.

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69%

Today, 69 percent of quality-led service providers have launched 5G for smartphones commercially.

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20ms

Fast, multiplayer interaction games require 20–30ms end-to-end network latency, with very high reliability in both uplink and downlink.

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1.7m

As of Q3 2020, 1.7 million connections are served across the US by FirstNet – built and managed by AT&T.

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Industry 4.0 can bring forth smarter enterprises and a more inclusive, interconnected world.

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Mobile subscriptions outlook

A total of 220 million 5G subscriptions are expected by the end of 2020.

The spread of COVID-19 continues to impact all parts of society. Despite the uncertainty caused by the pandemic, service providers continued to switch on 5G and more than 100 have now announced commercial 5G service launches.[1] The first 5G standalone (SA) networks have also been launched.

The net addition of mobile subscriptions was low during Q3 2020 – 11 million. This is likely due to the pandemic and associated lockdown restrictions. For the long term, the mobile subscriptions outlook has been slightly adjusted downwards, as multiple and inactive subscriptions are being removed. We now forecast 8.8 billion mobile subscriptions by the end of 2026.

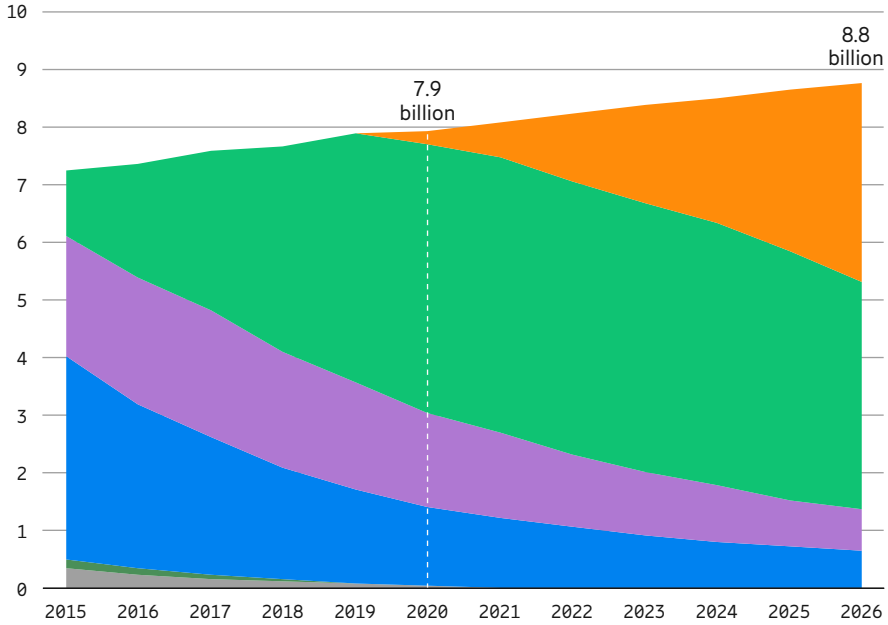
5G subscriptions with a 5G-capable device grew by around 50 million during the quarter to reach around 150 million.

We have increased our estimate for the number of 5G subscriptions[2] at the end of 2020, and now forecast 220 million. This is mainly due to a faster uptake in China than previously expected, driven by a national strategic focus, intense competition between service providers and more affordable 5G smartphones from several vendors. For North America, our forecast remains unchanged. Currently, North East Asia is the region with the highest 5G subscription penetration. However, in 2026 it is estimated that North America will be the region with the highest share of 5G subscriptions at 80 percent.

Over the forecast period, 5G subscription uptake is expected to be significantly faster than that of 4G (LTE), following its launch back in 2009. Key factors are China's earlier engagement with 5G compared to LTE, as well as the earlier availability of devices from several vendors. By the end of 2026, we forecast 3.5 billion 5G subscriptions globally, accounting for around 40 percent of all mobile subscriptions at that time.

LTE will remain the dominant mobile access technology by subscription over the forecast period. During Q3 2020, LTE subscriptions increased by approximately 70 million to reach a total of around 4.5 billion, equaling 57 percent of all mobile subscriptions. It is projected to peak in 2021 at 4.8 billion subscriptions and decline to around 3.9 billion subscriptions by the end of 2026 as more subscribers migrate to 5G.

Figure 1: Mobile subscriptions by technology (billion)



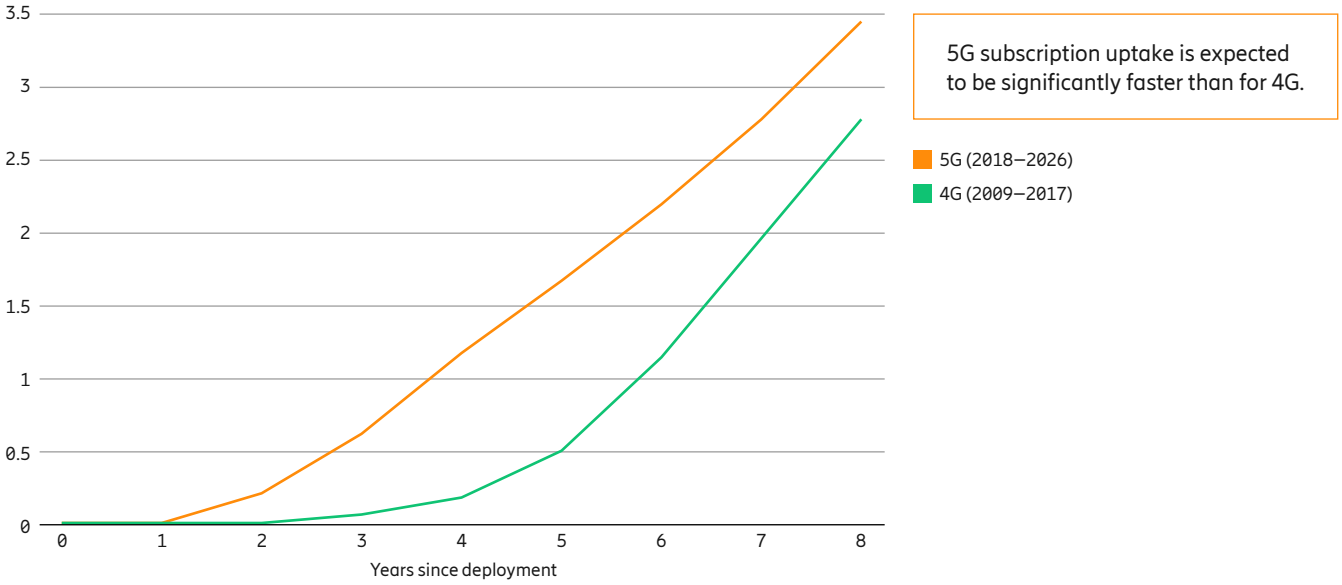
3.5bn

In 2026, 3.5 billion 5G subscriptions are forecast.

Note: IoT connections are not included in this graph. Fixed wireless access (FWA) connections are included.

[1] Ericsson and GSA (October 2020).
[2] A 5G subscription is counted as such when associated with a device that supports New Radio (NR), as specified in 3GPP Release 15, and is connected to a 5G-enabled network.

Figure 2: Comparison of 5G and 4G subscriptions uptake in the first years of deployment (billion)



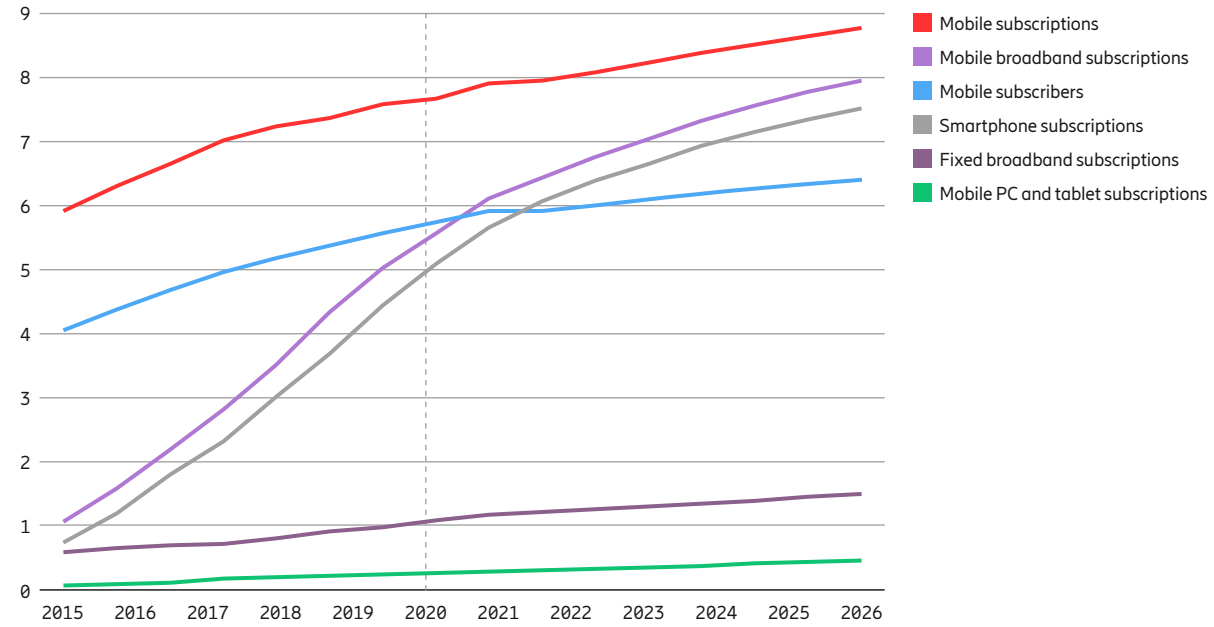
Subscriptions for mobile broadband projected at 91 percent in 2026

Today, there are around 7.9 billion mobile subscriptions. We estimate that this figure will increase to 8.8 billion by the end of 2026, out of which 91 percent will be for mobile broadband. The number of unique mobile subscribers is projected to be 6.4 billion by the end of the forecast period.

Smartphone penetration continues to rise, and subscriptions associated with smartphones account for about 75 percent of all mobile phone subscriptions. At the end of 2020, it is estimated there will be 6.1 billion smartphone subscriptions.

This number is forecast to reach 7.5 billion in 2026, which will account for around 85 percent of all mobile subscriptions at that time. Subscriptions for fixed broadband are expected to show limited growth of around 4 percent per year through 2026.[3] Subscriptions for mobile PCs and tablets are expected to show moderate growth, reaching around 450 million in 2026.

Figure 3: Subscriptions and subscribers (billion)

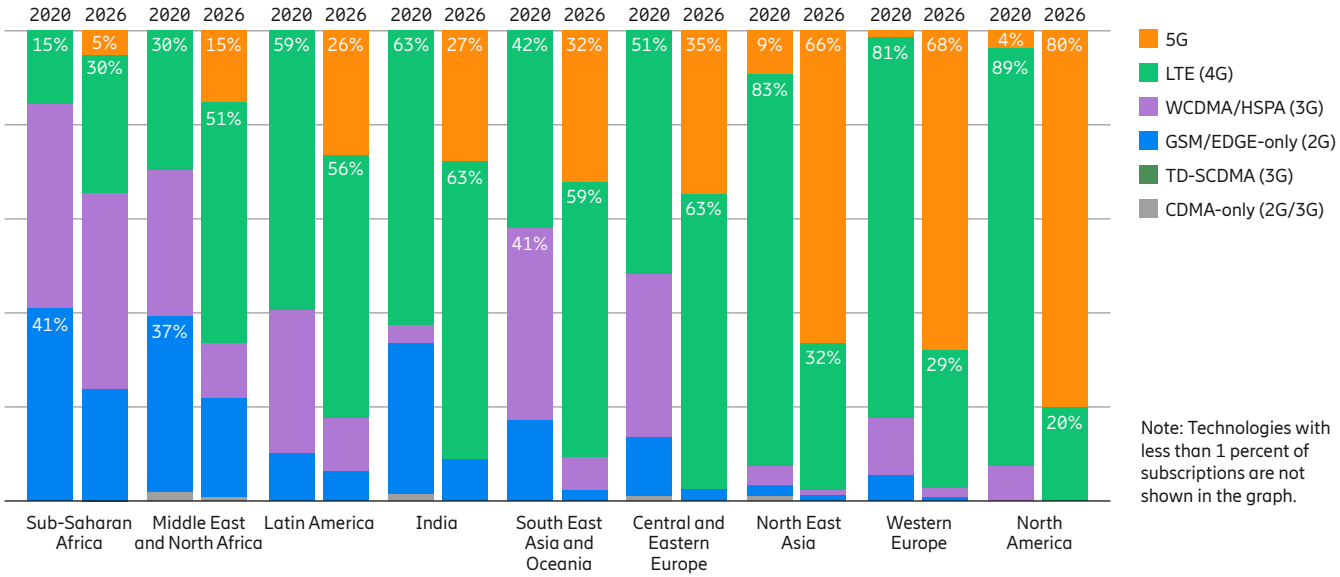


[3] The number of fixed broadband users is at least three times the number of fixed broadband connections due to shared subscriptions in households, enterprises and public access spots. It is the opposite for mobile phones, where subscription numbers exceed user numbers. FWA subscriptions are not part of the fixed broadband subscription estimate.

Regional subscriptions outlook

Mobile broadband subscriptions currently make up 81 percent of all mobile subscriptions.

Figure 4: Mobile subscriptions by region and technology (percent)



Note: Technologies with less than 1 percent of subscriptions are not shown in the graph.

Sub-Saharan Africa

In Sub-Saharan Africa, mobile subscriptions will continue to grow over the forecast period as mobile penetration, at 84 percent, is less than the global average. LTE is estimated to account for around 15 percent of subscriptions by the end of 2020. Over the forecast period mobile broadband[1] subscriptions are predicted to increase, reaching 76 percent of mobile subscriptions. While 5G and LTE subscriptions will continue to grow over the next 6 years, HSPA will remain the dominant technology with a share of over 40 percent in 2026. Driving factors behind the growth of mobile broadband subscriptions include a young, growing population with increasing digital skills and more affordable smartphones. Over the forecast period, discernible volumes of 5G subscriptions are expected from 2022, reaching 5 percent in 2026.

Middle East and North Africa

In the Middle East and North Africa region, around 30 percent of mobile subscriptions are estimated to be for LTE at the end of 2020. The region is anticipated to evolve over the forecast period, and by 2026, almost 80 percent of subscriptions are expected to be for mobile broadband, with LTE as the dominant technology with more than 50 percent of the subscriptions. Commercial 5G deployments with leading service providers have taken place here during 2019 and 2020 and 5G subscriptions will reach close to 1.4 million by the end of 2020, with most in the Gulf countries. Significant 5G volumes are expected in 2021 and the region is likely to reach around 130 million 5G subscriptions in 2026, representing around 15 percent of total mobile subscriptions.

Latin America

In Latin America, LTE remains the dominant radio access technology during the forecast period, accounting for 59 percent of subscriptions at the end of 2020 and a predicted 56 percent in 2026. A steady decline in WCDMA/HSPA is forecast as users migrate to LTE and 5G, falling from 30 to 11 percent. To date, Brazil and Colombia have launched commercial 5G services, and other countries such as Argentina, Chile and Mexico are investing in and deploying 5G. By the end of 2026, 5G is set to make up 26 percent of mobile subscriptions.

India

In the India region, LTE subscriptions are forecast to increase from 710 million in 2020 to 820 million in 2026, increasing at a compound annual growth rate (CAGR) of 2 percent. LTE remains the dominant technology in 2020, accounting for 63 percent of mobile subscriptions.

[1] Mobile broadband includes radio access technologies HSPA (3G), LTE (4G), 5G, CDMA2000 EV-DO, TD-SCDMA and Mobile WiMAX.

The technology will continue to be dominant, representing 63 percent of mobile subscriptions also in 2026, with 3G being phased out by that time. 5G will represent around 27 percent of mobile subscriptions in India at the end of 2026, estimated at about 350 million subscriptions. Mobile broadband technologies accounted for 67 percent of mobile subscriptions in 2020, and this figure is predicted to reach 91 percent by 2026, when the total number of mobile broadband subscriptions is set to reach close to 1.2 billion. The number of smartphone subscriptions has increased to 760 million in 2020 and is expected to grow at a CAGR of 7 percent, reaching close to 1.2 billion by 2026.

South East Asia and Oceania
The second half of the year has seen a number of commercial 5G launches in South East Asia and Oceania with live networks now in Australia, New Zealand, Thailand, Singapore and the Philippines. Upcoming spectrum auctions planned for 2021 in countries like Vietnam and Malaysia will bring additional 5G deployments next year. Though current commercial 5G networks in the region have mostly been deployed on mid-bands, market interest for high-band spectrum has driven successful trials for mmWave in Australia showcasing groundbreaking speeds.

Dynamic spectrum sharing has also been deployed in several countries in the region, enabling mobile operators to quickly increase their 5G footprint as rollouts continue. In addition to mobile broadband deployments, fixed wireless access (FWA) adoption is growing strong with live 5G networks already launched in Australia and the Philippines.

In 2026, 5G is predicted to be the second most popular technology in the region, only behind LTE, surpassing 380 million subscriptions and accounting for more than 30 percent of all mobile subscriptions.

Central and Eastern Europe
In Central and Eastern Europe, LTE is the dominant technology and now accounts for 51 percent of all subscriptions. To date, more than 10 5G networks have been commercially launched across the region. In 2026, LTE will remain the dominant technology and is expected to account for 63 percent of mobile subscriptions, while 5G subscriptions are forecast to make up 35 percent. During the forecast period, there will continue to be a significant decline in WCDMA/HSPA, from 36 percent to virtually zero, as users migrate to LTE and 5G.

Further spectrum auctions in the key frequency bands like 700MHz, 3.4–3.8GHz and 4.7GHz were planned for the end of 2020 and the beginning of 2021, some of which have now been delayed. This will have a short-term impact on 5G deployment in affected countries.

North East Asia
In North East Asia, 5G deployment has been accelerating during 2020 and all major service providers in the region have now launched 5G commercial services. In South Korea, 5G network coverage continues to improve, with the goal of nationwide coverage in 2021. In China, the top 3 service providers are building out large-scale 5G coverage, and the country is estimated to reach 175 million 5G subscriptions by the end of 2020. The leading service providers in Japan have launched commercial 5G services, but expected 5G subscription uptake has remained low, impacted by the postponement of the Tokyo summer sport event, as well as COVID-19. However, service providers in Japan are now accelerating 5G deployments, as well as dynamic spectrum sharing, and the number of subscriptions is expected to grow significantly with the increased availability of 5G-capable devices.

By the end of 2020 the region is anticipated to have more than 190 million 5G subscriptions, and at the close of the forecast period, the 5G subscription penetration is projected to reach 66 percent.

80%

5G will account for 80 percent of North American mobile subscriptions in 2026.

Western Europe
In Western Europe, LTE is the dominant access technology, accounting for 81 percent of all subscriptions. LTE is predicted to decline to 29 percent and WCDMA/HSPA to only 2 percent of subscriptions in 2026 as subscribers migrate to 5G. Around 35 service providers have launched 5G services across the region, delivering services to around 6.5 million subscribers by the end of 2020. Further spectrum auctions in the 700MHz and 3.4–3.8GHz bands were planned during 2020, but some have now been delayed, which will have a short-term impact on the deployment and coverage of 5G in the region. The 5G subscription penetration is projected to reach 68 percent by the end of 2026.

North America
In North America, 5G commercialization is moving at a rapid pace. Service providers have already launched commercial 5G services, focused on mobile broadband. The introduction of 5G smartphones supporting all three spectrum bands will make 2021 an eventful year for early 5G adopters. FWA will play a key role in closing the digital divide where the pandemic has exposed large gaps for education, remote working and small businesses. By 2026, more than 340 million 5G subscriptions are anticipated in the region, accounting for 80 percent of mobile subscriptions.

Fixed wireless access outlook

Fixed wireless access (FWA) connections are forecast to grow more than threefold and reach over 180 million by the end of 2026, accounting for around 25 percent of total mobile network data traffic globally.

Service providers offering FWA on the rise
It is well accepted by now that the COVID-19 pandemic is accelerating digitalization, as well as increasing the importance of, and need for, fast and reliable home broadband connectivity. FWA is, in many cases, the quickest alternative for service providers to meet this demand.

In October 2020, Ericsson updated its study of FWA retail packages offered by service providers worldwide. Out of the 311 service providers studied, 200 had an FWA offering, which represents an average of 64 percent globally. Service providers' adoption of FWA offerings has doubled since the first measurements in December 2018 compared to October 2020.

Looking at the regional breakdowns, there is growth across all regions since February 2020, except Asia-Pacific. Western Europe has the highest FWA adoption at 93 percent, with North America second at 80 percent. Central Europe, Latin America and North America all grew around 10 percentage points during the period of February to October 2020.

Definition of FWA
A connection that provides primary broadband access through wireless wide area mobile network enabled customer premises equipment (CPE). This includes various form factors of CPEs, such as indoor (desktop and window) and outdoor (rooftop and wall mounted). It does not include portable battery-based Wi-Fi routers or dongles.

Figure 5: Global number of service providers offering FWA

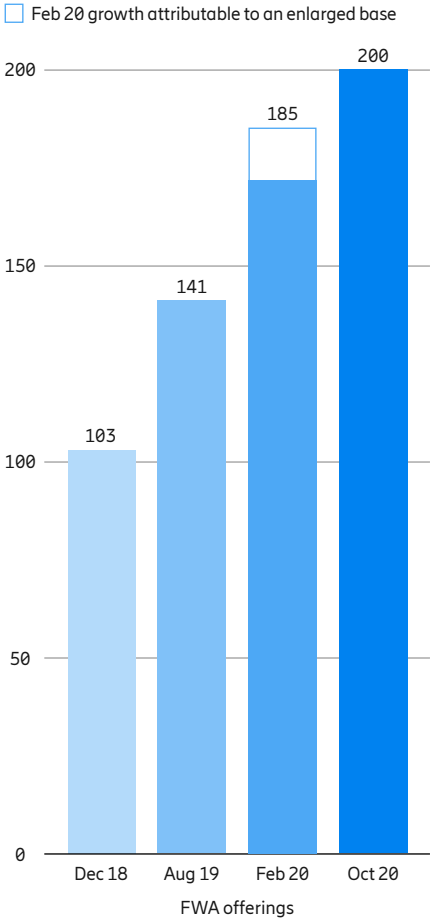


Figure 6: Regional percentage of service providers offering FWA

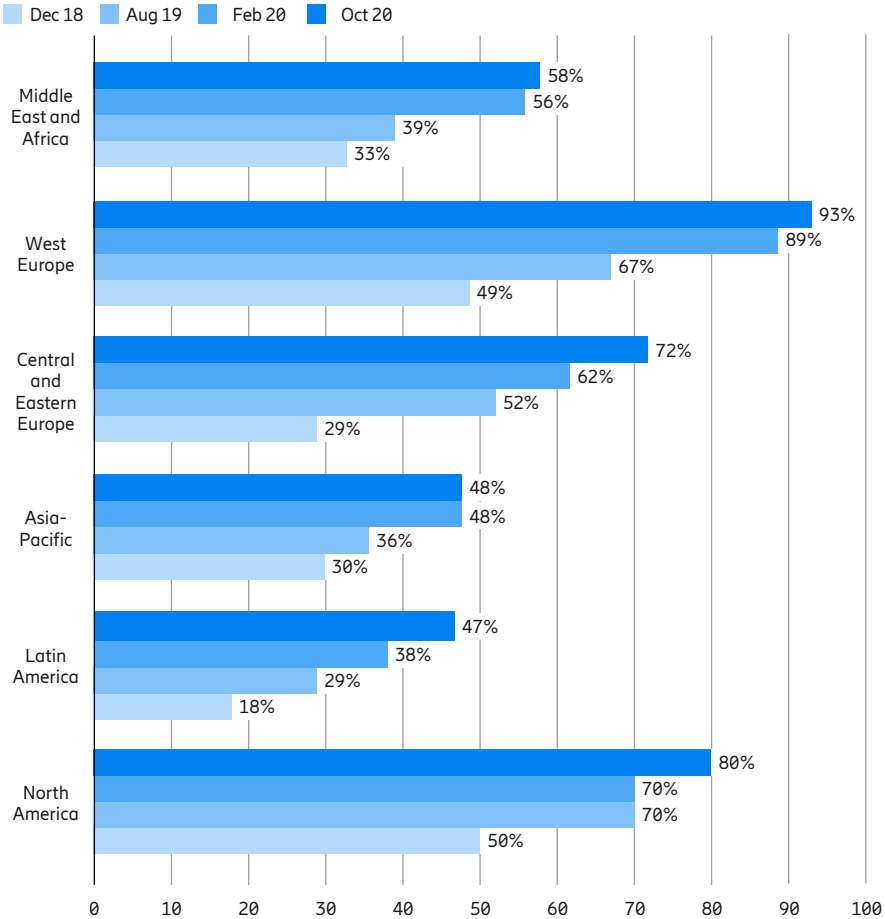


Figure 7: FWA connections

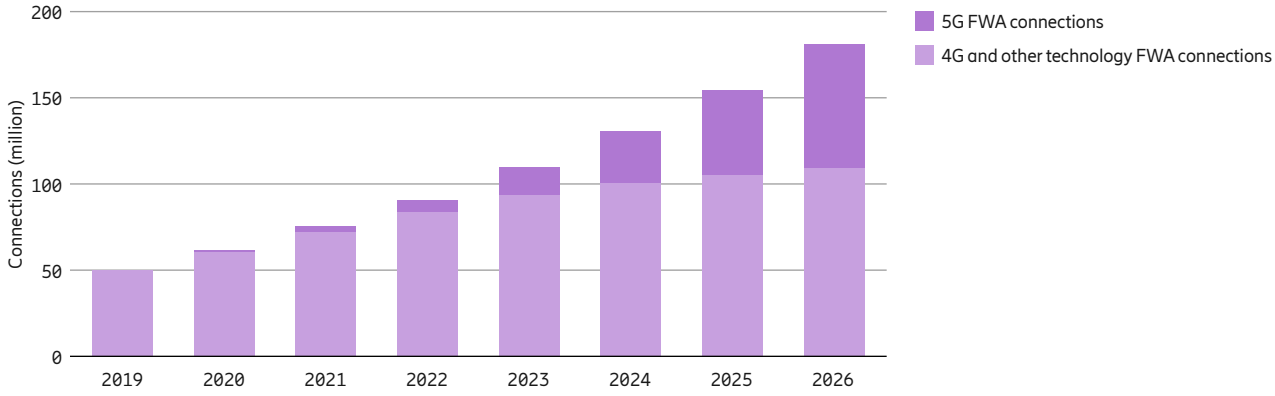
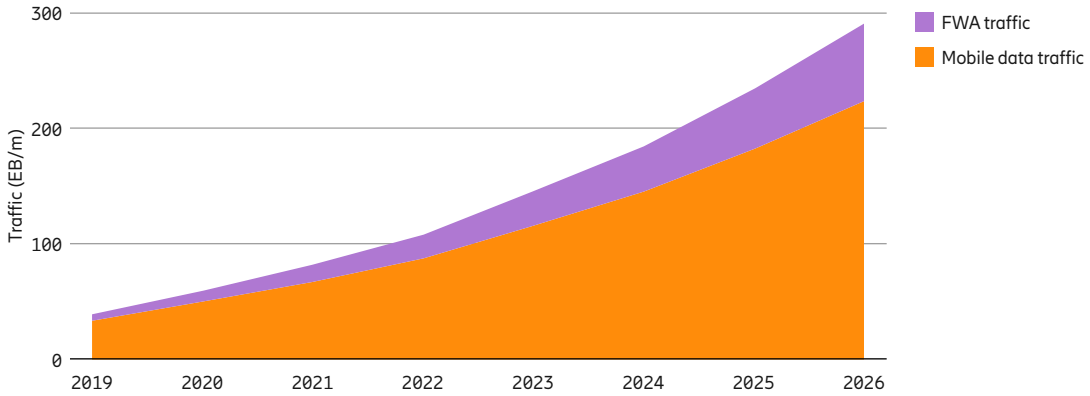


Figure 8: Mobile data and FWA traffic



FWA global connections uptake

In addition to the need driven by the pandemic, there are three main factors that drive FWA growth. First, demand from consumers and businesses for digital services continues, driving the need for broadband connectivity. Second, FWA delivered over 4G or 5G is an increasingly cost-efficient broadband alternative in areas with limited availability of fixed services, such as DSL, cable and fiber. Increasing capacity, allowed by greater spectrum allocations and technology advancements for 4G and 5G networks, is driving higher network efficiency in terms of the cost per delivered gigabyte. Third, governments are fueling broadband connectivity through programs and subsidies, as it is considered vital for digitalization efforts and economic growth.

The limited reporting from service providers and regulators of FWA connections, combined with varying FWA definitions, results in differences in the reported number of connections globally. However, we estimate there will be more than 60 million FWA connections by the end of 2020. This number is forecast to grow more than threefold through 2026, reaching over 180 million. Out of these, 5G FWA connections are expected to grow to more than 70 million by 2026, representing around 40 percent of total FWA connections.

FWA data traffic is estimated to represent around 15 percent of global mobile network data traffic by the end of 2020. This is projected to grow 7 times to reach 67EB in 2026, accounting for around 25 percent of total mobile network data traffic globally.

FWA Middle East and Africa connection uptake

Middle East and Africa is a region with limited broadband connectivity. We estimate that there will be around 65 million broadband connections by the end of 2020, representing a total household penetration of around 18 percent. Out of these broadband connections, FWA is estimated to represent around 20 percent.

There are several examples of service providers in this region that are successful in meeting the large demand for broadband connectivity. To give one example, a leading service provider in Turkey experienced 3.5 times growth from Q2 2019 to Q2 2020, with the FWA user base reaching 0.5 million connections in July 2020.

Most of the FWA offerings in this region are 4G based. However, in the Middle East, there is a growing number of 5G FWA offerings, complementing the 4G FWA offerings. For instance, a leading service provider in Oman showed a 171 percent annual growth in 4G and 5G FWA connections, representing 12 percent of their fixed broadband connections as of Q2 2020.

FWA is projected to grow more than threefold, reaching around 35 million connections by 2026 and representing around 35 percent of all broadband connections in the region.

FWA in the broadband context

There are approximately 2 billion households in the world. By the end of 2019, approximately 1.2 billion (60 percent) had a fixed broadband connection, and by the end of 2026 this will reach approximately 1.5 billion (around 70 percent). FWA will then represent 12 percent of all fixed broadband connections. However, it is worth mentioning that FWA is also seen as a replacement option for around 300 million existing DSL connections.

The FWA impact in society is larger than the number of FWA connections, as it brings connectivity to three to five people in a household depending on regional demographics. The forecast of over 180 million FWA connections by the end of 2026 represents approximately 650 million individuals having access to a wireless broadband connection.

5G device outlook

The introduction of New Radio (NR) functionality is accelerating.

5G adoption is growing in momentum in both the network and device domains:

- over 150 5G device models launched commercially, including iOS-capable devices
- many devices supporting 5G frequency division duplex (FDD), most capable of dynamic spectrum sharing (DSS)
- first standalone (SA) network launches in Asia and North America
- first chipsets and devices with NR carrier aggregation (CA) capability
- first 5G-capable devices with retail prices at USD 300 for sub 6GHz outside China and USD 400 for a device with mmWave support in the US
- new device chipsets for mmWave spectrum bands will lower the price points for these devices

2020 is the year of new NR functionality
During 2020 the pace of 5G introductions has accelerated, with many network developments including:

- the introduction of FDD bands for improved 5G coverage
- commercialization of SA
- deployment of DSS both for NSA and SA to share LTE and 5G on the same carrier
- deployment of CA, combining two NR carriers in the downlink – both for SA and NSA

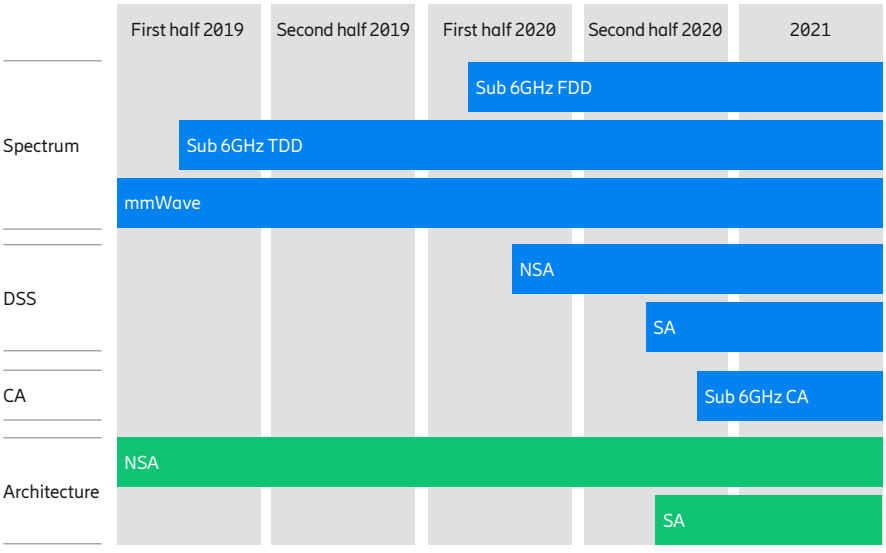
mmWave
Increased competition in the mmWave space has led to the first devices with a retail price around USD 400. With more competition in the chipset arena there will also be new entry models for devices supporting these frequency bands. More than five top-tier smartphone vendors now have mmWave-capable phones. Additionally, the fixed wireless access (FWA) use case has been strengthened by coverage enhancements in mmWave, both on devices and on the network.

Non-standalone (NSA) is no longer standing alone
5G SA networks have now been launched in North America and China. Devices have been upgraded via software updates to enable SA capabilities in applicable markets. Since networks can serve both NSA and SA users in the same cell, devices can choose between NSA and SA access. It is expected that deployed NSA and SA will coexist for several years.

CA on NR
In NSA, the first level of aggregation is provided by combining an LTE with an NR bearer. The next step is combining two or more NR carriers. This feature will provide a significant increase in time division duplex (TDD) coverage. Mobile broadband data rates can thereby be further boosted where additional TDD spectrum is available. This functionality has been matched by a fast introduction of new chipsets which will be utilized by device vendors.

The 5G device ecosystem is broadening
Availability of different device price tiers and operating systems is crucial for 5G adoption and now iOS users can also enjoy 5G. Chipset vendors are competing for the volume market with more and more attractive chipset models for mass device deployments. The first 5G smartphone outside of China to reach the USD 300 price point has emerged and it is expected that in 2021 some devices will even undercut that level.

Figure 9: 5G technology market readiness



Note: The graph illustrates availability of network functionality, as well as support in devices.

Voice and communication services trends and outlook

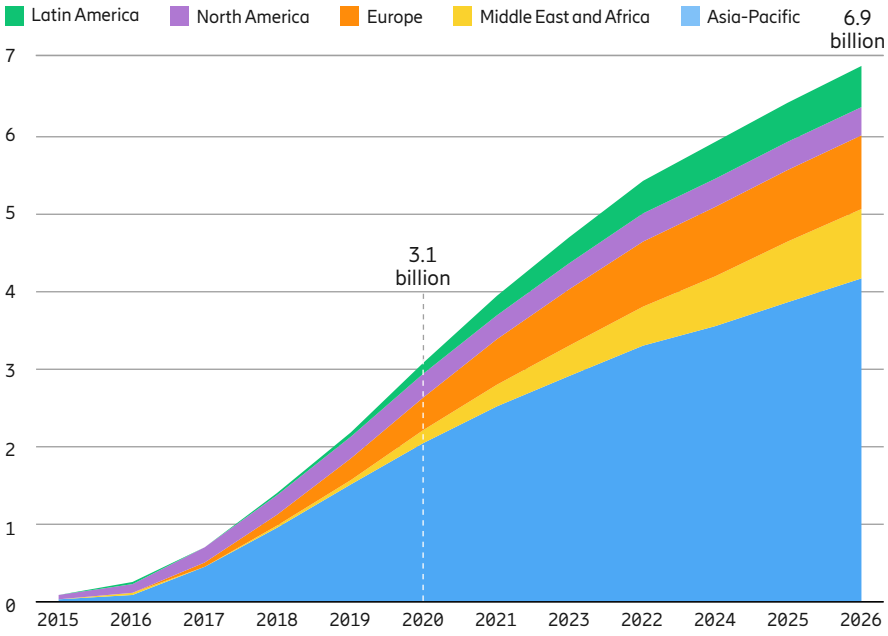
VoLTE is the foundation for enabling globally interoperable voice and communication services on 4G and 5G devices.

Service providers continue to evolve their networks to support VoLTE-based services. These have now been launched in over 220 networks in more than 100 countries. VoLTE services are being deployed using cloud technologies to enable cost-efficient network implementation and operations.

The number of subscriptions with VoLTE-enabled services is estimated to exceed 3 billion at the end of 2020 and reach 6.9 billion by the end of 2026 and account for more than 90 percent of all combined LTE and 5G subscriptions. When 2G and 3G networks are decommissioned, this will accelerate VoLTE adoption and VoLTE roaming agreements as the current most used 4G voice solution, Circuit-Switched Fallback (CSFB), will not work without 2G or 3G.

VoLTE (using IP Multimedia Subsystem, or IMS) is also the foundation for enabling 5G voice calls as well as SMS, rich communications services (RCS), and new communication services on 5G devices. IMS is the only standardized voice solution for 5G, and there is no circuit-switched voice fallback. Voice services will be deployed using several solutions in 5G networks: LTE-NR dual connectivity, Evolved Packet System fallback (EPS fallback) and Voice over New Radio (VoNR). The first EPS fallback voice-enabled network went live during the second half of 2020 in North America. End-to-end testing of 5G voice (VoNR) and 5G video calling with network infrastructure and the device ecosystem has been successfully completed.

Figure 10: VoLTE subscriptions by region (billion)



Device availability and use case uptake

There are 2,880 VoLTE-enabled 4G device models, of which around 85 percent are phones. Other devices include indoor CPE, fixed wireless phones, tablet PCs and smart watches. VoLTE-enabled smartphones also have enhanced functionalities, such as improved voice codecs and native video calling. More than 165 device models support HD Voice+ (Evolved Voice System, or EVS), and 410 devices support video calling over LTE (ViLTE). All 5G smartphones support VoLTE.

A recent service provider market offering is smart speakers with voice calling capabilities, using the same mobile phone number as that of a smartphone. This builds on VoLTE multi-device network capabilities which tie several devices, such as phones, smartwatches and smart speakers, to the same phone number. Over 100 service provider networks support cellular smartwatches enabled with voice services. Cellular wearables with standalone subscriptions, including voice calling, are being launched for new user groups such as kids and seniors.

Other VoLTE-based services include additional phone lines on the same phone, shared phone lines, enterprise collaboration services in combination with mobile HD voice, and voice for IoT devices.

5G-related service innovations are being considered, including combinations with AR and VR. A new 3GPP standardized functionality will enable 5G interactive calling, which combines a 5G voice call with real-time content sharing, for example joint web browsing on 5G smartphones, or business and enterprise media sharing between different devices and endpoints. This could become a mainstream 5G voice service in the future.

Note: Source for network and device statistics: Global mobile Suppliers Association (GSA).

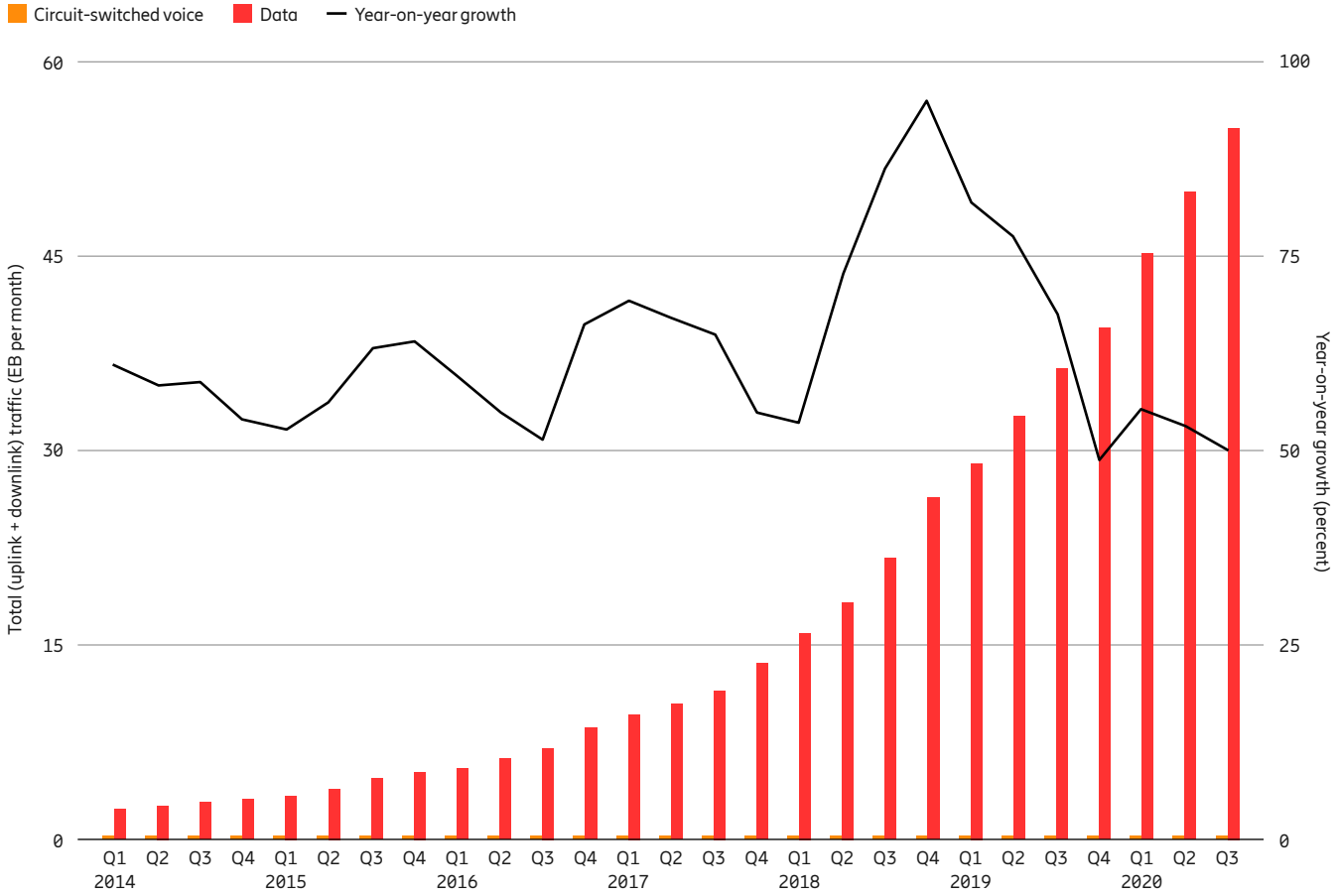
Mobile network traffic Q3 2020

Mobile network data traffic grew 50 percent between Q3 2019 and Q3 2020.

As in Q2 2020, the year-on-year traffic growth rate remained at a more normal level, around 50 percent, compared to the extraordinary peak in 2018 and the first part of 2019. The quarter-on-quarter growth for Q3 2020 was 10 percent. COVID-19 related restrictions, such as lockdowns and constraints on movement, continue to be reflected in people's communication patterns. However, mobile traffic and mobility are gradually returning to normal levels. In many countries, mobile traffic is, to a certain extent, still geographically shifted from public and office locations to homes and remote work locations. Some countries have seen an increase in mobile broadband data traffic, while others have experienced a decline supported by Wi-Fi offload in homes with good fixed broadband connections. These traffic patterns could change again if new waves of COVID-19 occur.

Over the long term, traffic[1] growth is driven by both the rising number of smartphone subscriptions and an increasing average data volume per subscription, fueled primarily by more viewing of video content. Figure 11 shows total global monthly network data and voice traffic from Q1 2014 to Q3 2020, along with the year-on-year percentage change for mobile network data traffic.

Figure 11: Global mobile network data traffic and year-on-year growth (EB per month)



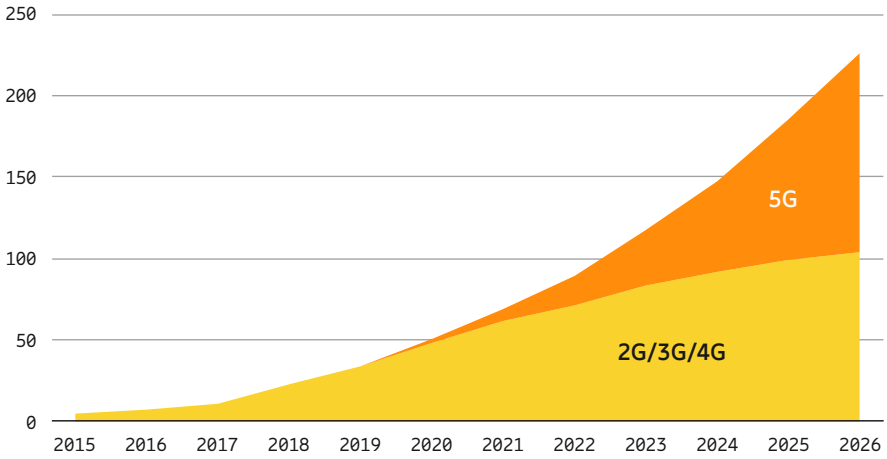
Note: Mobile network data traffic also includes traffic generated by fixed wireless access (FWA) services.

[1] Traffic does not include DVB-H, Wi-Fi or Mobile WiMAX. VoIP is included.

Mobile data traffic outlook

In 2026, 5G networks will carry more than half of the world's mobile data traffic.

Figure 12: Global mobile data traffic (EB per month)



Note: This graph does not include traffic generated by fixed wireless access (FWA) services.

54%

In 2026, 5G will account for an estimated 54 percent of total mobile data.

Global total mobile data traffic is estimated to reach around 51EB per month by the end of 2020 and is projected to grow by a factor of around 4.5 to reach 226EB per month in 2026. This figure represents the mobile data that will be consumed by more than 6 billion people using smartphones, laptops and a multitude of new devices at that time.

Video traffic currently accounts for 66 percent of all mobile data traffic, a share that is forecast to increase to 77 percent in 2026.

Smartphones continue to be at the epicenter of this development as they generate most of the mobile data traffic – about 95 percent – today, a share that is projected to increase throughout the forecast period.

Populous markets that launch 5G early are likely to lead traffic growth over the forecast period. By 2026, we expect that 54 percent of total mobile data traffic will be carried by 5G networks.

Large variations in traffic growth across regions

Traffic growth can be very volatile between years and can also vary significantly between countries, depending on local market dynamics. We have significantly increased our forecasts for North East Asia and South East Asia and Oceania, as we have seen that the data consumption is higher than earlier anticipated in markets with low average revenue per user (ARPU). In India for example, traffic growth continues an upward trajectory and remains the region with the highest monthly usage per smartphone at 15.7GB.

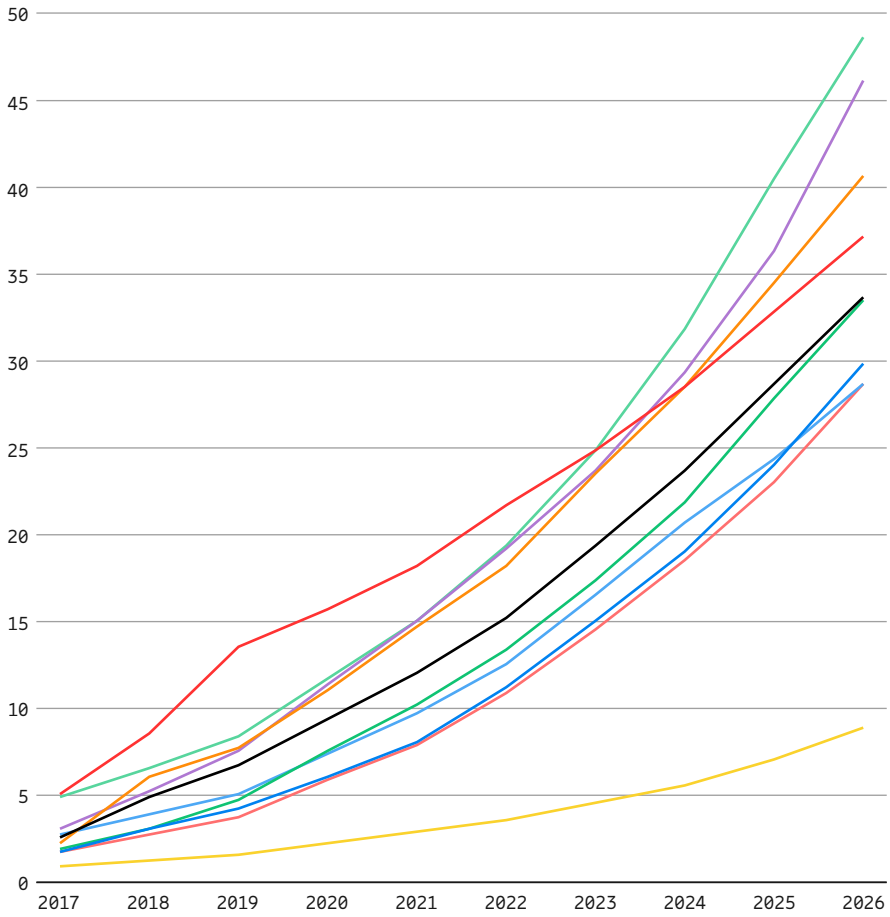
Globally, the growth in mobile data traffic per smartphone can be attributed to three main drivers: improved device capabilities, an increase in data-intensive content and more data throughput from subsequent generations of network technology.

Close to 1.2 billion smartphone subscriptions in India in 2026

In the India region, the average monthly mobile data usage per smartphone continues to show robust growth, boosted by the rapid adoption of 4G and people working from home during COVID-19. The reliance of people on their mobile networks to stay connected as well as work from home has contributed to the average traffic per smartphone user increasing from 13.5GB per month in 2019 to 15.7GB per month in 2020. The average traffic per smartphone is expected to further increase to around 37GB per month in 2026. Low prices for mobile broadband services, affordable smartphones and increased time spent by people online all contribute to monthly usage growth in the region.

Total traffic is projected to quadruple, reaching 35EB per month in 2026. This comes from two factors: high growth in the number of smartphone users, including growth in rural areas, and an increase in average usage per smartphone. An additional 390 million smartphone subscriptions are expected in India during the forecast period, taking the total number close to 1.2 billion in 2026.

Figure 13: Mobile data traffic per smartphone (GB per month)



Regions	2020	2026	CAGR 2020–2026
North America	11.8	49	27%
Western Europe	11.3	46	26%
North East Asia	11.1	41	24%
India	15.7	37	15%
Global average	9.4	34	24%
South East Asia and Oceania	7.6	33	28%
Middle East and North Africa	6.0	30	30%
Central and Eastern Europe	7.3	29	26%
Latin America	5.8	29	30%
Sub-Saharan Africa	2.2	8.9	26%

In North America, future monthly GB growth depends on 5G service adoption

The monthly average usage of mobile data in North America is expected to reach 49GB per month and smartphone in 2026. A smartphone-savvy consumer base and video-rich applications in combination with large data plans will drive traffic growth. While there may be strong growth in traffic per smartphone in the near term, the adoption of immersive consumer services using VR and AR is expected to lead to an even higher growth rate in the long term. In 2026, 5G subscription penetration is set to be the highest of all regions at 80 percent.

The **Western Europe** traffic growth rate follows a similar pattern to that expected in North America. The more fragmented market situation is anticipated to lead to later mass-market adoption of 5G, but in 2026 the traffic usage per smartphone is expected to be 46GB per month, which will be close to the usage in North America at that time.

High growth in monthly mobile data usage continues in North East Asia

Overall, mobile data usage keeps growing in North East Asia. Remote working due to COVID-19 has been one of the traffic drivers during 2020. The monthly usage per smartphone is estimated to reach 11.1GB by the end of the year, increasing from 7.8GB at the end of 2019. With 5G set to capture a great number of early adopters, we continue to expect high growth numbers in the region. In South Korea, a leading 5G market, average monthly data usage per 5G subscriber is over 25GB.
The data traffic per smartphone is expected to reach 41GB per month in 2026.

The **Middle East and North Africa** region is expected to have the highest growth rate during the forecast period, increasing total mobile data traffic by a factor of almost 7 between 2020 and 2026. The average data per smartphone is expected to reach 30GB per month in 2026.

Sub-Saharan Africa also has a very high growth rate, but from a relatively small base, with total mobile data traffic increasing from 0.87EB per month to 5.6EB in 2026. Average traffic per smartphone is expected to reach 8.9GB per month over the forecast period.

In **South East Asia and Oceania**, total mobile data traffic continues to grow steadily with a compound annual growth rate (CAGR) of 33 percent for the forecast period. It is expected to reach 32EB per month in 2026, equivalent to 33GB per month per smartphone. Growth in mobile data consumption has translated into more diversified and generous data plans from mobile operators across different geographies.

Latin America is expected to follow a similar trend as South East Asia over the forecast period on a regional level, while individual countries can show very different growth rates for traffic per smartphone. Traffic growth is driven by coverage build-out and continued adoption of 4G (and eventually 5G), linked to a rise in smartphone subscriptions and increases in average data usage per smartphone. The data traffic per smartphone is expected to reach 29GB per month in 2026.

In **Central and Eastern Europe**, growth is also fueled by 4G and 5G adoption, but the region has a somewhat higher traffic per smartphone starting point. Over the forecast period, the monthly traffic per smartphone is expected to increase from 7.3GB to 29GB per month.

It is important to bear in mind that there are significant variations in monthly data consumption within regions, with individual countries and service providers having considerably higher monthly consumption than any regional averages.

IoT connections outlook

In 2026, NB-IoT and Cat-M technologies are expected to make up 45 percent of all cellular IoT connections.

The Massive IoT technologies NB-IoT and Cat-M[1] continue to be rolled out around the world, but at a slightly slower pace in 2020 than previously forecast due to the impact of COVID-19. 2G and 3G connectivity still enable the majority of IoT applications, but during 2020, the numbers of Massive IoT connections are expected to have doubled, reaching close to 200 million connections.

Massive IoT primarily consists of wide-area use cases, connecting large numbers of low-complexity, low-cost devices that have long battery life and relatively low throughput. About 110 service providers have been identified as having launched NB-IoT and close to 50 as having launched Cat-M. NB-IoT and Cat-M technologies complement each other, and several service providers have launched both technologies. At the end of 2026, NB-IoT and Cat-M are projected to account for 45 percent of all cellular IoT connections. Cat-M and NB-IoT follow a smooth evolution path into 5G networks, and can continue to be deployed in the same bands as today, even when 5G is introduced. Commercial devices for Massive IoT include various types of meters, sensors, trackers and wearables.

Broadband IoT mainly includes wide-area use cases that require higher throughput, lower latency and larger data volumes than Massive IoT technologies can support. LTE is already supporting many use cases in this segment. By the end of 2026, 44 percent of cellular IoT connections will be broadband IoT, with 4G connecting the majority. With the introduction of 5G New Radio (NR) in old and new spectrum, throughput data rates will increase substantially for this segment.

Critical IoT is intended for time-critical communications in both wide- and local-area use cases that require guaranteed data delivery with specified latency targets. Critical IoT will be introduced in 5G networks with the advanced time-critical communication capabilities of 5G NR. It will enable a wide range of time-critical services for consumers, enterprises and public institutions across various sectors. Typical use cases include cloud-based AR/VR, cloud robotics, autonomous vehicles, advanced cloud gaming, and real-time coordination and control of machines and processes. Deployment of the first modules supporting Critical IoT use cases is expected in 2021.

North East Asia is leading in terms of the number of cellular IoT connections. At the end of 2020, the region is expected to account for 64 percent of all cellular IoT connections, a figure set to increase to 69 percent by 2026.

IoT devices

The first 5G NR-capable IoT platforms have recently been released. Modules from several vendors are available, as well as tailored platforms for PCs and advanced wearables. In the second half of 2020 and during 2021, this is expected to expand to include use cases involving personal and commercial vehicles, cameras, industry routers and gaming. Such devices will initially support mobile broadband capabilities, but performance is expected to evolve towards time-critical communication capabilities where needed, via software upgrades on devices and networks.

Figure 14: Cellular IoT connections by segment and technology (billion)

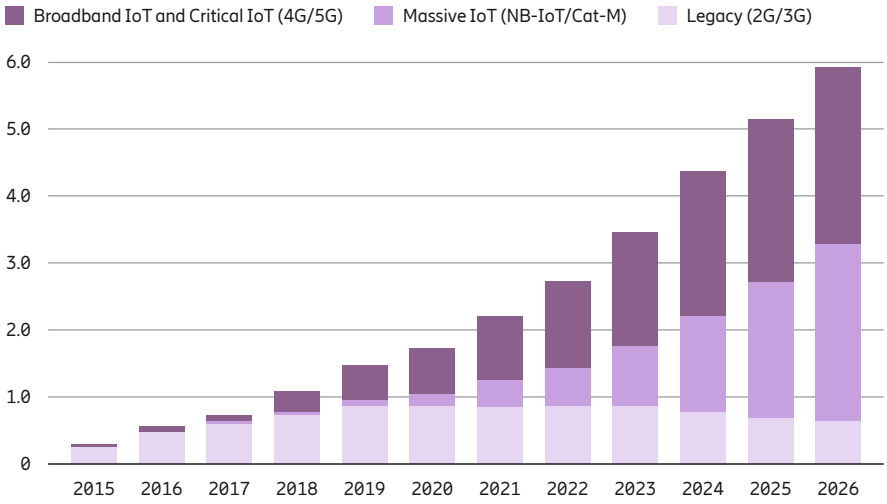


Figure 15: IoT connections (billion)

IoT	2020	2026	CAGR
Wide-area IoT	1.9	6.3	22%
Cellular IoT[2]	1.7	5.9	23%
Short-range IoT	10.7	20.6	12%
Total	**12.6**	**26.9**	**13%**

[1] Cat-M includes both Cat-M1 and Cat-M2. Only Cat-M1 is being supported today.
[2] These figures are also included in the figures for wide-area IoT.

Time-critical communications with 5G

Critical IoT will be introduced with 5G networks. It will enable a wide range of time-critical services for consumers, enterprises and public institutions across various sectors, with 5G public and dedicated networks.

Critical IoT is intended for time-critical applications that demand data delivery within a specified time duration with a certain guarantee; for example data delivery within 50ms with 99.9 percent certainty (reliability). This is fundamentally different from enhanced mobile broadband connectivity, which maximizes data rates without any guarantee on latency. Early adoption of time-critical communication is expected for remote control and real-time media applications via public and dedicated networks.

Time-critical communication enables new applications

There are four fundamental time-critical use case categories that are common across various verticals.

Real-time media – time-critical communication enables offloading of processing and rendering to the cloud, improving the user experience and enabling the use of lightweight devices in interactive cloud gaming and cloud AR/VR for enterprises and consumers.

Remote control refers to control of machines, equipment, and aerial and ground vehicles from a distance. Remote control can improve work environments by moving humans out of hazardous locations and giving access to a broader workforce. It is an important functionality for autonomous vehicles, in order to reliably take temporary control in case the autonomous function fails.

Industrial control includes real-time process monitoring and control, controller-to-controller communication, smart grid control, machine vision for robotics and motion control.

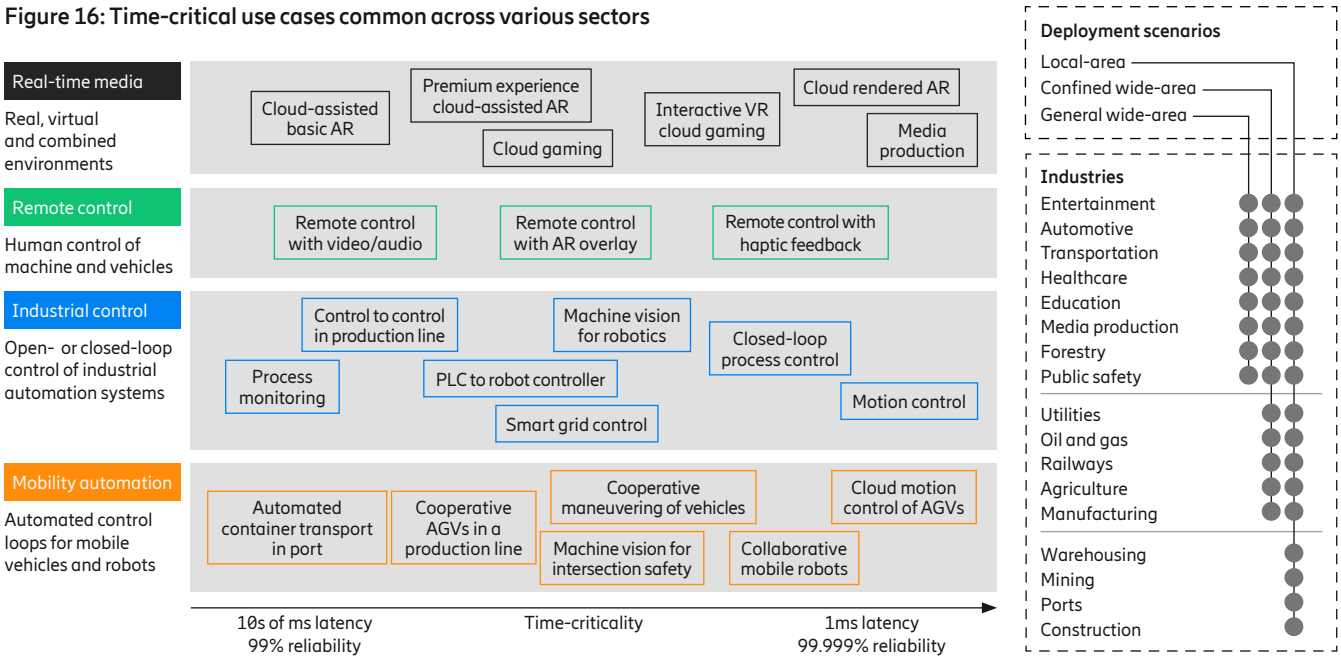
Mobility automation refers to the automation of control loops for vehicles and mobile robots. This can include automated guided vehicles (AGVs), cooperative maneuvering of vehicles and advanced intersection safety.

Network deployment strategy depends on coverage needs

There are three main network deployment scenarios. Local-area deployment includes indoor and outdoor coverage for a small geographical area such as a factory, port or mine. Confined wide-area deployment is for a predefined geographical area such as a highway or within a city center. General wide-area deployment is about serving devices almost anywhere.

Service providers can start to address time-critical use cases (such as the entertainment, healthcare, public safety and education sectors) in the wide area by adding support for Critical IoT connectivity to the NR carriers through upgrades. More stringent requirements demand network densification, edge computing, and further distribution and duplication of core network functions. In the confined wide area, relatively stringent requirements can be addressed with investments in infrastructure (for example, for automotive, railways, and utilities sectors). In local-area scenarios, extreme requirements can be supported once the end-to-end ecosystem is established.

Figure 16: Time-critical use cases common across various sectors



Network coverage

5G is estimated to cover 60 percent of the world's population in 2026.

Momentum continues in the build-out of 4G (LTE) networks. Global 4G population coverage will be over 80 percent at the end of 2020 and is forecast to reach around 95 percent in 2026. 4G networks are also evolving to deliver increased network capacity and faster data speeds. There are currently 795 commercial 4G networks deployed. Of these, 324 have been upgraded to LTE-Advanced, and 41 Gigabit LTE networks have been commercially launched.

5G launch and deployment as per the end of 2019

Global 5G population coverage was around 5 percent at the end of 2019, with the main deployments made in larger cities. The most extensive coverage build-outs have been in the US, China, South Korea and Switzerland. In South Korea, service providers rapidly built 5G networks that covered a large part of the population. In Switzerland, 5G population coverage reached over 90 percent at the end of 2019.

5G estimated to cover over 1 billion people by the end of 2020

To date, there have been more than 100 5G commercial launches across the world. The estimated population coverage by the end of 2020 is approximately 15 percent, equivalent to over 1 billion people.

5G coverage build-out can be divided into three broad deployments:

1. New bands in the sub-6GHz range
2. mmWave frequency bands
3. Existing LTE bands

There are big differences between countries in how service providers have deployed 5G. In the US, all three of these categories have been used, resulting in 5G coverage for a large part of the population. In Europe, countries such as Germany and Spain have used deployments in existing bands to create substantial coverage. China has mainly deployed new bands to achieve a large population coverage.

5G estimated to cover around 60 percent of the population in 2026

There are several global factors impacting the forecast; the most evident short-term ones are COVID-19 and the geopolitical situation. The exact impact of these factors on 5G population coverage remains to be seen. 5G is still expected to be the fastest deployed mobile communication technology in history and is forecast to cover about 60 percent of the world's population in 2026.

Figure 17: World population coverage by technology[1]

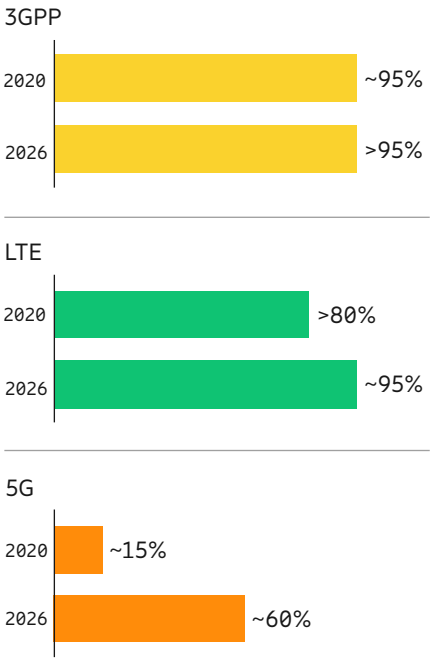
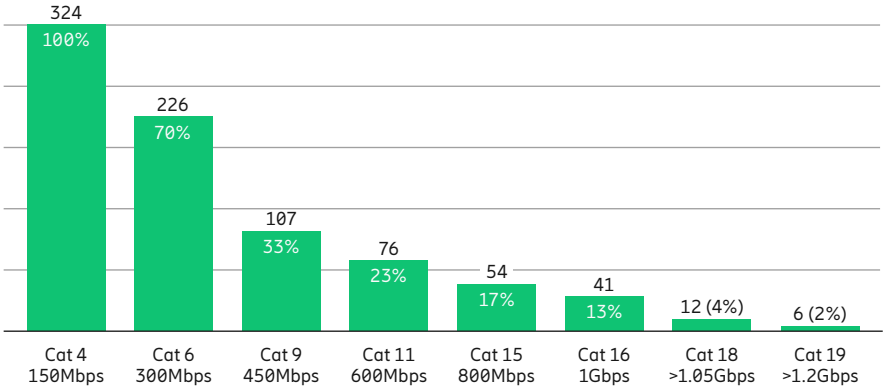


Figure 18: Percentage and number of LTE-Advanced networks supporting various categories of devices



Source: Ericsson and GSA (Nov 2020).

[1] The figures refer to coverage of each technology. The ability to utilize the technology is subject to factors such as access to devices and subscriptions.

2020: the ultimate stress-test for FirstNet

A reliable mission-critical network is vital for successful public safety operations – saving lives and protecting property.

2020 has proved to be an exceptional test year for a nationwide network deployed to serve first responders in the US. This has been triggered by the growth in emergencies related to the pandemic, one of the most active hurricane seasons on record, and severe wildfires. This article examines the role of FirstNet, the only nationwide network purpose-built to serve first responders, and the broader trend of using mobile broadband networks for public safety applications. FirstNet is deployed and operated by AT&T in the US in a first-of-its-kind, public–private partnership.

Public safety authorities embrace cellular

Public safety authorities worldwide have expressed a need for improving the network services used to link first responders in the field. To meet this need, they are increasingly turning to 3GPP-based solutions due to the capabilities provided by 4G and 5G, such as the secure and timely sharing of data, images and video.

A broader opportunity for public safety authorities is to improve and harmonize communication capabilities across different first responder types. With a 3GPP-based interoperable communication system like the nationwide public safety broadband network, cross-functional communications can effectively be established between first responders, different agencies and agencies closely affiliated to first responders, allowing for more agile responses in emergencies.

Service providers can add mission-critical capabilities to their networks to support consumers, businesses and first responders, all from one network. Networks for public safety applications can have very different requirements over time. The dimensioning must be sufficient to handle worst-case scenarios and provide high availability and reliability as events unfold. Emergencies are growing in complexity, and a shared connectivity network makes it possible for all first responders to effectively coordinate in the field. Between emergencies, the idle capacity can be utilized to enhance mobile broadband services for consumers and businesses on the same network.

FirstNet was born out of 9/11 and ready to serve

FirstNet is an initiative driven by US authorities with a history dating back to the 9/11 terrorist attack in 2001. The 2004 after-action report[1] of the attack identified two critical communication shortcomings. First, collaboration between police, firefighters and paramedics was hindered by communications relying on radio systems that were not optimized to work together. Second, the demand for network resources spiked for both consumers and first responders at the same time, saturating networks and impeding communications.

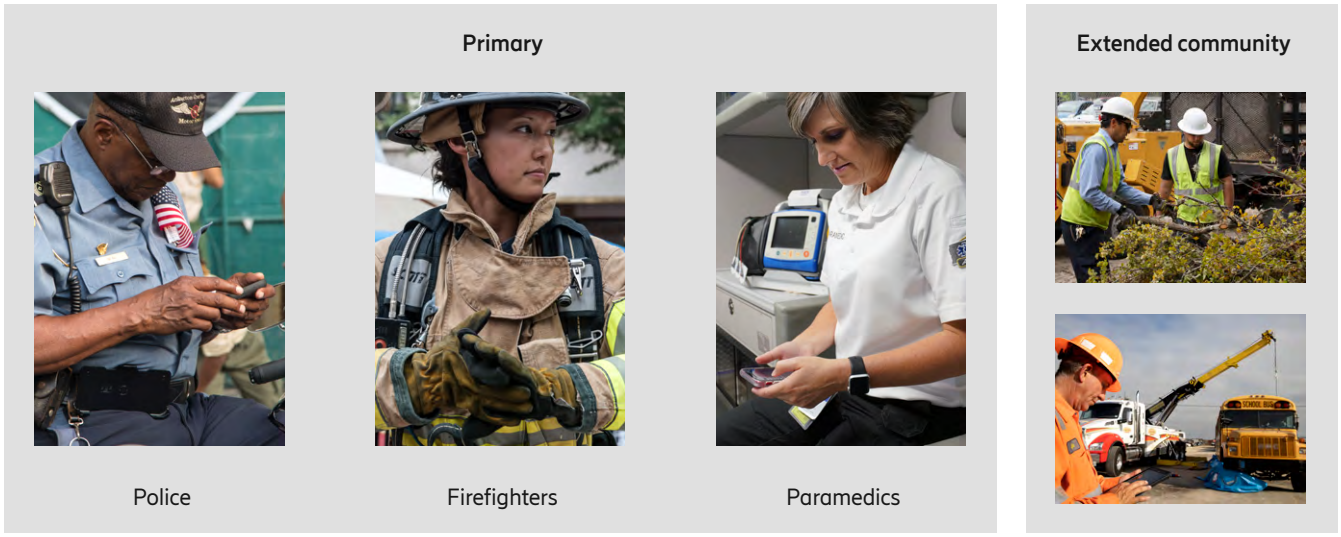
In the years after the report's release, public safety organizations and associations came together to press the US Congress to pass legislation establishing a reliable, dedicated and national high-speed network for first responders. This led to the First Responder Network Authority (FirstNet Authority) being created in 2012. The law that established the FirstNet Authority required it to consult with federal, state, tribal and local public safety entities to ensure that FirstNet was designed to meet the needs of public safety across the country.

This article was written in cooperation with AT&T, a market-leading global service provider delivering a range of innovative mobile and fixed-line communications-based services to help people, businesses and first responders stay connected.

The law associated with the formation of the FirstNet Authority included allocating 20MHz of spectrum nationwide and USD 7 billion to support the build-out of FirstNet. After consulting with states, territories, tribal governments and public safety agencies at every level, the FirstNet Authority sought to form a public–private partnership with a nationwide service provider.

[1] "The 9/11 Commission report" (July 2004).

Figure 19: FirstNet connects the public safety community



A communications ecosystem for public safety

FirstNet is exclusively for first responders and those who support their vital efforts. This includes law enforcement, emergency medical services and fire protection services, and important supporting services such as emergency (9-1-1) call dispatching, government Public Safety Answering Points and emergency planning and management offices. Other essential personnel who support first responders before, during and after an emergency can also subscribe to FirstNet. These organizations provide medical care, mitigation, remediation, overhaul, clean-up, restoration, or other such services during or after an incident.

In 2017, the FirstNet Authority selected AT&T to build and manage the FirstNet network for a period of 25 years. FirstNet is an entire communications ecosystem dedicated to public safety and characterized by:

- a shared radio network utilizing all AT&T LTE commercial spectrum bands, as well as 20MHz of nationwide coverage in the 700MHz bands, dedicated to first responders, and available to commercial users when not in use by public safety
- a highly secure, dedicated network core designed from the ground up to serve the public safety community
- a network launched with 4G LTE and currently being upgraded to provide 5G capabilities
- always-on, 24/7 priority and preemption across voice and data, with multiple priority levels that first responder users can allocate as needed to protect communications against commercial traffic congestion
- a nationwide, dedicated fleet of land-based and airborne portable cell sites to help provide coverage in remote locations or immediately following a disaster
- mission-centric ruggedized mobile devices, applications and features, including Mission-Critical Push-to-talk, to complement existing legacy radio networks communication services

The FirstNet Authority has laid out a comprehensive roadmap based on public safety input, to ensure mission-critical mobile broadband communications capabilities. These are:

- a dedicated core network to enable mission-critical capabilities
- sufficient spectrum capacity and coverage
- improved situational awareness (such as three-dimensional location services)
- mission-critical voice communication services
- high information security and integrity
- improved user experience for first responders

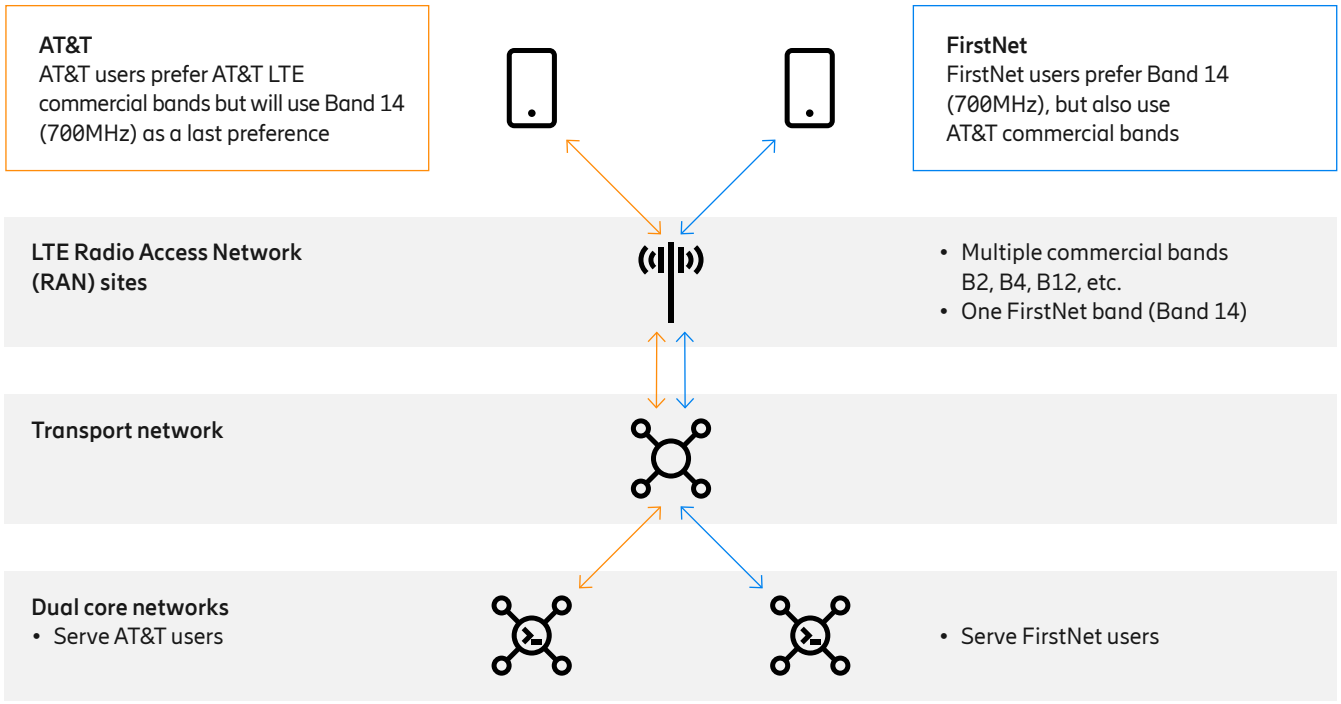
User experience represents an essential part of the vision for FirstNet. Once fully implemented, the value of the network will be measured by how much easier it has become for first responders to focus on their prime task. FirstNet already covers over 99 percent of the US population, and by mid-2020, the initial FirstNet build surpassed 80 percent completion, serving over 1.7 million connections in more than 14,000 agencies across the US. Fortunately, the initial FirstNet build had reached a sufficient level of completion to support the emergencies hitting the US this year.

In addition to the initial USD 6.5 billion investment allocated by the FirstNet Authority for the build-out, AT&T is investing about USD 40 billion to build, operate and maintain the network. This co-investment and public–private partnership approach is proving to be a successful model for a network serving public safety.

1.7m

As of Q3 2020, FirstNet has grown to serve over 1.7 million connections used by first responders and the extended public safety community.

Figure 20: FirstNet network architecture



Managing changing traffic demand during the pandemic

The emergencies hitting the US in 2020 caused substantial changes in traffic levels and patterns across consumer, business and public safety segments. During the first six months of the pandemic, mid-March to mid-September, the following changes in mobile traffic generated by consumers and businesses were observed in AT&T's network:

- The overall traffic grew by 20 percent, compared to pre-pandemic figures.
- Mobile traffic shifted from public/office to home/remote work locations, as 60 percent of Americans worked remotely.
- The mobile data traffic was flat to slightly declining, supported by Wi-Fi offload in homes with good fixed broadband connections.
- Mobile voice traffic increased by almost 40 percent.

Regarding FirstNet, public safety authorities made more than 450 requests for temporary network coverage solutions, such as cell on wheels (COW) deployables, in-building solutions and macro network enhancements to support planned and emergency events. This covered everything from drive-through COVID-19 testing sites to natural disasters like hurricanes and wildfires. Interestingly, throughout the pandemic, the average first responder consumed more than double the mobile data of the average consumer, which reinforces the importance of having a network service specifically for public safety – especially during times of crisis.

Flexible coverage solutions required during emergencies

The demand for temporary coverage solutions to support first responders in different emergency situations illustrates the high level of flexibility that FirstNet needs to support:

- Hospital ships, with 1,000 beds and 12 operating rooms, were deployed to offload hospitals in metropolitan areas hit hard by the pandemic. There was an immediate requirement to support a high concentration of first responders as soon as ships reached the ports.
- Hurricane landfall areas. FirstNet One, a 17m-long blimp flying up to 500m high, was deployed to elevate the cellular radios to address larger geographical areas than a COW can cover.
- Wildfires where ground forces need a bird's-eye perspective on the development in real time. Specialized aircrafts performed reconnaissance flights and fed real-time insights to first responders on the ground serviced by COWs, that can quickly move with changes in the firefighting location.

Overall, traffic patterns shift from known/predictable to more dynamic scenarios during acute emergencies. The ability to support these types of shifts is a key feature of FirstNet. Even when business and consumer traffic is surging, first responder communications are protected, with spectrum dedicated to public safety when needed, and prioritization across all AT&T LTE commercial spectrum bands. This gives public safety authorities immediate access to network connectivity as well as even more coverage and capacity. In addition, using shared network infrastructure enabled first responders to immediately access the early benefits and capabilities of FirstNet while AT&T built the dedicated FirstNet network core – designed with a defense-in-depth approach that helps maintain security at every level.

20%

Emergencies directly affect mobile traffic; in the first 6 months of the COVID-19 pandemic, mobile traffic grew by 20 percent.

An evolutionary path towards 5G capabilities

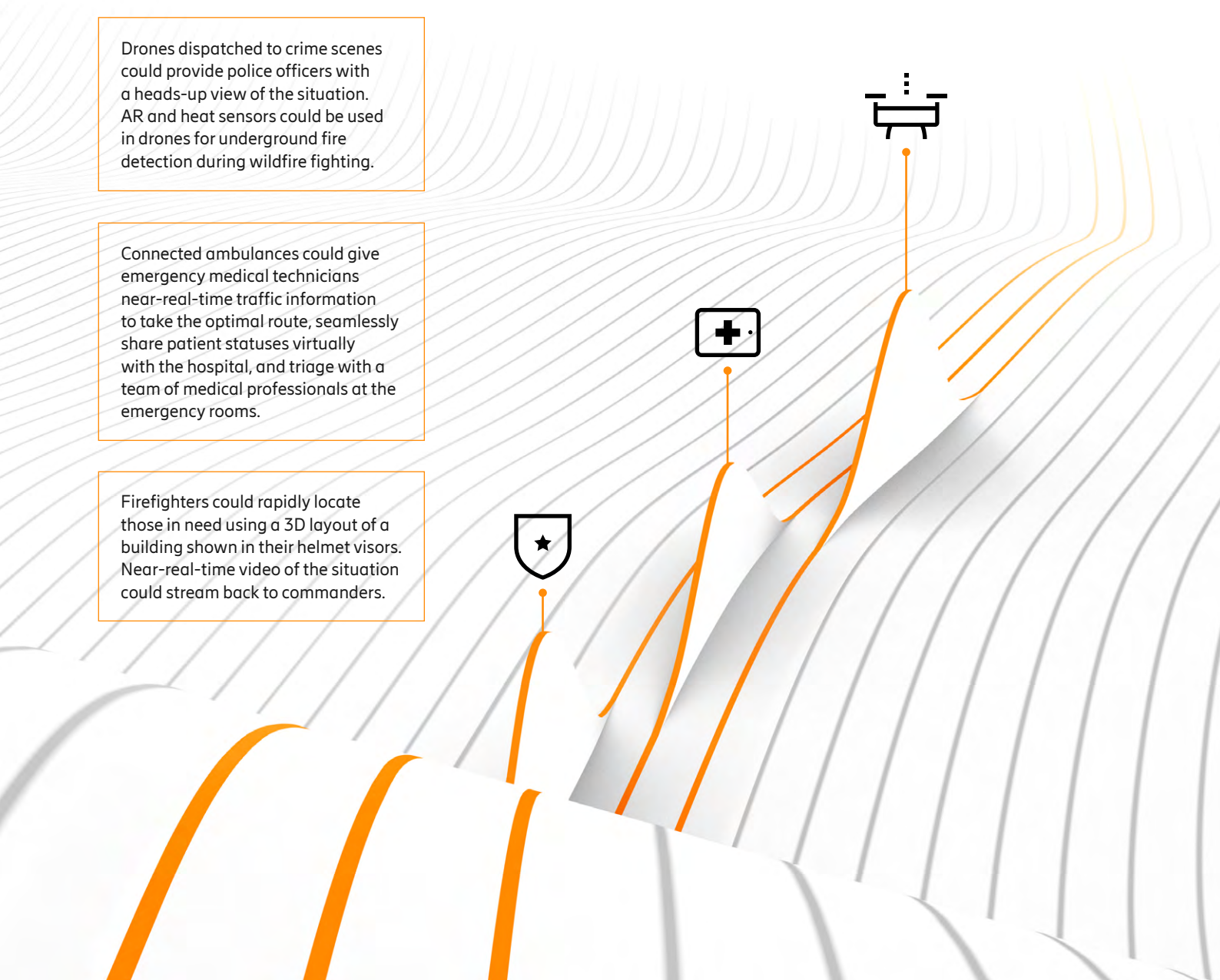
FirstNet and the mission to serve first responders during the exceptional challenges they are facing during 2020 have proven the value of mission-critical networks for public safety applications. The need for digital transformation is not limited to businesses, but also stretches into the public safety sector and first responders' needs. Paramedics can be in direct contact with the receiving hospital from the moment they reach their patients, aiding remote diagnosis and treatments. Fast deployment of temporary network coverage accelerates the recovery and reconstruction phase of local communities and society immediately after a hurricane. Firefighters get a better view of the nature of uncontrolled wildfires, saving their lives and the lives of others.

In June 2020, the FirstNet Authority Board approved USD 218 million – the first set of investments – for AT&T to upgrade the FirstNet core network with 5G technologies and expand the fleet of deployable network assets. This is the beginning of a multi-phase, multi-year journey to deliver full 5G capabilities on FirstNet for public safety. During the coming years, 5G technologies will provide a range of network improvements, including low (predictable) latency and capacity enhancements, that could enable new capabilities for mission-critical networks and public safety applications.

Today, many of the priority and preemption capabilities to efficiently manage LTE radio and network resources do not yet exist for 5G, but are works in progress. LTE is therefore the current platform for mission-critical mobile broadband and will remain so for years to come. Innovations in mission-critical features are still being developed and tested. However, the FirstNet Authority's investment is setting the stage for reliable, secure 5G for first responders in the US. It will ensure public safety services are able to take advantage of 5G's potential when it is ready for these applications. As it does today, FirstNet is designed to manage traffic so that public safety has the ultimate fit-for-purpose user experience – sending the data via the best route. That could be done over 5G or 4G with priority and preemption, but it will be an evolutionary path where 4G LTE and 5G will coexist.

As shown in Figure 21, 5G technology can enable a broad ecosystem of additional applications and use cases beyond what is possible today. 5G will eventually further improve first responder command, control and communications capabilities and be a catalyst for additional technological innovations to support emergency response and enhance the odds for positive outcomes and saving lives.

Figure 21: Examples of applications and use cases 5G could unlock for first responders



The networked industrial enterprise

Suppliers and manufacturers must design for resilience and flexibility in value chains. The transition to Industry 4.0 will depend on locally and globally interconnected operations to support smart production and life cycle management.

Around 70 percent of international trade today involves global value chains (GVCs). These are made up of domestic and international enterprises that trade and transfer materials, goods and services.

To compete in the global economy, enterprises become increasingly specialized. This has led to a considerable fragmentation of value-adding activities throughout the whole value chain, ranging from design and engineering through production to after-sales services. Historically designed and driven by cost concerns, GVCs today have grown so dispersed and complex that governance has become very challenging, leaving enterprises more vulnerable to disruptive shocks. According to a recent study, 60 percent of executives have zero visibility beyond their tier 1 suppliers.[1] The automotive industry is an example that illustrates the complexity; there is an average of 250 publicly disclosed tier 1 suppliers, extending up to 850 for the largest manufacturers. Yet, their respective and non-visible tier 2+ suppliers number 18,000.[2]

With rising market volatility, resilience and risk mitigation have increased in importance relative to cost and efficiency. Investing in improved information systems and communications infrastructure is one way to counteract sub-optimal operations or imbalances in supply and demand. For example, faster procurement of components from a reliable supplier supports just-in-time manufacturing, avoiding both delays and excessive inventory.

Although improving transparency and traceability on the shop floor will improve many internal metrics, an enterprise is not an island. It exchanges resources, capital and competence in markets subject to regional and geopolitical power dynamics.

Interconnectedness is key for adaptability

Multinational enterprises (MNEs) lead the fragmentation, shifting their activities depending on a variety of business criteria and cost conditions. They insource products and services both domestically and internationally, but outsourcing and offshoring are still dominating trends. Small to medium-sized enterprises (SMEs) make up most of the economy and act as partners, suppliers and distributors. They play a major role in inclusive growth in societies.[3]

Regardless of size and reach, the key to adaptability is to strengthen the interconnectedness of enterprises. This will not only optimize supply chains and material footprint, but ultimately create the most value for customers in each part of the value chain. However, networking capabilities to connect products, people and processes simultaneously on one common platform are often lacking.

The fragmentation of and interdependencies within GVCs make connectivity an even more critical foundation for growth. Connectivity not only improves internal and external collaboration and transparency, but upgrades the enterprises' own positions in the value chain.

Industry 4.0

The Fourth Industrial Revolution (Industry 4.0) changes the way products are manufactured and consumed. It creates unprecedented levels of automation, compliance and performance by merging physical and virtual worlds through a combination of technologies like Industrial Internet of Things (IIoT) and augmented reality (AR). This not only caters to smart operations at plant level but also applies through the entire supply chain.

According to the Organization for Economic Co-operation and Development (OECD), many SMEs struggle to link up to GVCs, and most fail to deliver products and services beyond their local market. By lowering the barriers to global marketplaces and strengthening specialization, purely domestic SMEs can enlarge their pool of buyers, increasing exports and ultimately improving national GDP.

There are three critical capabilities for successful involvement in GVCs:

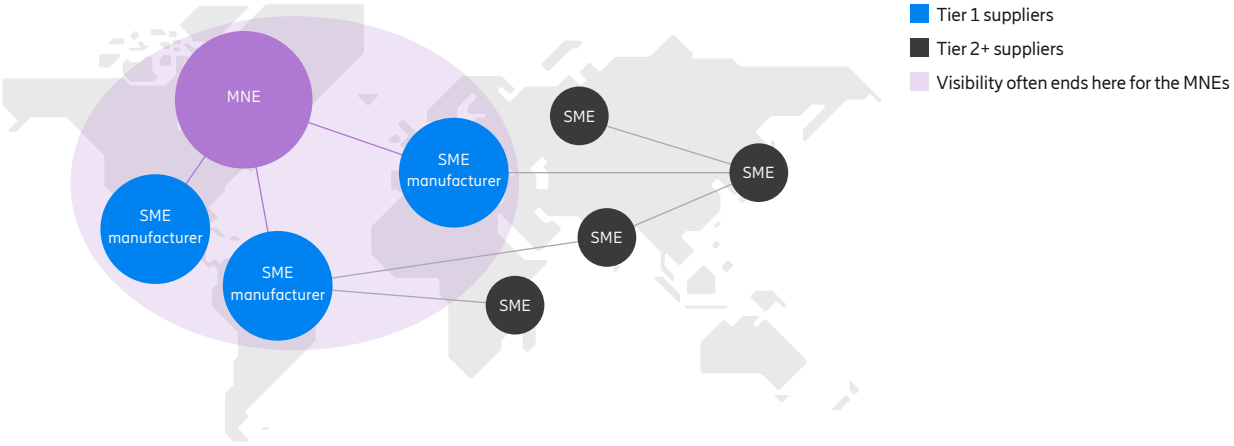
- unique products and services
- strong managerial and operational competencies
- flexibility to adapt to changing demands

These capabilities mark distinct competitive advantages that can be unlocked with Industry 4.0.

However, many SMEs lack the competence and investment capacity to implement the Industry 4.0 solutions (for example, IIoT, advanced automation, AR and predictive maintenance) necessary to fully enable these capabilities. On the other hand, MNEs have challenges with governance and improvement of their value chains, as these are seldom truly centralized or expertly coordinated.

[1] www.weforum.org/agenda/2020/09/4-ways-industry-make-supply-chains-sustainable
[2] www.mckinsey.com/business-functions/operations/our-insights/why-now-is-the-time-to-stress-test-your-industrial-supply-chain
[3] oecdobserver.org/news/fullstory.php/aid/6062/SMEs_are_key_for_more_inclusive_growth.html

Figure 22: The challenging governance of GVCs



Lowering barriers for interconnectedness

Advanced collaboration in the GVC will be dependent on high-performing networks with ubiquitous coverage. The choice of connectivity solutions determines the flexibility and quality of the enterprises' digital foundation and the possibility to improve operations. However, presently there is no standard "plug-and-play" model to cater for all MNEs' and SMEs' needs. Cellular networks can bridge both global and local needs of enterprises, but adoption barriers must be lowered, whether they are technical, economic or organizational. One way is to offer simpler packaged connectivity solutions to SMEs, or even private–public hybrids to MNEs.

To speed up enterprises' Industry 4.0 transformations, centers of excellence are established to test new infrastructure in collaborative environments where competence in new technologies is available, such as at the 5G-Industry Campus Europe in Aachen.[4]

The convergence of enterprises' operational technology and ICT can be accelerated through more open and tighter partnerships. The same is true for advanced operations. In order to develop true flexibility in the value chain, supply, manufacturing and business criteria must be aligned through system(s) integration. This is the only way to deliver smart, advanced operations. Effectively, this shift in the enterprise operating model also means departing from a linear, sequential view of supply and value chains to an interconnected cyber-physical system for better governance and decision-making on all factors related to input and output.

Digital integration – a new industry benchmark

The smart manufacturing process follows four distinct stages; connecting devices on site, connecting lines on the shop floor, connecting and digitalizing a whole factory, and finally establishing a "network of factories". Historically, MNEs have improved their position in the value chain through acquisitions and mergers of other enterprises and suppliers by either vertical or horizontal integration. Going forward, "digital integration" may become a new competitive benchmark. Instead of expanding through direct ownership and risking becoming overextended, the interconnected enterprise can network its way to smarter operations.

In many cases, up to 80 percent of supply chain costs are determined by the location of facilities and the flow of materials and products between those facilities. The ability to track, trace connected assets and exchange real-time insights and map dynamics of suppliers, distributors and buyers can considerably mitigate risk. Thus, a digitalized supply network presents a competitive advantage, particularly when navigating an increasingly complex global business environment.

The Ericsson Manufacturing and Supply footprint numbers four factories, eight electric manufacturing services sites and eight supply hubs globally. By investing in one common Ericsson Factory Network, sites can deploy smart manufacturing faster by collaborating internally and connecting to an ecosystem of equipment suppliers. Shifting from linear and siloed processes, the digital supply network can integrate business demands with operational needs, responding faster to change and new customer requirements. The benefits for Ericsson as an MNE are higher quality, better resource management, faster product introduction and delivery precision.

[4] www.5g-industry-campus.com

Figure 23: How the Industry 4.0 transformation affects economic models

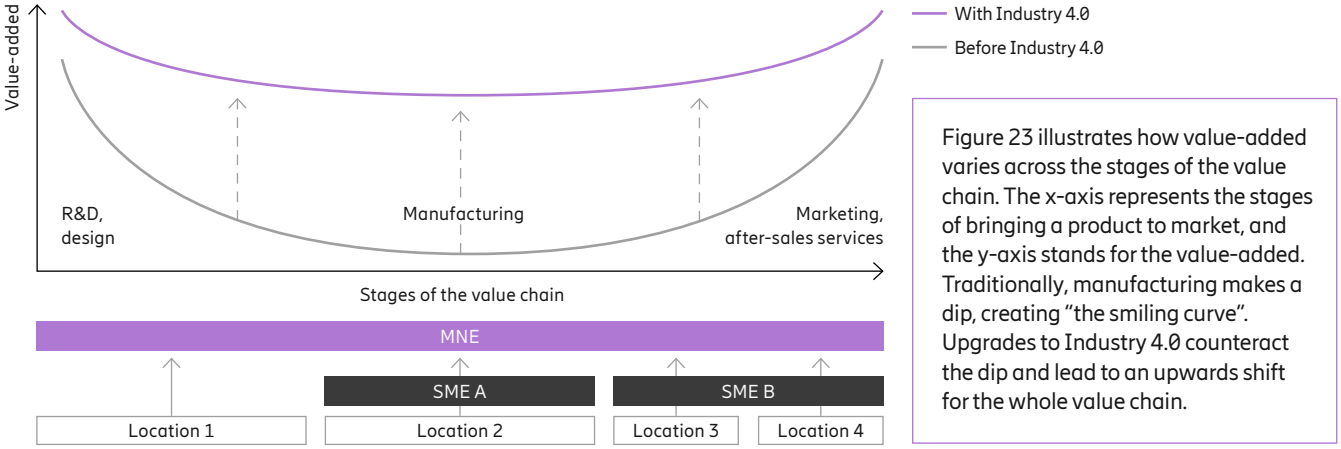


Figure 23 illustrates how value-added varies across the stages of the value chain. The x-axis represents the stages of bringing a product to market, and the y-axis stands for the value-added. Traditionally, manufacturing makes a dip, creating "the smiling curve". Upgrades to Industry 4.0 counteract the dip and lead to an upwards shift for the whole value chain.

Multi-SIM lowers barriers for roaming

To enhance GVCs there is a need for different connectivity solutions. In order to support both central and local decision-making for manufacturing and logistics, there are several network options available for MNEs and SMEs responsible for different value stages and sites.

A private (dedicated) network executes critical applications locally so sensitive data does not leave the factory premises, which is a basic requirement for most manufacturers. On the other hand, a public network connects sites and assets that need wide-area coverage at customer premises and during transit for smarter logistics. A digital supply network or the extended enterprise might need both, connecting dedicated sites, product flows and services.

To support interconnected operations, factory assets like OEM machines can be connected throughout their lifecycles with multi-SIM card technology. With the capability to store multiple or dual profiles, the asset can easily shift between public and private networks. As profile switching typically takes 20–30 seconds, this approach does not support seamless roaming, but it does not require any reboot of the device either. Applications like automated guided vehicles (AGVs) or autonomous mobile robots (AMRs) that are constantly moving between a private and public network on a campus are not suited for this solution.

However, there are many applications where a short break in connectivity is acceptable when the identity is saved.

For example, when products are assembled at multiple factory sites, traceability from one to the other is valuable, both when it comes to fast fault-finding and to facilitate just-in-time manufacturing. To improve governance and customer management, new connected industrial assets can switch "roles" from shipping to deployment and even to service mode. Naturally, each stage may have specific connectivity requirements and rules as to when the device should switch profile.

Interconnected enterprises transform economic models

In Figure 23, whether the enterprise controls the entire value chain end-to-end (MNE) or is a contributor (SMEs A and B) in the chain, smarter integration of manufacturing and business can lead to shifts in traditional economic models.

The manufacturing stage, providing standardized products in high volumes, has historically been viewed as having the lowest value-add in both the value and supply chains, whereas the highest value-adding stages have been R&D, marketing and after-sales services.

With the development of the digital factory within the context of Industry 4.0, the value-add of the manufacturing stage will increase alongside the evolution of advanced industrial automation and reshoring. The R&D stage will also signify a higher value-add, as Industry 4.0 implies investments in advanced industrial automation, artificial intelligence (AI), up-skilling labor and co-creation with customers. Increased interconnectedness with manufacturing would bring faster prototyping and deployment of innovations.

The goal of the digital factory is to effectively align business needs and operational processes through advanced information systems. These can be well supported by cellular solutions interlinking the globally dispersed enterprise. The integrated information flows limit waste with smarter, timelier decisions. Even if most use cases today focus on optimizing a production line or site, the integration and potential savings go well beyond the shop floor. Smart manufacturing takes place across locations with feedback loops, for example with digital twins strengthening design and quality of the product, or faster sourcing of components from a supplier that is more resilient to disruptive events. The ability to change or tailor even in-process orders, constantly incorporating customer needs through marketing insights, better balances actual demand with supply. Enhancing and exploiting these types of interlinkages is where efficiencies and value can be unlocked for the enterprise, regardless of its place or participation in the value chain.

By lowering barriers to cooperation, actual networks can help mitigate some of the volatility, uncertainty and complexity of industrial governance and trade. In turn, this encourages digital integration and the establishment of networked enterprises.

New technologies have always driven waves of globalization. Industry 4.0 can bring forth the networked enterprise for smarter collaboration across borders, advancing a more inclusive and interconnected world.

Mobile cloud gaming – an evolving business opportunity

Communications service providers and gaming companies are seizing the business opportunities created by devoted gamers' requirements for a consistent and lag-free mobile gaming experience.

The first game streaming services were launched a few years ago. Initially, they were targeted towards console and PC gamers. Today, new opportunities to expand the mobile gaming market and further develop the gaming experience are emerging, with 5G networks and cloud gaming services becoming increasingly accessible on smartphones and tablets. The combined capabilities provided by 5G networks and edge compute technologies will enable game streaming services on smartphones with a quality of experience (QoE) on a par with PC or console, and also open up for innovative, immersive mobile games based on mobility.

Smartphones dwarf console sales

Although the mobile cloud gaming market is still in its infancy, the wider mobile games market is already large. There are presently more than 2.4 billion mobile gamers globally, where Asia is the biggest market with over USD 41 billion in revenue.[1] Mobile games generate about 50 percent of total global gaming industry revenues.[2] In 2019, 33 percent of all app downloads worldwide were related to mobile games, accounting for 74 percent of all consumer expenditure at the 2 major digital distribution platforms for the Android and iOS operating systems.[3]

Annual volumes of current-generation video game consoles have been 40–50 million units worldwide over the last 3 years. In comparison, over the same time period incremental 4G subscriptions have averaged 685 million. Furthermore, the number of 5G smartphone users is forecast to increase from about 200 million in 2020 to over 3 billion by the end of 2026. The strong growth in smartphone users and the evolving capabilities of 4G and 5G networks open a much larger addressable market for new gaming services.

Market drivers for mobile game streaming services include:

- continued strong growth of smartphone users
- imminent deployment of 5G networks, with high user data rates, network capacity and emerging time-critical communications, or ultra-reliable low-latency communication (URLLC)
- increase of cloud data centers with large compute and storage resources (central, edge)
- increasing partnerships between communications service providers, edge cloud providers and cloud gaming service providers
- new cloud gaming services launched by new and incumbent (console) gaming service providers
- communications service providers launching their own services
- future development of new types of devices, based on AR, VR and XR

Mobile cloud gaming services from 5G communications service providers rising

Out of 106 communications service providers that have launched commercial 5G service offerings,[4] 22 have announced the availability of mobile cloud gaming services on a separate subscription basis, or as a service bundled with a premium 5G data plan. The majority of offerings, from 19 communications service providers, are subscriptions to a gaming service in partnership with a cloud gaming provider. The number of games included typically ranges from 30 to more than 100. Depending on the gaming service provider, monthly subscription fees typically range from USD 6–18. In addition, a few communications service providers include zero-rating for gaming[5] on some of their premium data plans. Games included in present service catalogs, occasionally marketed as a 5G cloud gaming offer, range from casual games to more complex multiplayer games. Many games presently included can be played over a 4G network and do not require 5G for a good gaming experience. However, immersive games are better experienced over 5G, as these demand higher bandwidths and lower (predictable) latency. An important objective for partnerships between communications service providers and cloud gaming providers is to explore how both 5G and 4G networks need to be managed and optimized to support high QoE.

[1] www.statista.com
[2] www.dotcominfoway.com
[3] App Annie, "The state of mobile 2019".
[4] Ericsson analysis, October 2020.
[5] Traffic generated by the gaming service does not count against the subscriber's monthly data plan.

Streaming games popular among 5G subscribers in South Korea

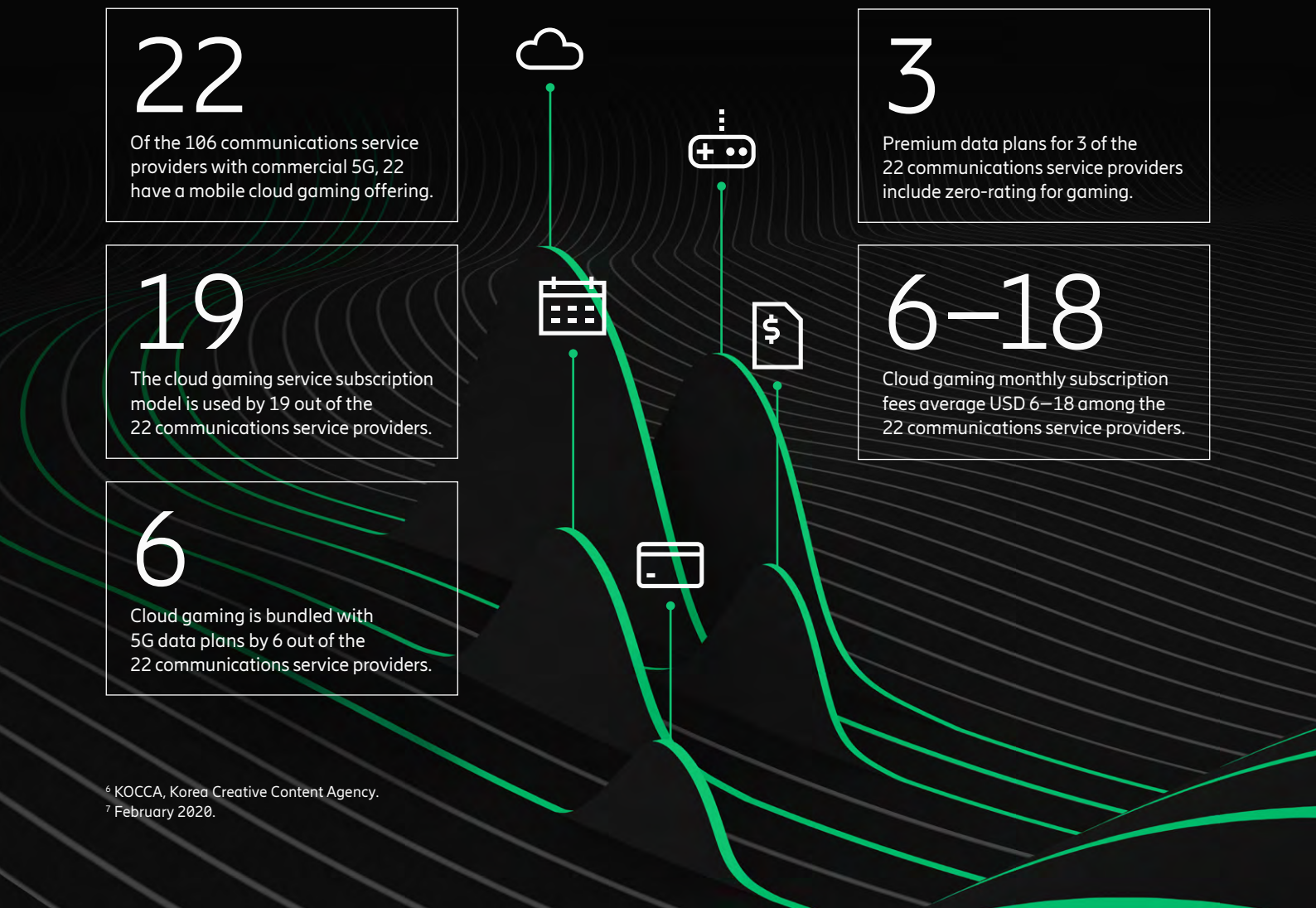
An interesting example of an evolving gaming market is South Korea. It is ranked the fourth largest mobile gaming market after the US, China and Japan, and has a strong gaming culture, with professional gamers dominating in international esports competitions. With smartphone penetration among the highest in the world, smartphones have become the most popular gaming device. According to a 2020 Korean game user report,[6] over 88 percent of mobile gamers play games at least 2–3 days per week, whereas 44 percent play every day. The average time of playing mobile games is 96 minutes per day on weekdays, and 121 minutes per day on weekends. The three main South Korean communications service providers have teamed up with major international gaming service providers, offering subscription-based mobile cloud game streaming services. For two of these subscriptions, it is not necessary to be a mobile subscriber to the specific communications service provider. All three communications service providers also provide access to their own portfolio of streaming and downloadable games, including streaming VR (through goggles connected to smartphones) and downloadable AR versions, on their own developed platforms. These are free of charge for 5G premium plan subscribers. According to SK Telecom,[7] 5G subscribers are using game apps 2.7 times more often than 4G subscribers. To play games on SK Telecom's own developed cloud gaming platform, 55 percent of smartphone gamers use Wi-Fi and 45 percent cellular connectivity.

The cloud gaming subscription model rules

Today, mobile gaming is dominated by casual gamers, but new segments will be addressable as premium games with high-quality experience become accessible from game publishers and communications service providers, without the need for dedicated and expensive hardware or PCs. One market challenge is to convert casual players to paying subscriptions for gaming services. Subscription-based business models for digital audio and video streaming services have disrupted those industries, with millions of people willing to pay a monthly fee without becoming owners of DVDs or CDs. For the streaming service provider, it brings predictability in revenues and cash flow. Through digital customer interaction and engagement, the improved customer understanding lets them tailor their offerings per individual subscriber rather than for customer segments. Many gaming service providers are now including a subscription-based business model in their gaming portfolios.

Agreements between communications service providers and gaming service providers vary by market, depending on the scope of collaboration. For example, a communications service provider may have an own-branded game offering, based on a white-label solution from a cloud gaming service provider, or have marketing- and channel-partnership agreements. These agreements may include revenue sharing, but other important business drivers are new customer acquisition and retention, and a differentiating value proposition to entice subscriber migration to 5G. There are also different approaches among communications service providers with own-branded game services; some offer exclusivity to loyal subscribers, while others are open to all mobile users in the market.

Figure 24: Mobile cloud gaming among 106 5G service providers



[6] KOCCA, Korea Creative Content Agency.
[7] February 2020.

Advanced gaming performance requirements open up new business opportunities

Advanced gaming use cases with strong network performance requirements will drive a need for premium connectivity and edge computing capabilities. These capabilities could be offered by communications service providers directly to gaming providers, via or jointly with partners. However, this will also require new types of partnerships to jointly address future mobile gaming use case opportunities. Gaming ecosystem partnerships require high flexibility to cater for cost-efficient cooperation, in parallel with a multitude of different gaming partners, all having different requirements and interests.

Higher network performance requirements as game complexity increases

A large part of total cloud gaming traffic is expected to be transported over fixed networks, as is the case for streaming video. However, 5G mobile and fixed wireless access (FWA) networks are also expected to carry a significant amount of future cloud gaming traffic. To stimulate uptake of cloud gaming services, games service providers would have to adapt to the capability of the mobile network and devices, while maintaining the QoE. This implies that a 4K resolution, real-time video game, streamed over a fixed network connection to a large screen, could be downsized to a 720p video gaming stream over a mobile network, without distorting the QoE for most games played on a smartphone. Streaming games consumes several times more data than a video stream of equivalent quality. This is due to the need for faster video encoding, which helps maintain the required low latency during gameplay, but with a higher data rate. Some cloud-based gaming platform providers recommend 10Mbps reliable downlink throughput as the minimum for current games to be played over a mobile network for a good QoE on a smartphone.

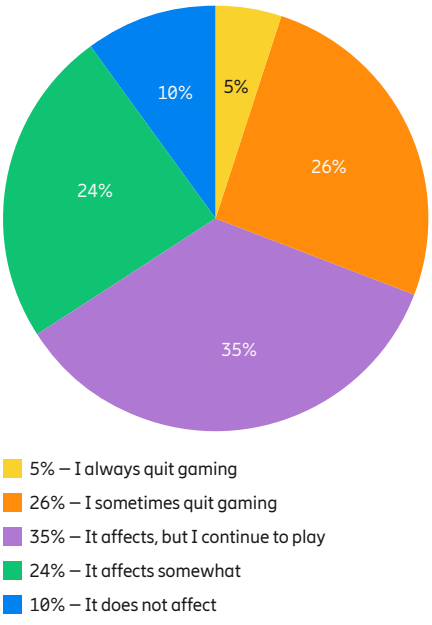
However, other cloud gaming platforms stream fast-paced games with complex graphics that require an average of 15Mbps throughput with peaks of 25Mbps or more. As games become faster and more complex, even lower network latency and higher bandwidth will be required. More time-critical cloud gaming use cases, such as first-person shooter games and fast multiplayer interactions, will require 20–30ms end-to-end network latency, with around 99.9 percent likelihood (reliability) in both uplink and downlink, for a quality experience. For an immersive VR gaming experience, the latency and reliability requirements are even more demanding.

QoE can be game-changing

Different game genres have different data rates, latency and reliability requirements on mobile networks. A fast-moving, first-person shooter game requires high reliability, low latency (time-critical) communications, compared to a slow-moving strategy game that works well with the best-effort latency typically required for mobile broadband services. Depending on the game genre, there are different expectations for QoE. Higher frame rate versus resolution is typically preferred for first- and third-person shooters, while high resolution is preferred over frame rate for fantasy games not requiring fast reaction times.

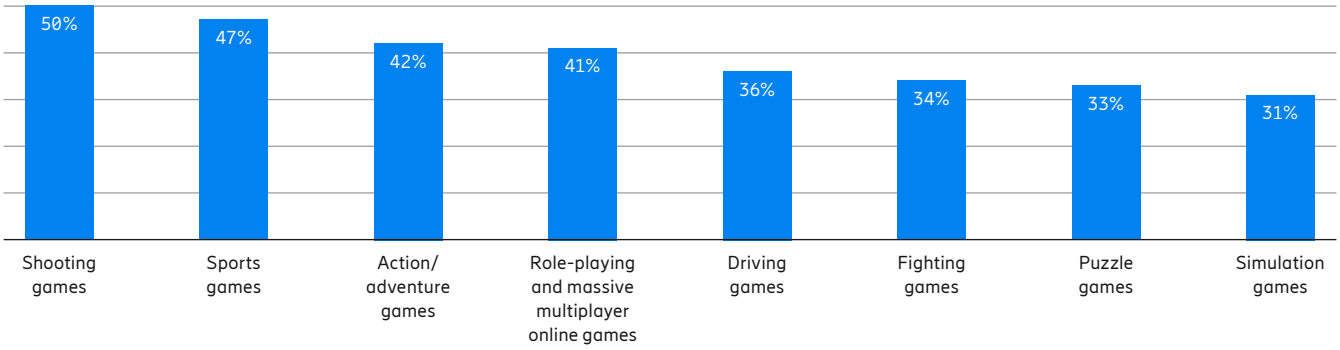
Considering the natural variation in radio channel quality, game video streaming must be adapted to changes in radio network conditions, mobility (handovers), buffering and more to ensure a good QoE for different game categories. In the case of video streaming, data is buffered in the game client to allow for connectivity variation. But for game streaming, the latency between game input and view is important and does not allow for client buffering. Game streaming services can have adaptable qualities, but without large media buffers, unstable network connectivity will impact QoE. The latency requirement for a specific gaming service is dependent on several factors, such as game genre, personal skills and delay acceptance.

Figure 25: Gamers' reaction to gaming lag (network latency)



Source: Ericsson ConsumerLab (2019).
Base: At-least-weekly gamers aged 15–69 in Brazil, China, France, Japan, South Korea, the UK and the US (7,000 respondents).

Figure 26: Share of gamers experiencing gaming lag (network latency) by game genre



Source: Ericsson ConsumerLab (2019).
Base: At-least-weekly gamers aged 15–69 in Brazil, China, France, Japan, South Korea, the UK and the US (7,000 respondents).

Lag (network latency) is one of the most common issues when playing online games and has a strong impact on the level of satisfaction with the gaming experience. In a ConsumerLab study, based on an online survey with 7,000 consumers, 90 percent of those who play video games at least weekly were negatively affected by lag when playing, with at least 1 in 3 sometimes quitting as a result. Gamers' perceived experience of lag depends on the type of game played; those requiring fast responses experience lag more often in comparison to other genres.

5G will enable next-level gaming

Just like video streaming, service providers are developing original content for their subscribers. Cloud gaming providers could be expected to develop "5G original" cloud streaming games, adapted to the specifics of mobile devices (for example, small screens and limited input options), but also to the surrounding environment where a mobile gamer is situated when playing (new types of VR, AR games). By utilizing the full range of sensors on a mobile device, such as the camera, light sensors, GPS, accelerometer and sound, it could sense the environment and contextualize it to adaptively generate new game content, enriching the gaming experience.

New games and gaming platform requirements are becoming more demanding, and solutions that work for regular video streaming are not enough for advanced gaming use cases. As networks evolve to 5G, time-critical communications will take cloud gaming to the next level. Time-critical communications aims for data delivery within a specified latency budget with a required guarantee; for example, 50ms network latency with 99.9 percent reliability. It is fundamentally different from mobile broadband, which maximizes data rates without any guarantee on latency.

Communications service providers can add support for time-critical communications to the 5G NR carriers through software upgrades. The slicing framework in 5G networks can reserve dedicated resources for gaming by configuring and connecting computing and networking resources across the radio, transport and core networks. As networks evolve towards more cloud native design, with better flexibility in placement and deployment of network functions (NFs), parts of the game workloads can be collocated with the NFs to ensure gaming performance requirements are met.

The time-critical communications ecosystem is starting to develop from 2021 with end-to-end network slicing and edge computing. Major functionality growth for time-critical communications is expected over standalone 5G networks beyond 2021.

Cloud gaming represents the full potential of 5G for both consumers and businesses – gamers benefit from enriched experiences, including lighter and more affordable gaming devices, a longer battery life and new immersive gaming experiences, while communications service providers get a wide range of new business opportunities.

Major functionalities for realizing time-critical communications/URLLC in the radio access network include:

- network slicing
- high-reliability link adaptation and scheduling
- uplink configured grant
- RAN rate recommendation
- multiple transmission and reception points
- redundant transmissions
- robust signal transmission formats
- QoS-aware admission and load control
- instant preemption and prioritization mechanisms
- conditional handovers
- dual active protocol stack
- rapid retransmission protocols
- slot aggregation

Service providers face three alternative paths to success

Service providers can be categorized into three distinct strategies depending on whether they lead, challenge or follow the market, and the chosen strategies directly correlate with market performance.

Having an executable strategy is key to succeeding in any business. Selecting the right strategy based on business assets, market conditions and competitive landscape is critical. An Ericsson study looked at over 300 service providers around the world to see what similarities and differences can be found in their strategies, and identified the key characteristics of best-in-class service providers which successfully execute their strategy to maximize returns.

Service providers compete with distinct strategies

The three strategies that service providers were found to adhere to in this study are labeled quality-led, offering-led and industry-led.[1] Although the strategies have different focuses and are distinct, each is built upon several, common key elements, for which service providers put in varying degrees of effort based on their strengths and selected business goals.

19%

The quality-led strategy is deployed by 19 percent of service providers – who lead in network performance.

28%

The offering-led strategy is deployed by 28 percent of service providers – who challenge with new services.

38%

The industry-led strategy is deployed by 38 percent of service providers – who focus on value-for-money propositions.

Quality-led

Market leaders typically apply the quality-led strategy, often coming from the incumbent position, and therefore tend to maintain their lead in terms of network coverage and quality. The focus and investments are on network transformation, sites, spectrum and being first to deploy the latest technology to maintain their number one leading position in quality. Their marketing typically showcases their leading position in network performance. Often having greater resources than their competition, quality-led service providers are more selective and choose to have few strategic partnerships.

Offering-led

The offering-led strategy is mostly deployed by challengers. The ambition is to be first to market with new offerings. Prominent in this strategy is maintaining a high level of market innovation to capture market share, often with one-for-all offerings, coupled with targeted distribution. These challengers use extensive campaigns and promotional programs to gain traction and capitalize on their "first-mover advantage". Offering-led service providers also work with multiple partners in the area of products and services. They typically use modern technology – such as AI – in their operations, as well as a wide use of omni-channel strategies for customer experience management.

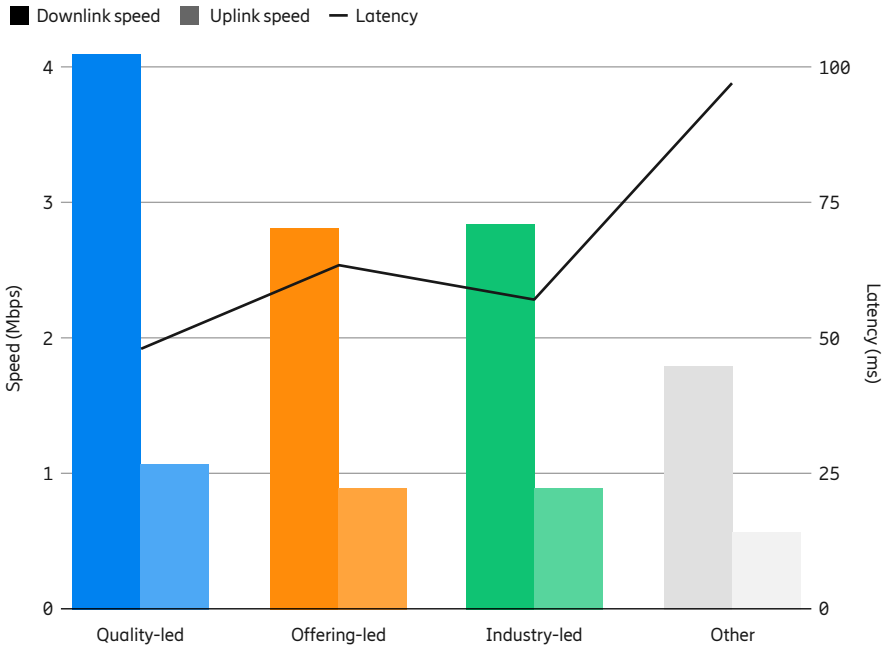
Industry-led

Most service providers follow general market trends, referred to here as the industry-led strategy. These service providers are seldom, or never, first to market. This is illustrated by their approach to network quality, which is similar to the quality-led strategy, but without the ambition or potential to reach a leading position. This also applies to their go-to-market strategy for service offerings, distribution, campaigns and use of sub-brands. Industry-led service providers find success as fast followers, focusing on a value-for-money proposition that delivers what their customer segment desires, and typically have lower levels of average revenue per user (ARPU).

[1] Fifteen percent of service providers scored low in the strategy elements analyzed, making it unclear which strategy they were executing. These have been classified as "other".

Methodology
For this Ericsson study, 308 service providers, in 121 countries worldwide, were researched and analyzed using publicly available information. A strategy analysis framework, originally developed by C. Campbell-Hunt at MIT, was applied and revised to fit the telecom industry. Analysis of service providers' financial performance, service offerings and network performance has been extended by cross-comparing the findings with other owned studies or external sources. Data was collected during Q1–Q3 2020.

Figure 27: Network performance on a global level



69%

Today, 69 percent of quality-led service providers have launched 5G for smartphones commercially.

Differentiation through sustainable leadership in network performance

Network performance data[2] shows the throughput delivered with a 90 percent probability, meaning 90 percent of the samples have better performance than shown in Figure 27. This illustrates that service providers with a quality-led approach successfully execute their strategies to build a network performance gap, having significantly better results in terms of downlink and uplink speeds as well as lower latency. Both offering- and industry-led service providers aim to have "good enough" network performance, trailing the quality-led operators but not investing as heavily in network transformation.

Today, 69 percent of the quality-led service providers have launched 5G for smartphones commercially, leveraging their position further through a moderate price premium on 5G. Only 31 percent of offering-led and 16 percent of industry-led have launched 5G. Although the offering-led group chose a price position very close to the quality-led, the industry-led service providers have a premium that is more than 50 percent higher than the others. This indicates a skimming strategy in the short term, targeting early adopters rather than driving a quick uptake, whilst waiting for the market to be ready. Similarly, the quality-led are more active in the area of fixed wireless access (FWA), leveraging network performance to complement or directly compete against fixed networks. Of these, nearly 80 percent have FWA offerings on the market, compared to the average of 65 percent globally. Quality-led service providers will look to maintain their lead. Offering-led will have pressure to improve in this area to support innovative 5G services, like cloud gaming, that require lower latency and higher bandwidth than often provided today by this group.[3]

A look at service offerings[4] reveals that offering-led service providers tend to couple network performance with specific use cases and end-user expectations, like promoting the best network for video streaming. Quality-led providers, on the other hand, mainly focus on coverage and performance and are more likely to have promotions that leverage network performance as well as their existing premium customer segments.

Strategies follow regional market conditions

At about 45 percent, the Middle East has the highest proportion of quality-led service providers, as the execution of this strategy requires large investments in the network. Western Europe seems to have the largest variation of strategies per market.

45%

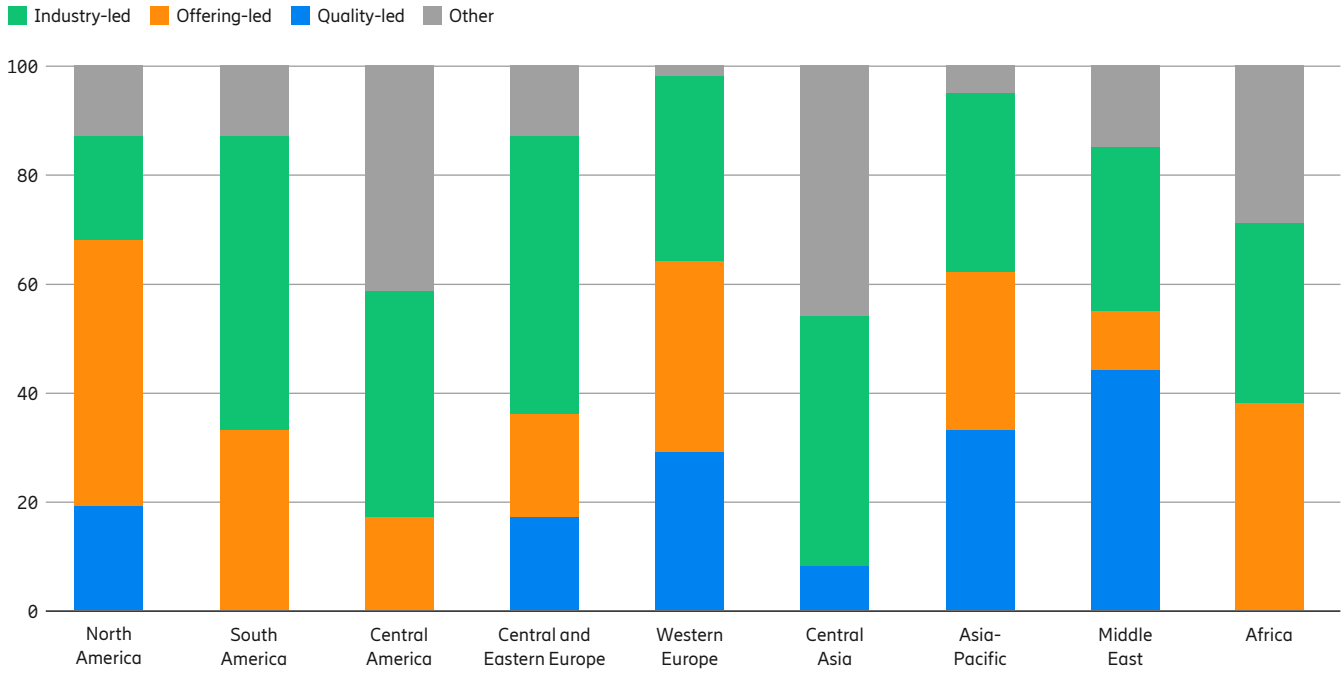
The Middle East region has the highest proportion of quality-led service providers with 45 percent.

Within Africa, offering-led is the most common strategy, frequently offering a wide range of services linked to mobile subscriptions such as gaming, mobile banking and insurance. The quality-led strategy was not found here, similar to Central and South America.

Central and Eastern Europe deviates from the global average, with a significantly higher share of industry-led service providers and fewer quality-led service providers. Previously state-owned incumbents in Central and Eastern Europe typically held the number one position in the market with aspects of a quality-led strategy. However, the region shows a low percentage of quality-led service providers globally, indicating that incumbents here didn't focus as much as their peers from other regions on network transformation, and didn't keep up investment levels to score higher in our analysis. At the same time, global service providers, primarily from Western Europe, have often been acquiring the number two or three player in many of the markets. With the added financial support, they have then been able to move their position to match or even take the lead in terms of network performance.

[2] Source: Ericsson analysis on Speedtest Intelligence® data from Ookla®, (Q3 2020). Data represents the lowest performing 10 percent of samples.
[3] Ericsson Mobility Report, "Mobile cloud gaming – an evolving business opportunity" pp. 25–28 (November 2020).
[4] More service offering choices for the consumer: www.ericsson.com/en/mobility-report/articles/service-offering-choices-for-the-consumer.

Figure 28: Spread of strategies within each region (percent)



Strategies reward different financial KPIs

The strategies give different outcomes when cross-analyzed against performance metrics, illustrating how the strategies support distinct business goals. Globally, industry-led is slightly ahead on revenue growth, with the most service providers amongst the top 50 in the world.

Quality-led service providers, on the other hand, take a firm lead for EBITDA, market share and ARPU leadership. The same is true when looking at capex to sales ratio, which would be expected, as the quality-led strategy is focused on network transformation and quality.

Quality-led service providers perform best in local markets for four out of six KPIs

Studying local markets where we have financial data for two or more service providers, and ranking each strategy based on the performance in each financial KPI, we can find out which strategy type takes which position in each market.

No. 1

Offering-led service providers often take the number one spot for the five-year revenue growth KPI.

The offering-led strategy takes the top spot most often when looking at five-year revenue growth. Quality-led service providers have the highest market share as well as the best cash flow in the majority of markets. They also have the highest ARPU closely followed by offering-led service providers. The industry-led strategy takes the top spot for EBITDA, with quality-led just behind.

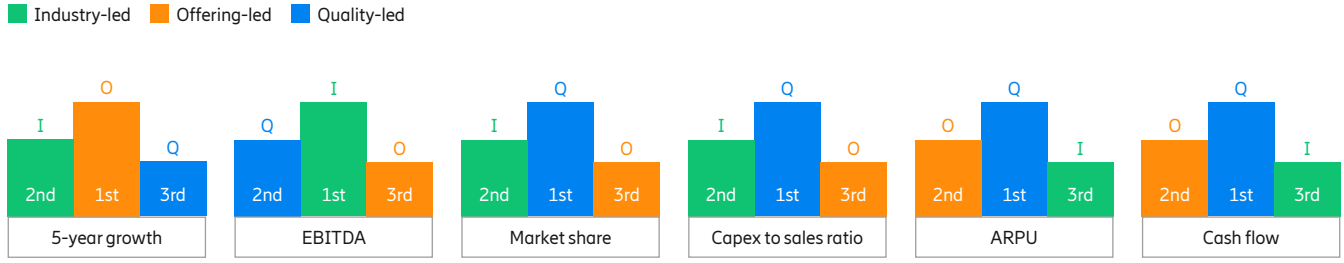
One KPI that stands out is the market share, where quality-led service providers are taking the number one place in more than half of the markets analyzed. Offering-led, on the other hand, places third in 50 percent of the markets.

This is likely a natural consequence of the market leader commonly choosing a quality-led strategy, whilst challengers tend to adopt an offering-led strategy.

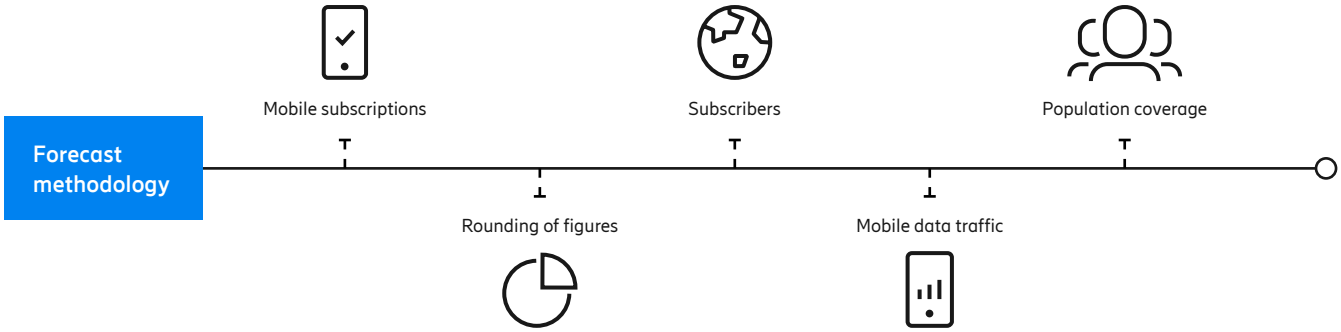
Selection and execution are key to success

Service providers compete using distinct strategies, which give different returns. By understanding their local market conditions and business assets, best-in-class service providers challenge the market with a focused competitive advantage, optimizing their returns. Quality-led providers build and maintain a sustainable gap in network performance, offering-led innovate with service offerings and customer experience management, while industry-led act as fast followers. All these strategies have their advantages and disadvantages, and the adoption of a certain strategy is carefully considered by service providers based on their specific situation.

Figure 29: The ranking of service providers which lead in KPIs, in their respective local markets



Methodology



Forecast methodology
Ericsson makes forecasts on a regular basis to support internal decisions and planning, as well as market communications. The forecast time horizon in the Mobility Report is six years and is moved forward one year in the November report each year. The subscription and traffic forecast baseline in this report is established using historical data from various sources, validated with Ericsson internal data, including measurements in customer networks. Future developments are estimated based on macroeconomic trends, user trends, market maturity and technological advances. Other sources include industry analyst reports, together with internal assumptions and analyses.

Historical data may be revised if the underlying data changes – for example, if service providers report updated subscription figures.

Mobile subscriptions
Mobile subscriptions include all mobile technologies. Subscriptions are defined by the most advanced technology that the mobile phone and network are capable of. Our mobile subscriptions by technology findings divide subscriptions according to the highest-enabled technology they can be used for. LTE subscriptions, in most cases, also include the possibility for the subscription to access 3G (WCDMA/HSPA) and 2G (GSM or CDMA in some markets) networks. A 5G subscription is counted as such when associated with a device that supports New Radio as specified in 3GPP Release 15, and connected to a 5G-enabled network. Mobile broadband includes radio access technologies HSPA (3G), LTE (4G), 5G, CDMA2000 EV-DO, TD-SCDMA and Mobile WiMAX. WCDMA without HSPA and GPRS/EDGE are not included.

FWA is defined as a connection that provides broadband access through a mobile network enabled customer premises equipment (CPE). This includes both indoor (desktop and window) and outdoor (rooftop and wall-mounted) CPE. It does not include portable battery-based Wi-Fi routers or dongles.

Rounding of figures
As figures are rounded, summing up data may result in slight differences from the actual totals. In tables with key figures,subscriptions have been rounded to the nearest 10th of a million. However, when used in highlights in the articles, subscriptions are usually expressed in full billions or to one decimal place. Compound annual growth rate (CAGR) is calculated on the underlying, unrounded numbers and is then rounded to the nearest full percentage figure. Traffic volumes are expressed in two or three significant figures.

Subscribers
There is a large difference between the numbers of subscriptions and subscribers. This is because many subscribers have several subscriptions. Reasons for this could include users lowering traffic costs by using optimized subscriptions for different types of calls, maximizing coverage and having different subscriptions for mobile PCs/tablets and mobile phones. In addition, it takes time before inactive subscriptions are removed from service provider databases. Consequently, subscription penetration can be above 100 percent, which is the case in many countries today. However, in some developing regions, it is common for several people to share one subscription, for example via a family- or community-shared phone.

Mobile network traffic
Ericsson regularly performs traffic measurements in over 100 live networks covering all major regions of the world. These measurements form a representative base for calculating worldwide total mobile traffic. More detailed measurements are made in a selected number of commercial networks with the purpose of understanding how mobile data traffic evolves. No subscriber data is included in these measurements.

Please note that the Ericsson Mobility Report data traffic forecast, both global and regional, represents the estimated traffic volume in all networks over the duration of a month. Traffic (in terms of throughput) in high-traffic areas will be much higher than the average traffic.

Population coverage
Population coverage is estimated using a database of regional population and territory distribution, based on population density. This is then combined with proprietary data on the installed base of radio base stations (RBS), together with estimated coverage per RBS for each of six population density categories (from metro to wilderness). Based on this, the portion of each area that is covered by a certain technology can be estimated, as well as the percentage of the population it represents. By aggregating these areas, world population coverage per technology can be calculated.

Glossary

2G: 2nd generation mobile networks (GSM, CDMA 1x)

3G: 3rd generation mobile networks (WCDMA/HSPA, TD-SCDMA, CDMA EV-DO, Mobile WiMAX)

3GPP: 3rd Generation Partnership Project

4G: 4th generation mobile networks (LTE, LTE-A)

4K: In video, a horizontal display resolution of approximately 4,000 pixels. A resolution of 3840 × 2160 (4K UHD) is used in television and consumer media. In the movie projection industry, 4096 × 2160 (DCI 4K) is dominant

5G: 5th generation mobile networks (IMT-2020)

App: A software application that can be downloaded and run on a smartphone or tablet

AR: Augmented reality. An interactive experience of a real-world environment whereby the objects that reside in the real world are "augmented" by computer-generated information

CAGR: Compound annual growth rate

Cat-M1: A 3GPP standardized low-power wide-area (LPWA) cellular technology for IoT connectivity

CDMA: Code-division multiple access

dB: In radio transmission, a decibel is a logarithmic unit that can be used to sum up total signal gains or losses from a transmitter to a receiver

EB: Exabyte, 10^{18} bytes

EBITDA: Earnings before interest, taxes, depreciation, and amortization

EDGE: Enhanced Data Rates for Global Evolution

FDD: Frequency division duplex

GB: Gigabyte, 10^{9} bytes

Gbps: Gigabits per second

GHz: Gigahertz, 10^{9} hertz (unit of frequency)

GSA: Global mobile Suppliers Association

GSM: Global System for Mobile Communications

GSMA: GSM Association

HSPA: High speed packet access

Kbps: Kilobits per second

LTE: Long-Term Evolution

MB: Megabyte, 10^{6} bytes

Mbps: Megabits per second

MHz: Megahertz, 10^{6} hertz (unit of frequency)

MIMO: Multiple Input Multiple Output is the use of multiple transmitters and receivers (multiple antennas) on wireless devices for improved performance

mmWave: Radio waves in the extremely high frequency range. In 5G, mmWave refers to frequencies between 24 and 71GHz

Mobile broadband: Mobile data service using radio access technologies including 5G, LTE, HSPA, CDMA2000 EV-DO, Mobile WiMAX and TD-SCDMA

Mobile PC: Defined as laptop or desktop PC devices with built-in cellular modem or external USB dongle

Mobile router: A device with a cellular network connection to the internet and Wi-Fi or Ethernet connection to one or several clients (such as PCs or tablets)

NB-IoT: A 3GPP standardized low-power wide-area (LPWA) cellular technology for IoT connectivity

NFV: Network functions virtualization

NR: New Radio as defined by 3GPP Release 15

OEM: Original equipment manufacturer

OT: Operational technology

PB: Petabyte, 10^{15} bytes

Short-range IoT: Segment that largely consists of devices connected by unlicensed radio technologies, with a typical range of up to 100 meters, such as Wi-Fi, Bluetooth and Zigbee

SLA: Service level agreement

Smartphone: Mobile phone with OS capable of downloading and running "apps", e.g. iPhones, Android OS phones, Windows phones and also Symbian and Blackberry OS

TD-SCDMA: Time division-synchronous code-division multiple access

TDD: Time division duplex

VoIP: Voice over IP (Internet Protocol)

VoLTE: Voice over LTE as defined by GSMA IR.92 specification

WCDMA: Wideband code-division multiple access

Wide-area IoT: Segment made up of devices using cellular connections or unlicensed low-power technologies like Sigfox and LoRa

Global and regional key figures

Ericsson Mobility Visualizer
Explore actual and forecast data from the Mobility Report in our new interactive web application. It contains a range of data types, including mobile subscriptions, mobile broadband subscriptions, mobile data traffic, traffic per application type, VoLTE statistics, monthly data usage per device and an IoT connected device forecast. Data can be exported and charts generated for publication subject to the inclusion of an Ericsson source attribution.

Find out more
Scan the QR code, or visit
www.ericsson.com/en/mobility-report/mobility-visualizer

Global key figures

Mobile subscriptions	2019	2020	Forecast 2026	CAGR* 2020–2026	Unit
Worldwide mobile subscriptions	7,900	7,940	8,770	2%	million
• Smartphone subscriptions	5,640	6,060	7,520	4%	million
• Mobile PC, tablet and mobile router subscriptions	270	290	450	8%	million
• Mobile broadband subscriptions	6,100	6,420	7,950	4%	million
• Mobile subscriptions, GSM/EDGE-only	1,650	1,370	650	-12%	million
• Mobile subscriptions, WCDMA/HSPA	1,860	1,630	700	-13%	million
• Mobile subscriptions, LTE	4,290	4,670	3,940	-3%	million
• Mobile subscriptions, 5G	-	220	3,470	59%	million
• FWA connections	51	62	180	20%	million
Fixed broadband connections	**1,160**	**1,200**	**1,500**	**4%**	**million**
Mobile data traffic					
• Data traffic per smartphone	6.7	9.4	34	24%	GB/month
• Data traffic per mobile PC	15	17	29	9%	GB/month
• Data traffic per tablet	6.9	8.2	18	14%	GB/month
Total data traffic**					
Mobile data traffic	34	51	226	28%	EB/month
• Smartphones	32	49	220	29%	EB/month
• Mobile PCs and routers	0.8	1.0	1.6	9%	EB/month
• Tablets	0.9	1.1	3.9	23%	EB/month
Fixed wireless access	6.2	9.3	67	39%	EB/month
Total fixed data traffic	140	170	490	19%	EB/month

Regional key figures

Mobile subscriptions	2019	2020	Forecast 2026	CAGR* 2020–2026	Unit
North America	380	390	430	2%	million
Latin America	660	650	700	1%	million
Western Europe	510	510	520	0%	million
Central and Eastern Europe	570	550	560	0%	million
North East Asia	2,040	2,080	2,230	1%	million
China[1]	1,600	1,620	1,710	1%	million
South East Asia and Oceania	1,130	1,110	1,200	1%	million
India, Nepal and Bhutan	1,120	1,130	1,290	2%	million
Middle East and North Africa	710	710	850	3%	million
Sub-Saharan Africa	770	800	990	4%	million

[1] These figures are also included in the figures for North East Asia.

Regional key figures

Smartphone subscriptions	2019	2020	Forecast 2026	CAGR* 2020–2026	Unit
North America	310	320	350	2%	million
Latin America	500	510	560	2%	million
Western Europe	420	420	430	0%	million
Central and Eastern Europe	380	390	430	2%	million
North East Asia	1,810	1,910	2,110	2%	million
China[1]	1,440	1,510	1,640	1%	million
South East Asia and Oceania	770	810	1,050	4%	million
India, Nepal and Bhutan	620	760	1,150	7%	million
Middle East and North Africa	440	500	710	6%	million
Sub-Saharan Africa	390	450	720	8%	million
LTE subscriptions					
North America	350	350	80	-21%	million
Latin America	340	390	390	0%	million
Western Europe	380	410	150	-15%	million
Central and Eastern Europe	240	280	350	4%	million
North East Asia	1,800	1,730	700	-14%	million
China[1]	1,230	1,410	530	-15%	million
South East Asia and Oceania	390	470	700	7%	million
India, Nepal and Bhutan	550	710	820	2%	million
Middle East and North Africa	170	210	440	13%	million
Sub-Saharan Africa	90	120	290	15%	million
5G subscriptions					
North America	1	14	340	-	million
Latin America	0	1	180	-	million
Western Europe	1	6	350	-	million
Central and Eastern Europe	0	0	200	-	million
North East Asia	9	193	1,470	-	million
China[1]	5	175	1,220	-	million
South East Asia and Oceania	0	2	380	-	million
India, Nepal and Bhutan	0	0	350	-	million
Middle East and North Africa	1	1	130	-	million
Sub-Saharan Africa	0	0	50	-	million
Data traffic per smartphone					
North America	8.4	11.8	49	27%	GB/month
Latin America	3.8	5.8	29	30%	GB/month
Western Europe	7.6	11.3	46	26%	GB/month
Central and Eastern Europe	5.1	7.3	29	26%	GB/month
North East Asia	7.8	11.1	41	24%	GB/month
China[1]	7.8	11.0	39	24%	GB/month
South East Asia and Oceania	4.7	7.6	33	28%	GB/month
India, Nepal and Bhutan	13.5	15.7	37	15%	GB/month
Middle East and North Africa	4.2	6.0	30	30%	GB/month
Sub-Saharan Africa	1.6	2.2	8.9	26%	GB/month
Mobile data traffic					
North America	2.8	3.9	17	28%	EB/month
Latin America	1.6	2.5	14	33%	EB/month
Western Europe	3.1	4.4	17	25%	EB/month
Central and Eastern Europe	1.5	2.2	10	27%	EB/month
North East Asia	12.7	19	78	27%	EB/month
China[1]	10.2	15	59	25%	EB/month
South East Asia and Oceania	3.3	5.6	32	33%	EB/month
India, Nepal and Bhutan	6.7	9.6	35	24%	EB/month
Middle East and North Africa	1.6	2.6	18	38%	EB/month
Sub-Saharan Africa	0.55	0.87	5.6	36%	EB/month

* CAGR is calculated on unrounded figures.
** Figures are rounded (see methodology) and therefore summing up of rounded data may result in slight differences from the actual total.

Ericsson enables communications service providers to capture the full value of connectivity. The company's portfolio spans Networks, Digital Services, Managed Services, and Emerging Business and is designed to help our customers go digital, increase efficiency and find new revenue streams. Ericsson's investments in innovation have delivered the benefits of telephony and mobile broadband to billions of people around the world. The Ericsson stock is listed on Nasdaq Stockholm and on Nasdaq New York.

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