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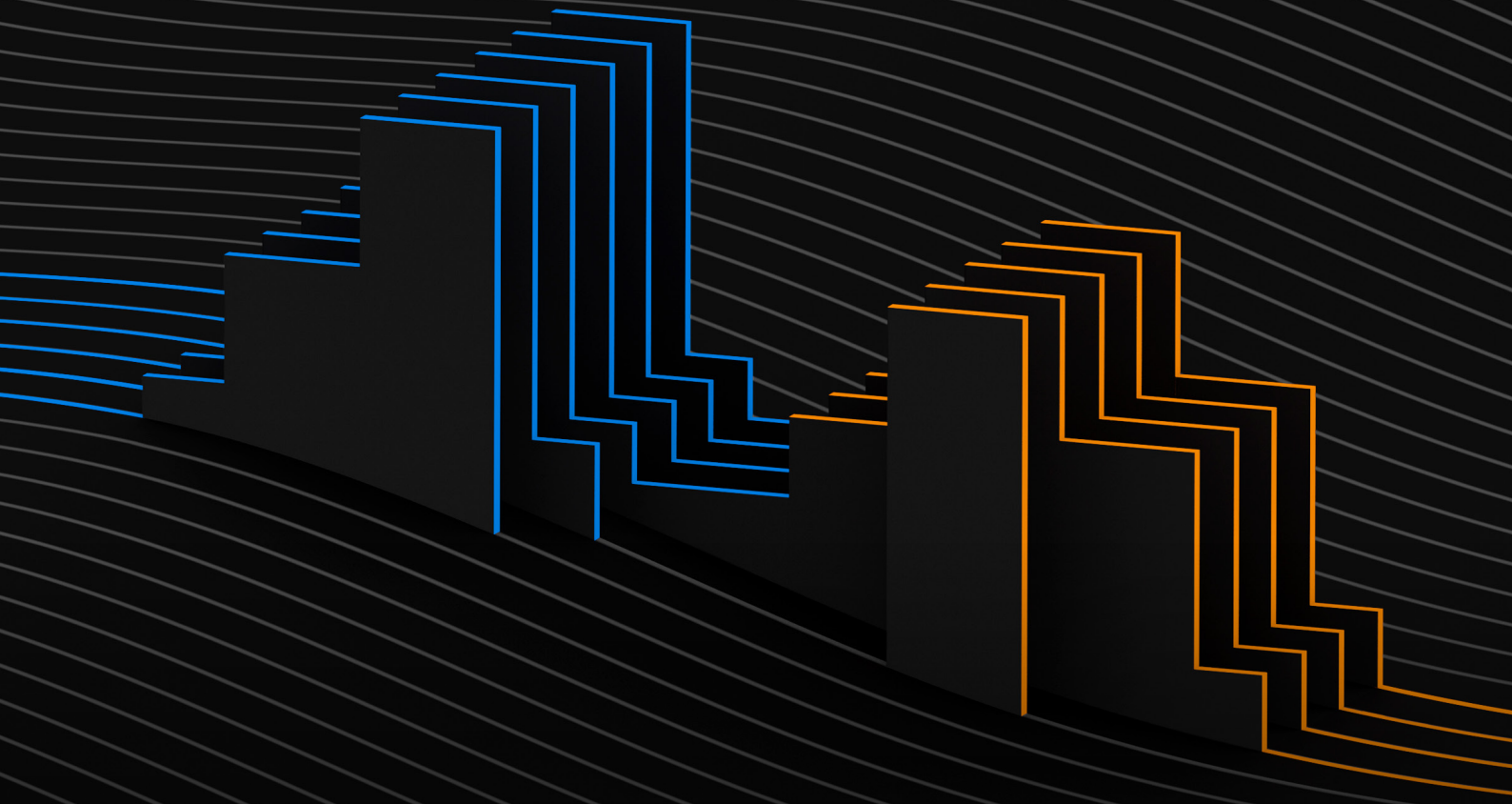
Ericsson Mobility Report



June 2020

Subscriptions
FWA connections are forecast to grow threefold and reach close to 160 million by the end of 2025

Mobile data traffic
After a peak in traffic growth in 2018 and 2019, the growth rate has returned to a more normal level

Co-written article
Verizon plans to double the places it is building out 5G on mmWave spectrum during 2020

Letter from the publisher

Adapting to new realities

We are living in unprecedented times. Directly or indirectly, COVID-19 has affected everyone around the world. Social distancing and keeping millions at home has placed significant demands on infrastructure. Systems supporting healthcare, education and businesses of all types are under stress. Today, connectivity is key and so far, telecom networks have stood up to the task. This massive disruption has highlighted the value of the network, as recognized clearly by the consumers we surveyed for this edition of the Ericsson Mobility Report.

While in some markets 5G subscription growth has slowed as a result of the pandemic, this is outweighed by other markets where it is accelerating, leading us to raise our forecast of global 5G subscriptions at the end of 2020. However, the success of 5G cannot be measured in subscriptions alone. The value 5G brings will be determined by the success of new use cases and applications for consumers and businesses. In this report we cover aspects of fixed wireless access, gaming and dedicated networks to give a broad picture of the progress of an industry that – despite the current situation – continues to rapidly evolve.

5G was made for innovation and, as the value of the digital infrastructure has been further evidenced during these recent times, 5G investments can play a significant role in restarting economies.

We hope you find the report engaging and useful!

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

Key contributors

Executive Editor:	Patrik Cerwall
Project Manager:	Anette Lundvall
Editors:	Peter Jonsson, Stephen Carson
Forecasts:	Richard Möller
Articles:	Peter Jonsson, Stephen Carson, Steven Davis, Greger Blennerud, Per Lindberg, Kati Öhman, Jeff Travers, Finn Pedersen, Peter Linder, Jasmeet Singh Sethi, Peter Rinderud, Jose Alonso-Rubio, Jorge Luque Garcia
Co-authors:	Heidi Hemmer, Chris Ashraf, Amelia Powell: Verizon (US)

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190m

5G subscriptions are expected to reach 190 million by the end of 2020

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14%

Mobile data traffic grew by 14 percent between Q4 2019 and Q1 2020

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83%

During lockdown, 83 percent of smartphone users claim that ICT helped them a lot to cope

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25%

By the end of 2025, 25 percent of the world's mobile network data traffic is forecast to be fixed wireless access

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With Verizon, we explore deploying 5G using mmWave spectrum in the US

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A -10 to 20 percent change in data traffic has been experienced by service providers during the initial COVID-19 lockdown restriction phase

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Find out more
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Communication needs in times of crisis

The first months of 2020 saw the spread of a novel coronavirus around the globe. Subsequent behavioral changes, due to lockdown restrictions in many countries, caused measurable changes in the usage of both fixed and mobile networks.

Coronavirus disease 2019 (COVID-19) forced an unprecedented number of people all over the world to change their workplace from office to home and become accustomed to new routines in their daily lives. As new digital behaviors are forming, the critical role of communications service providers to support a functioning society with flawless digital communication capabilities in times of crisis has become apparent.

Network traffic and service impact

As people spent more time online at home, network traffic loads shifted geographically from city centers and office areas to suburban residential areas. The largest share of the traffic increase as lockdowns went into place was absorbed by the fixed residential network, but many service providers also experienced an increased demand on the mobile network.

Networks are dimensioned to support traffic demand during peak hours of usage, which for data traffic normally occurs in the evening. However, the data traffic generated as people worked from home also created additional peak hours of usage during daytime. It was primarily these peak hours of data usage that needed to be supported with a sufficient level of network performance to avoid service quality degradation, e.g. by measures like capacity upgrades, load balancing and traffic optimization.

There are different minimum network throughput requirements for various apps that need to be maintained to provide a service at a specific quality level, such as fast web download times, short video start times and good picture quality. Conversational and bidirectional apps, such as video calling, require at least 1Mbps downlink/uplink throughput, while media consumption could require up to 20Mbps downlink throughput for a good service quality.

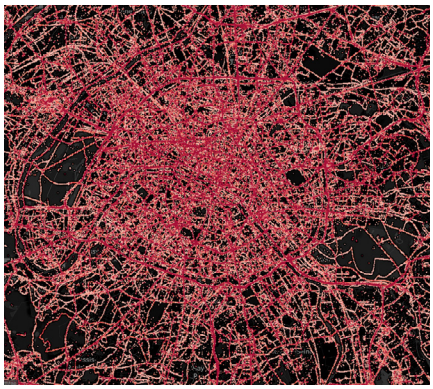
The increased data consumption was mainly driven by a rising usage of bidirectional remote work-related apps, such as audio, web and video conferencing, entertainment apps (streaming video and audio), social media and messaging.

Networks rising to the challenge

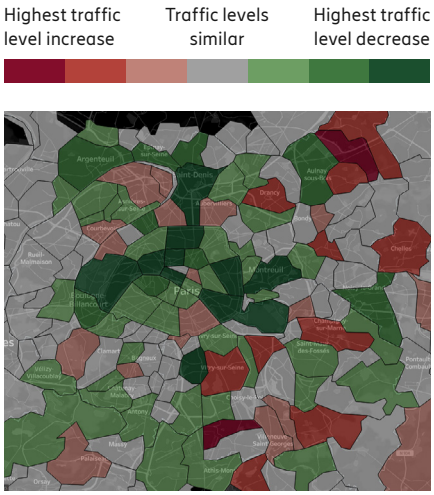
A substantial increase in the volume and duration of mobile voice calls across networks – ranging from 20 to 70 percent – was observed in the most impacted regions during the initial lockdown phase. Mobile data traffic growth was typically moderate, or even negative, ranging from -10 to 20 percent in different networks. However, the traffic increase was unevenly distributed, with some cells experiencing a large increase despite overall moderate or even decreasing traffic growth throughout the network. In markets with limited penetration of fixed residential networks, the mobile data demand increase was especially high. In general, service providers managed to provide sufficient network performance despite changing traffic patterns and increased traffic demand.

In some markets, a contributing factor to mobile data traffic growth was that service providers made temporary changes to data plans and either increased the "bucket size" or allowed unlimited data for a certain period of time.

Figure 1: The lockdown restriction effect on mobility and mobile traffic levels



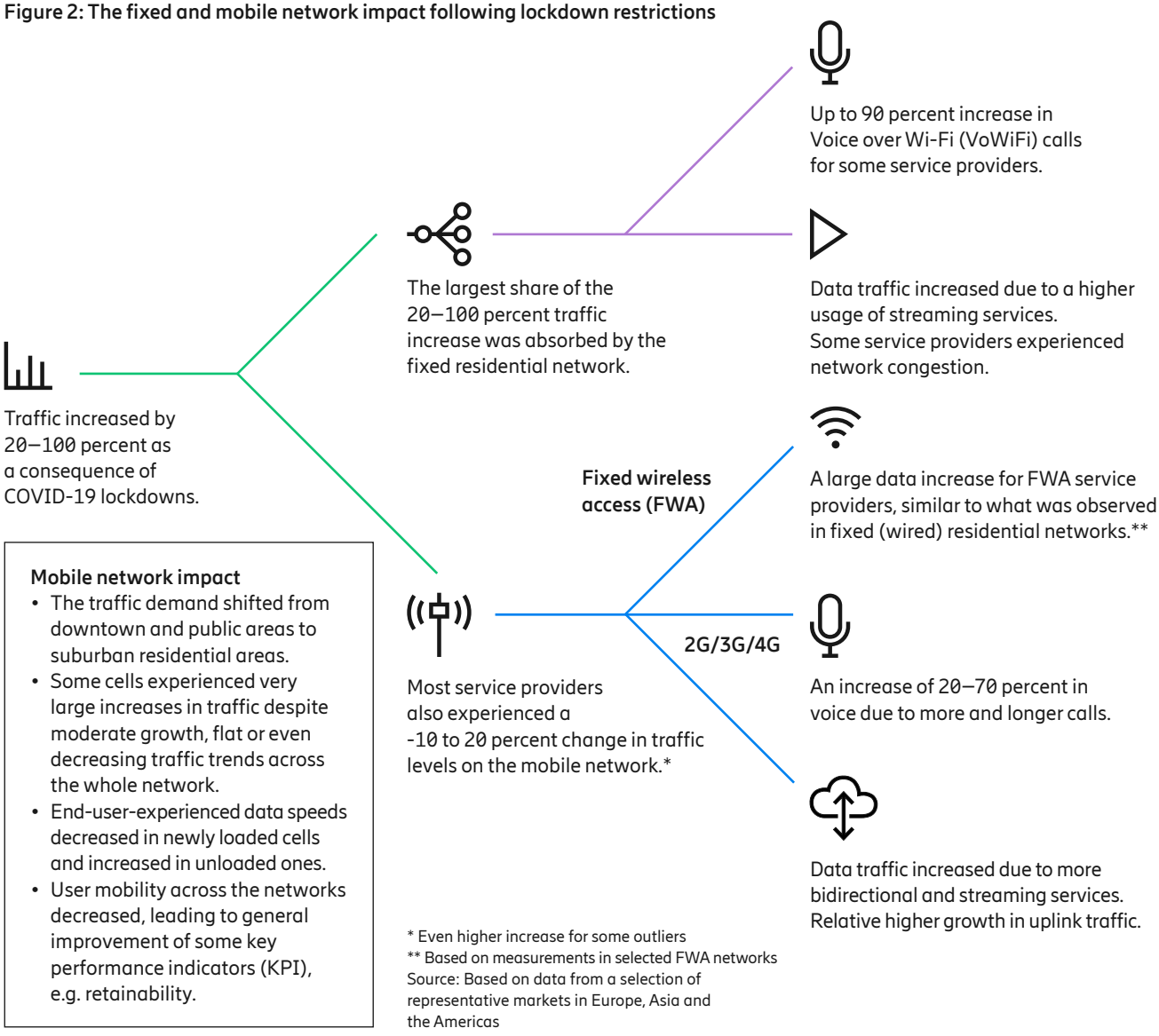
Change in density of mobile network users throughout central Paris two weeks before and after lockdown in mid-March



Change in mobile data traffic levels in the Paris area two weeks before and after lockdown in mid-March, showing a geographical shift in demand from central to adjacent and suburban areas

Source: Ericsson Analytics based on crowdsourced data

Figure 2: The fixed and mobile network impact following lockdown restrictions



Mobile network impact

- The traffic demand shifted from downtown and public areas to suburban residential areas.
- Some cells experienced very large increases in traffic despite moderate growth, flat or even decreasing traffic trends across the whole network.
- End-user-experienced data speeds decreased in newly loaded cells and increased in unloaded ones.
- User mobility across the networks decreased, leading to general improvement of some key performance indicators (KPI), e.g. retainability.

* Even higher increase for some outliers
** Based on measurements in selected FWA networks
Source: Based on data from a selection of representative markets in Europe, Asia and the Americas

On rare occasions, minor degradation in mobile network performance was observed, typically on individual cell level where capacity upgrades were needed. In many cases, overall network performance even improved due to reduced population movement and less mobile traffic. It is often difficult for consumers to distinguish network performance issues from application server congestion, or under-dimensioned corporate VPN capacity. In many cases, perceived performance problems are related to specific services and increased load on their related servers (e.g. during video conferencing).

As consumers and enterprises try out new digital behaviors imposed by COVID-19, an increased importance may emerge for e-health, wellness apps, e-learning, public sector data access and similar digital utility services.

Keeping connected during the crisis

Consumers' communication behavior has partly changed, where video calling and video conferencing services appear to stand out, especially among white-collar workers and seniors (60+).

Previously, consumers have not fully embraced video calling as one could have expected, as is evidenced by a relatively low uptake in most countries. Now, as many as half of respondents in a recently conducted consumer study claim they have increased their usage of video calls.[1] It also appears that video calling is the service that most have started to use during the crisis. As many as 85 percent of consumers now use video calling, making it the second most important way of contacting family and friends during the crisis, after voice calls. The study also shows that the quality of video calls with friends and family is the most important experience when consumers were asked to judge their mobile network performance during the crisis.

Among seniors, 74 percent claim they now use video calls and 4 out of 10 have increased their video usage due to social distancing. Among white-collar workers, 88 percent now use video calls, and as many as 60 percent say they have increased their usage of video calls.

This behavior among seniors is likely to continue and remain established after the crisis ends. For white-collar workers, the habit of using video conferencing seems likely to continue into the future as 7 in 10 believe they will be working more from home after the crisis than they did before. They also agree that the traditional way of conducting voice-based conference calls will change to video-based conference calls.

[1] Ericsson Consumer & IndustryLab, Keeping consumers connected in a COVID-19 context (April 2020)
Base: Smartphone users aged 15–69 within Brazil, China, France, Germany, India, Italy, South Korea, Spain, Sweden, the UK and the US

Connected consumers getting through the pandemic

The COVID-19 pandemic has had a substantial impact on people in many countries and their daily lives, but consumers see resilient networks as a vital help in coping with everyday life.

The pandemic has prompted authorities around the world to implement a variety of social distancing measures to slow transmission of the virus. A recently conducted consumer study[1] documents the extent smartphone users in 11 countries state they have been impacted. The perceived impact on daily life ranges across the markets based on the level of restrictions imposed, from 82 percent in India stating their personal life is highly impacted to only 45 percent in Sweden.

Three in four of the highly impacted parents state that ICT has helped their children a lot in accessing education and keeping them entertained. Two in three among those who say that the crisis has had a high impact on their personal life agree that reliable connectivity has helped them work remotely.

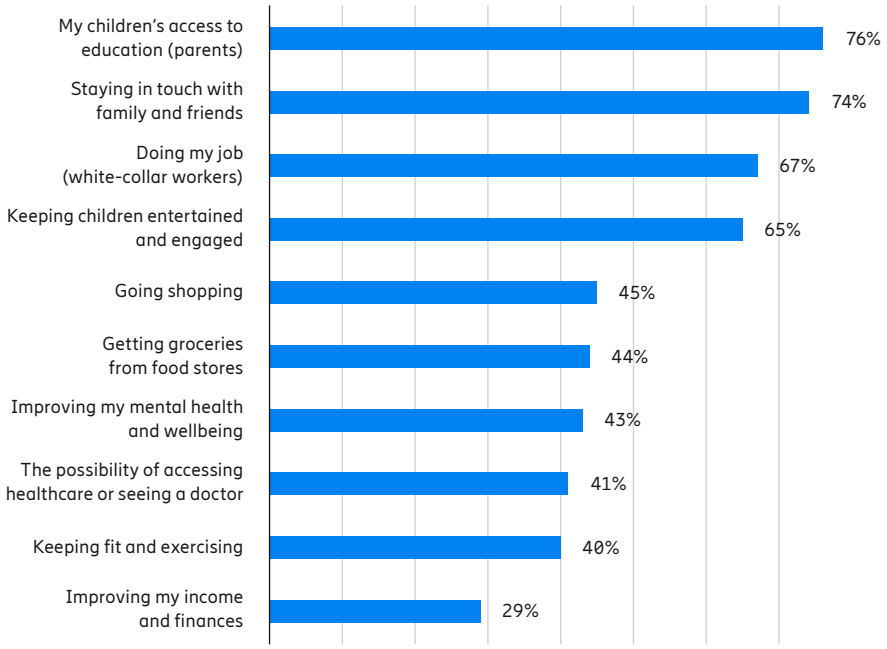
83%

Of the survey respondents, 83 percent claim that ICT helped them a lot, in one way or another, to cope with the lockdown.

ICT vital for consumers to cope with everyday life

Across all the surveyed markets, 83 percent of respondents claim that information and communications technology (ICT) has helped them a lot in coping with the impact of the pandemic in various ways. There is a higher than average degree of feeling supported by ICT among career millennials,[2] parents with children at home and those living in centers of larger cities. Among the seniors (60+), 3 in 4 also state that ICT has helped them a lot during the crisis, especially in being able to stay in touch with family and friends. The most important communication services among all respondents for this purpose have been voice calls and instant messaging. Among seniors, 4 in 10 ranked video calls as 1 of the 3 most important communication services.

Figure 3: Share of smartphone users who consider ICT has helped them a lot with different tasks in their daily lives during the COVID-19 pandemic

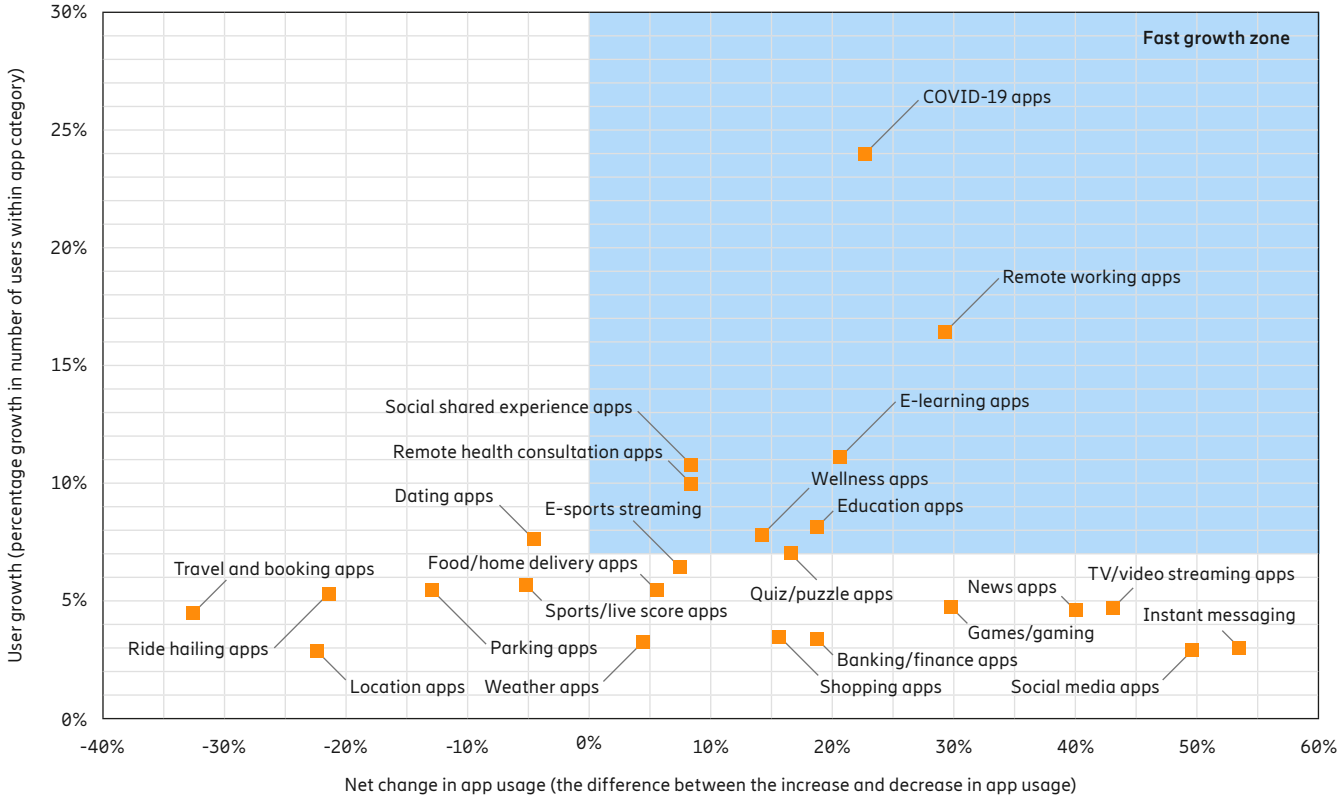


Base: Smartphone users aged 15–69 who claim their daily life is highly impacted by the lockdown restrictions, in Brazil, China, France, Germany, India, Italy, South Korea, Spain, Sweden, the UK and the US

[1] Ericsson Consumer & IndustryLab, Keeping consumers connected in a COVID-19 context (April 2020): www.ericsson.com/en/reports-and-papers/consumerlab/reports/keeping-consumers-connected-during-the-covid-19-crisis

[2] Age 23–39 years

Figure 4: Smartphone apps – user growth and net change in usage during COVID-19 lockdown restrictions



The importance of networks is reflected in increased usage

The daily time consumers spent connected to fixed broadband increased by two and a half hours during the crisis, while the time spent connected to mobile broadband increased by an average of one hour per day. As many as 46 percent have spent significantly more time on fixed broadband, while 16 percent have done the same on mobile broadband.

In markets with limited penetration of fixed residential networks, the mobile broadband network was especially valued. For example, in India, 33 percent claim mobile broadband is more important than fixed broadband, as 37 percent only or most often rely on mobile broadband to connect at home. In South Korea, the US, China, Italy and Brazil, almost half of respondents claim that the networks are equally important to them.

While most online activities on smartphones were mainly done connected to Wi-Fi at home, some activities were an exception. Thirty-eight percent of all respondents in the survey claim that they spend half of their overall time using social media apps connected to a mobile broadband network rather than a fixed network.

Networks cope well with the increased usage

Compared with before the lockdown restrictions, 74 percent experience their mobile broadband network as the same or better than before the crisis, while 21 percent say it is worse. About half of all consumers say they are very satisfied with their fixed broadband's overall performance. This shows that both mobile and fixed broadband have coped well with the increased internet usage.

Changes in service usage behavior

Although the pandemic created new concerns for consumers, they are still buying new devices and expanding their usage of ICT services. About 1 in 10 have bought new devices, and 2 in 10 have started to use new services. However, far more consumers have increased their usage of the online services they already use. Across the 11 markets, 87 percent have increased their usage of existing online services. A majority has increased usage of (in descending order): web browsing, instant messaging, streaming of videos, social media, video calls and voice calls.

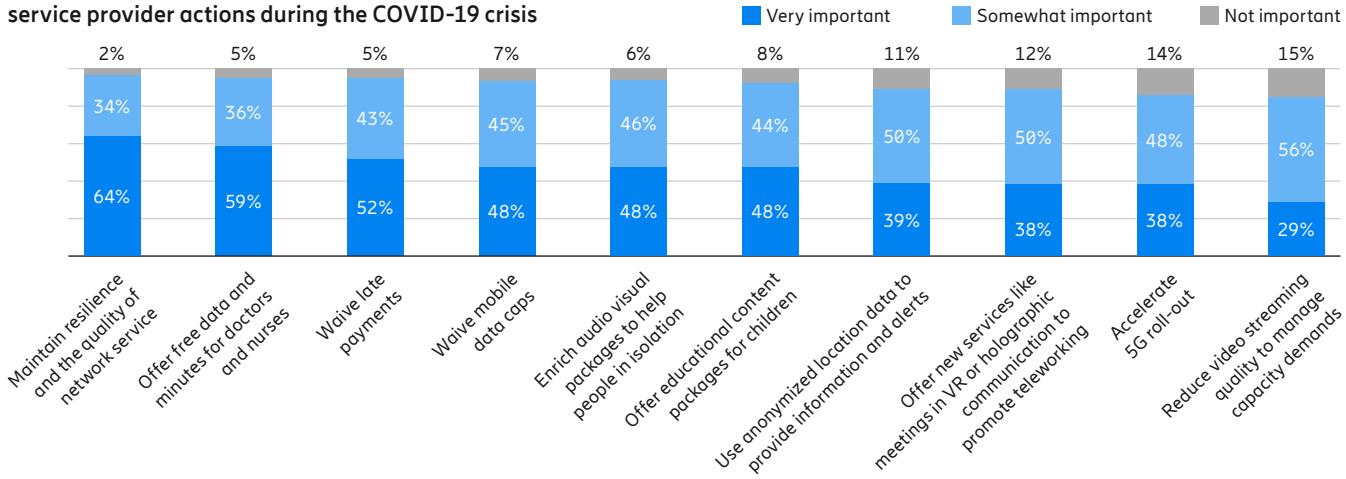
Analysis of the net changes in app usage and new user growth reveals that apps for COVID-19 information and symptom tracking, e-learning, remote working and wellness all experienced an increase in usage, as well as a net new user growth of at least 8 percent or more. In addition, the need to socialize while in isolation and avoiding physical visits to doctors during the crisis drove users to start using remote health consultations and social shared experience apps. However, apps related to travel and booking, sports and navigation decreased the most in usage.

Methodology

This article is based on data from an Ericsson Consumer & IndustryLab survey among smartphone users aged 15–69 years across 11 countries: Brazil, China, France, Germany, India, Italy, South Korea, Spain, Sweden, the UK and the US. The data has been collected through online questionnaires between April 8–24, 2020. The sample of 1,000 respondents in each country – a total of 11,000 respondents – statistically represents at least 700 million smartphone users across these markets.

The average time spent on Wi-Fi increased by two and a half hours per day, while mobile broadband usage increased by one hour per day.

Figure 5: Level of importance respondents give to the following service provider actions during the COVID-19 crisis



Service providers expected to deliver resilient networks and innovative offers

Many smartphone users expect service providers to be creative in meeting the new demands and needs of their customers and communities. In the study, several statements were tested to see the relative importance of different actions service providers could take with the network and service packaging. Six in 10 consumers think it is very important that service providers maintain the resilience and quality of the networks. A majority expect that their service provider assists frontline workers, such as doctors, nurses and first responders, by rewarding them with free usage of data and voice calls. They are also expected to refrain from charging additional fees for late payments and remove any existing data caps.

It is worth noting that certain segments are over-represented in specific requirements, for example 61 percent of parents expecting educational content packages for children, and 48 percent of white-collar workers expecting new services like meetings in virtual reality (VR).

Consumer expectations of 5G networks

In times of crisis, when connectivity is important for consumers to carry out work- and leisure-related activities, expectations for better network experiences become higher. Six in 10 smartphone users have a clear positive attitude towards the role 5G could have played during the crisis, and about half of them strongly agree that 5G could have offered both better network capacity and higher speeds compared to 4G. They also believe that society overall could have benefited hugely from 5G. There was a similar level of agreement related to 5G's role from a medical perspective. For example, medical specialists could have used 5G to control medical equipment via remote centers or 5G-enabled robots could have carried out tests, reducing the time medical staff need to spend in infectious spaces.

On average, 16 percent of smartphone users across 5 EU markets (Sweden, France, Germany, Italy and Spain) and 41 percent in India and China indicate that they plan to upgrade to 5G as soon as the crisis subsides.

The survey also reveals that current 5G users carry out more activities online than 4G users, such as grocery shopping, streaming videos and playing games. 5G users are also more optimistic about 5G's potential. Although 4 in 10 respondents strongly agree that 5G coverage should be rolled out much faster, so they can have a faster network than their fixed broadband at home, as many as 6 in 10 5G users strongly agree with this.

Current 5G users agree to a larger extent than 4G users that mobile broadband is more important to them than fixed broadband. In fact, 23 percent of current 5G users think mobile broadband is more important in a comparison with fixed, while another 48 percent say the networks are equally important.

The pandemic has driven adoption and increased usage of many ICT services that have enabled consumers to build a new normal underpinned by connectivity. This has also built an exciting foundation for the potential role that 5G could play in enriching services and making the management of such a crisis much easier, helping to keep us all connected when we have to stay apart. While 57 percent will save money for financial security, one-third plan to invest in 5G and better broadband at home to be prepared for a potential next wave.

64%

Of the consumers asked, 64 percent think it is very important that service providers maintain the resilience and quality of the networks.

New digital behaviors may remain

Based on their behavioral changes during the lockdown restrictions, consumers predict that their new digital behaviors will remain after the crisis. Some of the predicted trends are:

1. **Networks redefined:** Resilient networks will be valued. Seven in 10 say being connected during the crisis is not only important now, but will be in the future as well.
2. **Autonomous commerce:** Six in 10 predict that deliveries will be carried out by automated drones or driverless cars, due to rising demand for contact-free interactions.
3. **Borderless workspaces:** After working well away from their offices, 7 in 10 white-collar professionals now predict that remote working will be the new normal.
4. **Synchronous care:** Six in 10 respondents in the US and UK predict that online healthcare consultations will become more popular than physical visits to the doctor.
5. **Virtual experience economy:** Augmented and virtual reality (AR/VR) applications could evolve into attractive new travel, social or educational service offerings. Six in 10 respondents say VR will allow us to have the experiences we want, even in isolation.

More service offering choices for the consumer

Commercial 5G offerings are on the rise, leading to subtle shifts in service packaging trends.

Over March–April 2020, Ericsson updated its study of retail packages offered by service providers worldwide. This is the third iteration, complementing those completed in December 2018 and August 2019.[1] The study classifies tariff plans on offer to consumers, based on data from service providers' websites.

In 2018/19, 264 service providers were analyzed. Since then, 1 service provider has withdrawn from the market and another 46 have been added to the analysis. However, to maintain the possibility of comparison with previous iterations, analysis of the additional 46 will be referenced separately when applicable.

Changes in service packaging

The "bucket model", typically expressed in gigabytes (GB) per month, continues to be the core offering for an overwhelming majority of service providers. As in the previous iterations, all but four service providers use the bucket model as their base offering. These four service providers offer unlimited data as their only main alternative. A small increase was seen in the number of service providers which offered an option that included unlimited data as a premium package, mainly among service providers in Western/Central Europe and the Middle East and Africa.

A variation of the bucket model, referred to as off-peak, includes a discount provision for data volume consumed during night-time and weekends when the network is less loaded. Today, 54 service providers offer this model, up from 40 in the previous study. Half of the increase was due to organic growth, and the other half due to the enlarged base.

Service-based packages targeting specific services – such as social media, music and video – are being used by 123 service providers. Packages targeting high-demand services like video and music streaming, which are particularly interesting as 5G arrives, are becoming even more popular; they are offered by 85 out of the 123 service providers, up from 75 out of 112 in the previous study.

Commercial 5G on the rise

Two package types related to 5G consumer use cases (consumer IoT and home broadband) show exceptional growth. These are represented in the device-based and fixed wireless access (FWA) offerings, which increased to 66 and 175 respectively. Within the group of 46 service providers that was added in 2020, 10 service providers also offered FWA, bringing this number up to 185 out of 309. Additionally, there are 26 service providers offering broadband using a mobile battery-powered pocket router.

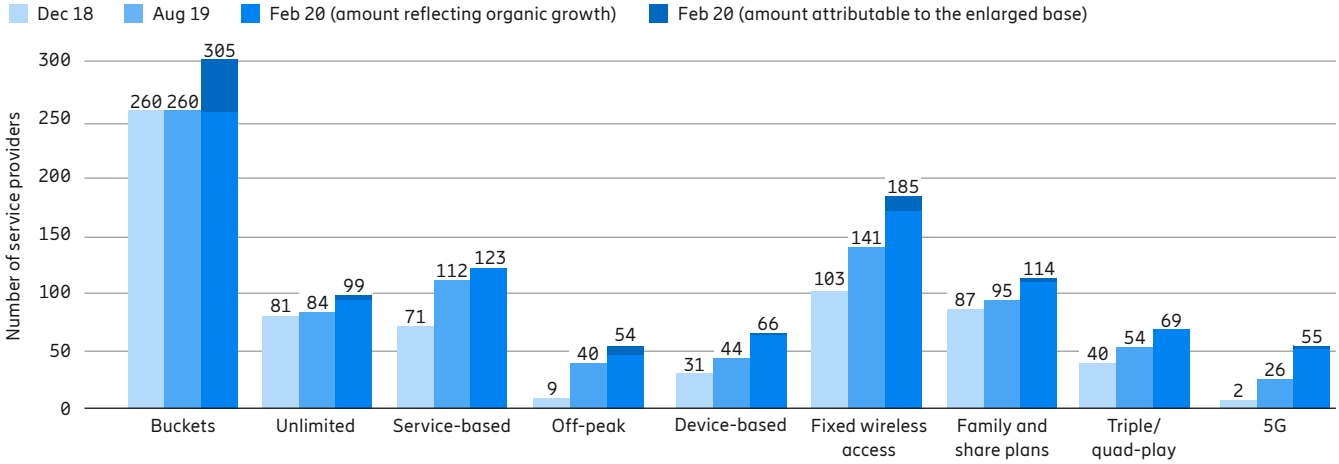
The number of service providers with commercial 5G offerings grew from 26 in the previous study to 55 in the latest. Of these, 49 offered 5G for smartphones and 6 offered solely FWA over 5G.

Around two-thirds of the service providers with 5G offerings charged a premium over their 4G pricing. The premium varied tremendously, from 6.8 percent up to 96 percent, but on average was 32 percent.

A varied offering

Service providers continue to provide more choice for consumers as they explore new forms of segmentation and differentiation. Additionally, most of the newly introduced elements are provided as add-ons, with buckets remaining the basis of the offers. Unlimited packages have been overtaken by service-based offerings as a top-tier option. Offerings related to 5G represent the strongest growth, as service providers try new ways of packaging their services in search of new revenues.

Figure 6: Number of service providers per type of offering



[1] Ericsson Mobility Report, "Mobile service packaging trends" (November 2019)

Mobile subscriptions outlook

A total of 190 million 5G subscriptions are expected by the end of 2020.

The spread of COVID-19 during the first part of 2020 impacted all parts of society globally, including the telecommunications sector. Despite the uncertainty caused by the pandemic, service providers continued to switch on 5G, and more than 75 of them have now announced commercial 5G service launches.[1]

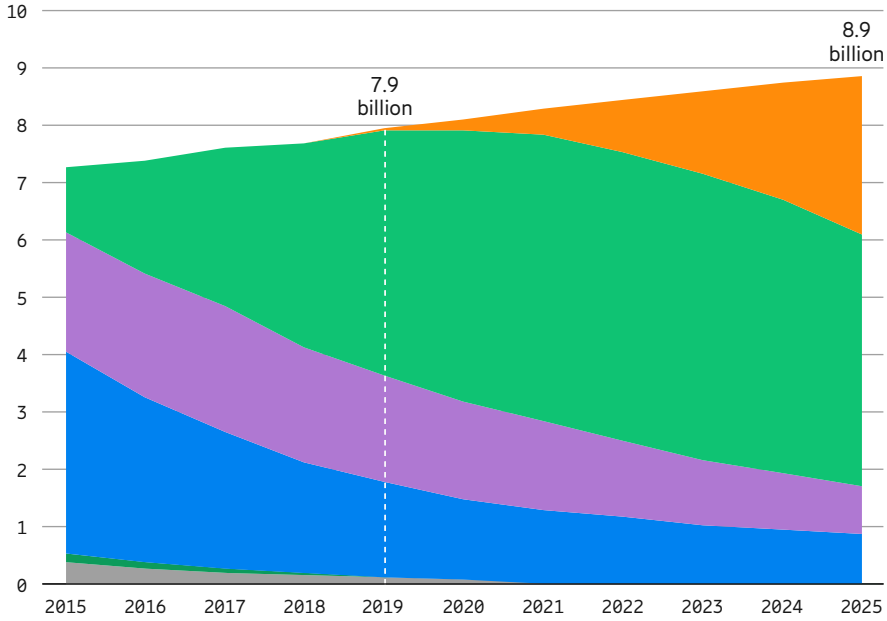
We have increased our estimate for the number of 5G subscriptions,[2] and now forecast about 190 million by the end of 2020. This is mainly due to a faster uptake in China than previously expected. For other parts of the world, slight downward adjustments have been made due to the effects of the pandemic. For example, several spectrum auctions in Europe have been delayed, with a slower uptake of 5G subscriptions in the near term expected as a result.

We have slightly decreased our 5G subscriptions forecast for 2020 and 2021 in North America, compared to previous estimates. Both Europe and North America are expected to reach the same 5G subscription figures by 2025 as previously forecast.[3]

Over the forecast period, 5G subscription uptake is expected to be significantly faster than that of LTE, following its launch back in 2009. Key factors are China's earlier engagement with 5G compared to 4G (LTE), as well as the earlier availability of devices from several vendors. By the end of 2025, we forecast 2.8 billion 5G subscriptions globally, accounting for around 30 percent of all mobile subscriptions at that time.

LTE will remain the dominant mobile access technology by subscription during the forecast period. It is projected to peak in 2022 at 5.1 billion subscriptions and decline to around 4.4 billion subscriptions by the end of 2025 as more subscribers migrate to 5G.

Figure 7: Mobile subscriptions by technology (billion)



2.8bn

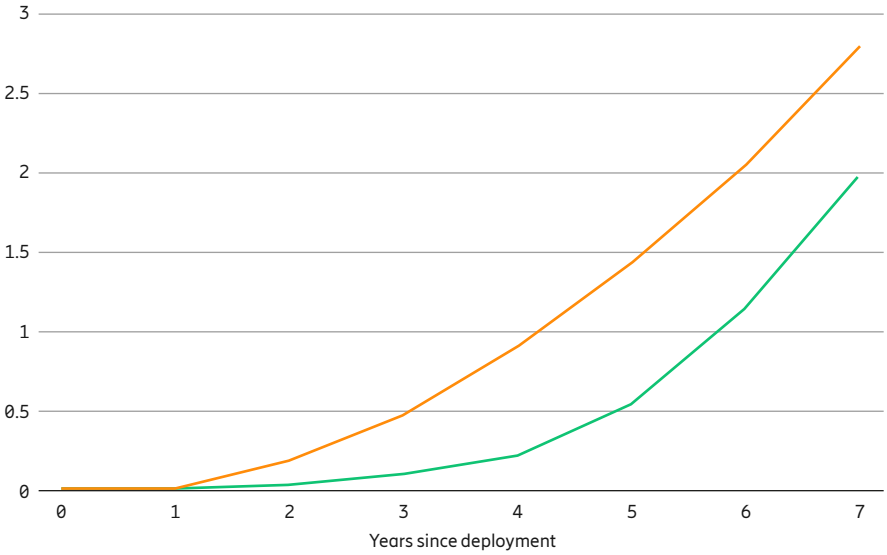
In 2025, 2.8 billion 5G subscriptions are forecast.

- 5G
- LTE (4G)
- WCDMA/HSPA (3G)
- GSM/EDGE-only (2G)
- TD-SCDMA (3G)
- CDMA-only (2G/3G)

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

[1] Ericsson and GSA (May 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
[3] Ericsson Mobility Report (November 2019)

Figure 8: Comparison of 5G and 4G subscriptions uptake in the first years of deployment (billion)



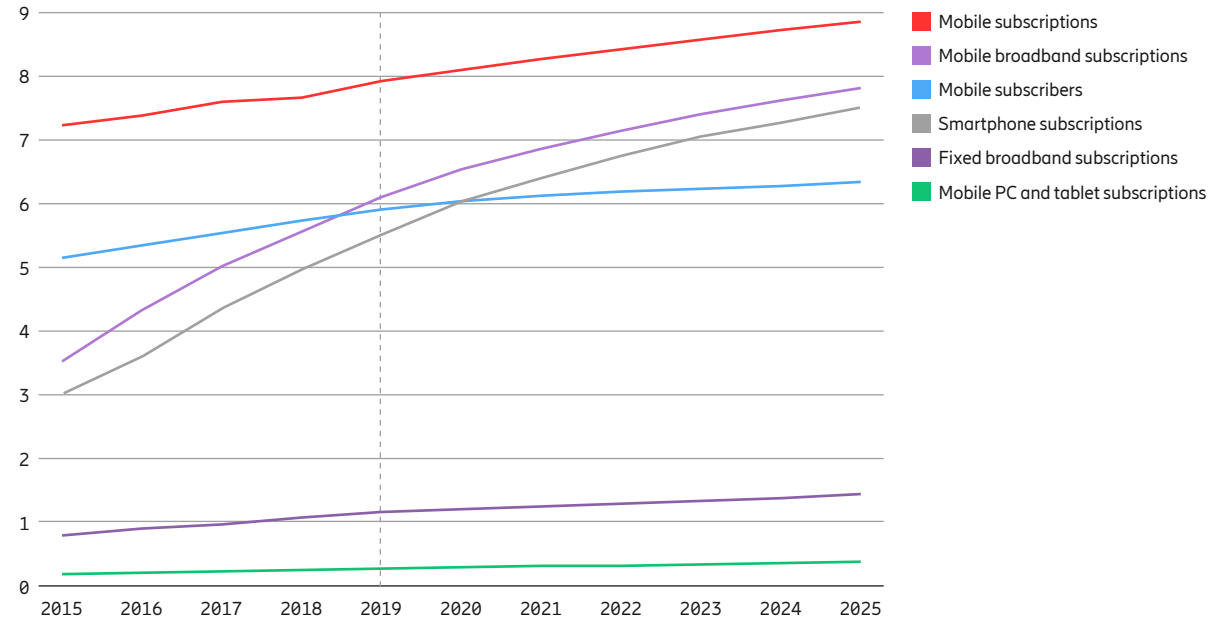
5G subscription uptake is expected to be significantly faster than for 4G.

In 2025, 88 percent of subscriptions are projected to be for mobile broadband

Today, there are around 8 billion mobile subscriptions. We estimate that this figure will increase to 8.9 billion by the end of 2025, out of which 88 percent will be for mobile broadband. This is a slightly lower share than previously forecast, due to a slower decline in 2G (GSM/EDGE-only) subscriptions mainly in the India region. The number of unique mobile subscribers is projected to reach 6.3 billion by the end of the forecast period.

Smartphone penetration continues to rise. Subscriptions associated with smartphones account for about 70 percent of all mobile phone subscriptions. There were 5.5 billion smartphone subscriptions at the end of 2019. The number of smartphone subscriptions is forecast to reach 7.5 billion in 2025, which accounts for around 85 percent of all mobile subscriptions. Subscriptions for fixed broadband are expected to show limited growth of around 4 percent per year through 2025.[4] Subscriptions for mobile PCs and tablets are expected to show moderate growth, reaching around 390 million in 2025.

Figure 9: Subscriptions and subscribers (billion)

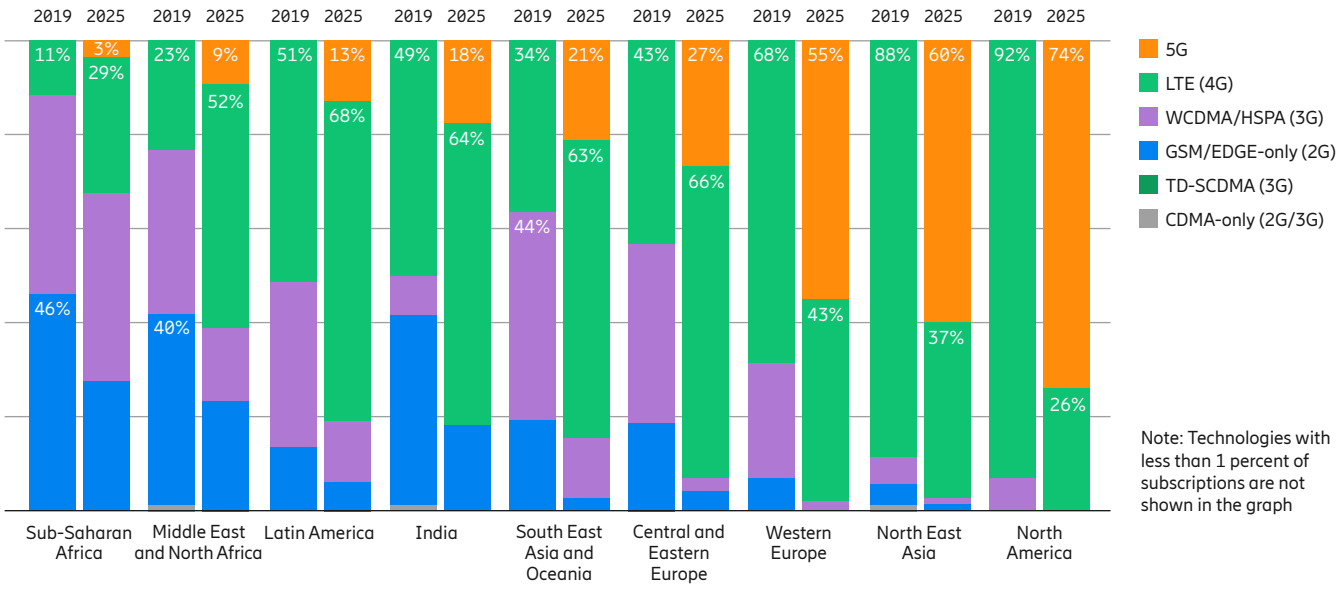


[4] The number of fixed broadband users is at least three times the number of fixed broadband connections due to shared subscriptions in households, enterprises and public access spots. It is the opposite for mobile phones, where subscription numbers exceed user numbers. FWA subscriptions are not part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

Regional subscriptions outlook

Mobile broadband subscriptions currently make up 77 percent of all mobile subscriptions.

Figure 10: Mobile subscriptions by region and technology (percent)



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

In **Sub-Saharan Africa**, LTE accounted for around 11 percent of subscriptions in 2019. Over the forecast period mobile broadband[1] subscriptions are predicted to increase, reaching over 70 percent of mobile subscriptions. LTE share will reach around 30 percent by the end of the forecast period, but HSPA will remain the dominant technology with a share of around 40 percent, which is similar to 2019. 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 3 percent by 2025.

In the **Middle East and North Africa** region, around 23 percent of mobile subscriptions were for LTE at the end of 2019. The region is anticipated to evolve over the forecast period, and by 2025, 77 percent of subscriptions are expected to be for mobile broadband. Commercial 5G deployments with leading service providers have taken place here during 2019 and 5G subscriptions have already passed 500,000, mainly in the Gulf countries. Significant volumes are expected in 2021 and the region is likely to reach around 80 million 5G subscriptions by 2025, representing around 10 percent of total mobile subscriptions.

In **Latin America**, LTE remains the dominant radio access technology during the forecast period, accounting for 51 percent of subscriptions at the end of 2019 and a predicted 68 percent in 2025. A steady decline in WCDMA/HSPA is forecast as users migrate to LTE and 5G, falling from 36 to 13 percent. The first 5G network deployments are expected during 2020 in the region, with Argentina, Brazil, Chile, Colombia and Mexico anticipated to be the first countries. The subscription uptake is forecast to commence in 2020 and, by the end of 2025, 5G is set to make up 13 percent of mobile subscriptions.

72%

Mobile broadband subscriptions are set to account for 72 percent of all mobile subscriptions in Sub-Saharan Africa in 2025.

In the **India** region, LTE subscriptions are forecast to increase from 550 million in 2019 to 820 million in 2025, increasing at a compound annual growth rate (CAGR) of 7 percent. LTE remains the dominant technology, accounting for 49 percent of mobile subscriptions in 2019. LTE will continue to be dominant, representing 64 percent of mobile subscriptions in 2025. 5G will represent around 18 percent of mobile subscriptions in India at the end of 2025. Mobile broadband technologies accounted for 58 percent

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

of mobile subscriptions in 2019, and this figure is predicted to reach 82 percent by 2025. The total number of mobile broadband subscriptions is set to exceed 1 billion by 2025. The number of smartphone subscriptions has increased to 620 million in 2019 and is expected to grow at a CAGR of 9 percent, reaching 1 billion by 2025.

The second half of 2020 is gearing up to be dynamic for 5G in **South East Asia and Oceania**. Deployments continue in Australia, with all service providers rolling out 5G networks after having deployed some of the first commercial networks in 2019. Other countries in the region are expected to follow. In Singapore, three nationwide 5G licenses have been awarded, and more than half of the country is expected to have 5G mobile network coverage by the end of 2022. In Thailand, several service providers are deploying 5G, making the country one of the first in South East Asia to enable this technology. Still in its early stages, there were more than 220,000 5G subscriptions in the region at the end of 2019, mostly concentrated in Australia. By 2025, 5G is predicted to be the second most popular cellular technology in the region, only behind LTE, surpassing 270 million subscriptions and accounting for around 20 percent of all mobile subscriptions.

In **Central and Eastern Europe**, LTE became the dominant technology in 2019, and now accounts for 43 percent of all subscriptions. To date more than five 5G networks have been commercially launched across the region. In 2025, LTE will remain the dominant technology and is expected to account for 66 percent of mobile subscriptions, while 5G subscriptions are forecast to make up 27 percent. During the forecast period, there will continue to be a significant decline in WCDMA/HSPA, from 38 percent to 3 percent of all subscriptions, 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.

In **Western Europe**, LTE is the dominant access technology, accounting for 68 percent of all subscriptions. LTE is predicted to decline to 43 percent and WCDMA/HSPA to only 2 percent of subscriptions by 2025. Around 20 service providers launched 5G services across the region in 2019, delivering services to around 230,000 subscribers. 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 55 percent by the end of 2025.

In **North East Asia**, the share of LTE subscriptions is high, reaching 88 percent at the end of 2019, with China alone having 1.4 billion LTE subscriptions. During 2020, 5G development has been accelerating in the region. In South Korea, 5G network coverage continues to improve, with the goal of nationwide coverage by 2021. In China, the top three service providers have started to build out large-scale 5G coverage. The leading service providers in Japan have now launched commercial 5G services. In addition, more service providers in the region plan to start the 5G network roll-out, aiming at providing 5G services in 2020. By the end of 2020 the region is anticipated to have nearly 170 million 5G subscriptions, and at the close of the forecast period, the 5G subscription penetration is projected to reach 60 percent.

74%

5G will account for 74 percent of North American mobile subscriptions in 2025.

In **North America**, 5G commercialization is moving at a rapid pace. Service providers have already launched commercial 5G services, focused on mobile broadband. North America's LTE penetration is currently 92 percent, which is the highest share globally. By the end of 2025, we anticipate close to 325 million 5G subscriptions in the region, accounting for 74 percent of mobile subscriptions.

North America, **North East Asia** and **Western Europe** have high shares of mobile broadband subscriptions. Countries within these regions have developed economies, enabling a high adoption rate of information and communications technology.

Fixed wireless access outlook

Fixed wireless access (FWA) connections are forecast to grow threefold and reach close to 160 million by the end of 2025, accounting for 25 percent of total mobile network data traffic globally.

FWA subscriptions uptake

There are three main factors that drive the FWA market and the uptake of connections. 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 or 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.

In a recently conducted study of mobile service provider offerings, 185 out of 309 providers had an FWA offering.[1] Compared to December 2018, this number has almost doubled.

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. We estimate there were 51 million FWA connections by the end of 2019. This number is forecast to grow threefold through 2025, reaching close to 160 million.

FWA data traffic is estimated to have represented around 15 percent of global mobile network data traffic by the end of 2019. This is projected to grow by a factor of around 8 to reach 53EB in 2025, accounting for 25 percent of total mobile network data traffic globally.

Definition of FWA

FWA is defined as a connection that provides broadband access through a 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.

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 2025 this will reach approximately 70 percent.[2] In this context, FWA will represent 10 percent of fixed broadband connections. However, it is worth mentioning that FWA is also seen as a replacement option for around 300 million existing DSL connections.

Considering the number of FWA connections, many households consist of several individuals using the same connection. However, in the mobile broadband context, there are more connections than individuals. The forecast of close to 160 million FWA connections by the end of 2025 represents approximately 570 million individuals having access to a wireless broadband connection.

With the disruption caused by COVID-19, the demand for wireless household broadband has probably never been greater.

Figure 11: FWA connections

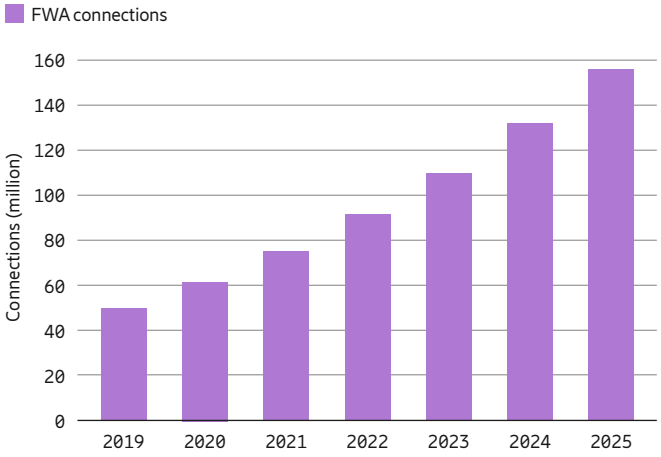
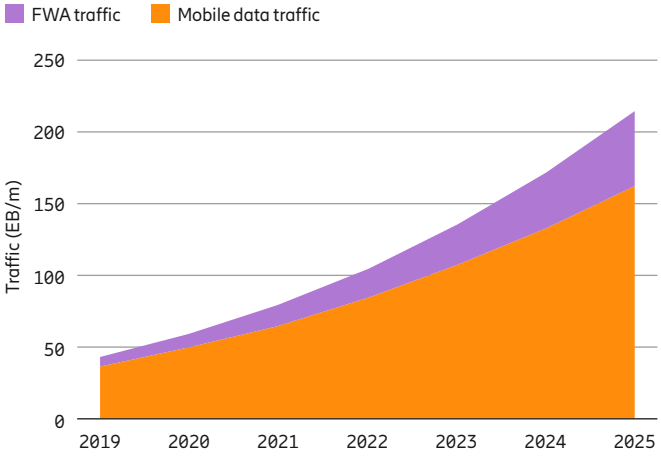


Figure 12: Mobile data and FWA traffic



[1] The 309 service providers included in the study represent 98 percent of global mobile service revenues
[2] Omdia, based on Country Statistics offices and the United Nations

5G device outlook

With third-generation chipsets, it's time for performance optimization.

Despite the uncertainty caused by the COVID-19 crisis, the 5G device ecosystem is continuing to expand, as both standalone (SA) and non-standalone (NSA) networks are rolled out and new frequency bands are utilized:

- over 100 commercial 5G device models
- increasing support for mmWave frequency bands
- fixed wireless terminals (FWT), modules and connected PCs gaining traction
- an additional chipset player in the commercial 5G ecosystem
- retail prices of 5G devices as low as USD 300–400 expected in the second half of 2020, reaching mid- to low-tier segments

While COVID-19 will impact device volumes in the short to medium term, at this point the pace of new developments appears to be intact.

From volume to performance optimization
Second-generation chipsets started the volume deployment of 5G devices, with vendors launching flagship models in the first quarter of 2020. Third-generation chipsets will reach the interoperability labs this year, enabling performance-optimized 5G devices in 2021. New manufacturing processes will improve power consumption and allow new features that focus on end-user performance in the 5G SA domain. Based on the third-generation chipsets, devices will reach lower mid-tier or even low-cost segments.

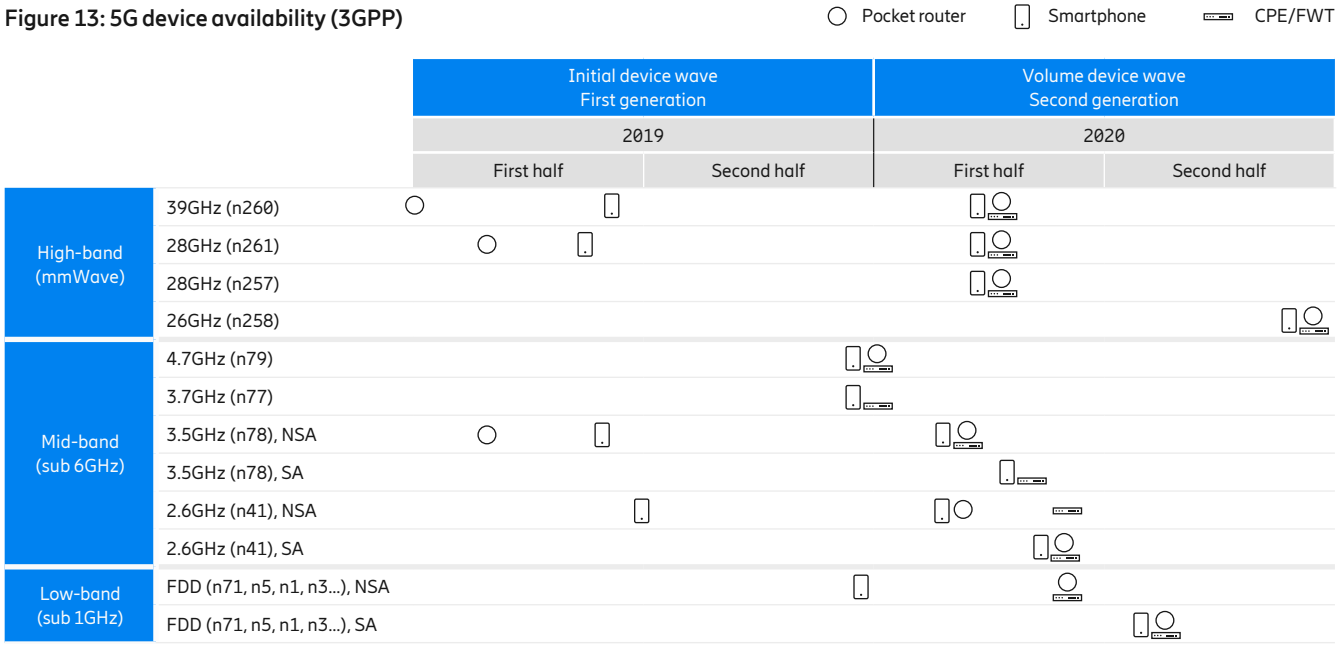
Taking advantage of mmWave frequency support
Spectrum is available in the 24, 28 and 39GHz mmWave frequency bands. Currently, this spectrum enables devices capable of end-user bitrates of over 4Gbps. The US has led investments in mmWave spectrum and technology, and consequently other markets are expected to take advantage of developments in the high-band device ecosystem. There are a growing number of device models supporting mmWave both in smartphone and customer premises equipment (CPE)/FWT form factors for use in markets across North America, South East Asia and South Korea.

Low-band also gaining momentum
The first networks using low-band spectrum for 5G are live and the number of compatible devices is increasing. This also includes support for spectrum sharing, starting with a few band combinations fitting the initial launches, and more expected over time.

5G SA is gaining momentum in China, with devices configured to support SA on service provider activation. In Europe, the demand for 5G SA devices for dedicated network applications is growing, driving requirements for form factors beyond smartphones.

In the US, the initial target is to introduce SA using low-bands for mobile broadband. During 2020, devices will be released with the capability to go between SA and NSA modes where both network architectures are deployed.

Figure 13: 5G device availability (3GPP)



Voice and communication services trends and outlook

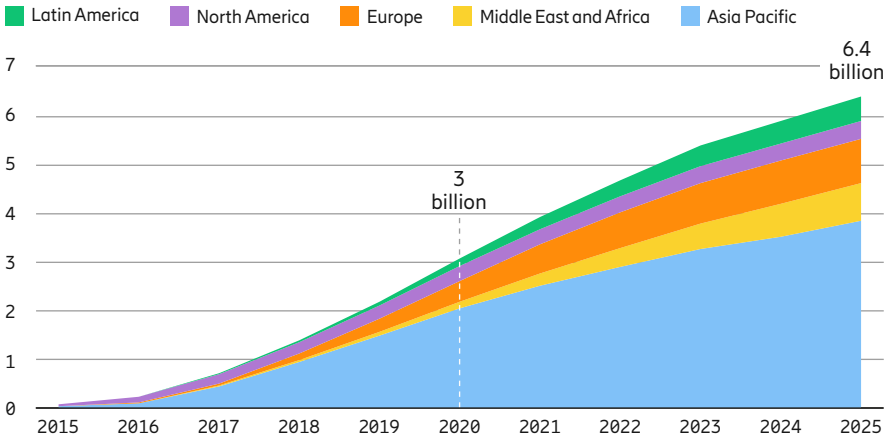
VoLTE is the foundation for enabling globally interoperable voice and communication services on 4G and 5G devices. Subscriptions are expected to reach 3 billion by the end of 2020.

Reliable, high-quality voice services are more crucial than ever. Service providers continue to evolve their networks to support VoLTE-based services. These have now been launched in more than 210 networks in 100 countries.[1] VoLTE services are being deployed using cloud technologies to enable cost-efficient network operations, easier capacity scaling and faster service deployment.

VoLTE subscriptions are estimated to reach 3 billion at the end of 2020 and 6.4 billion by the end of 2025. This will account for almost 90 percent of all combined LTE and 5G subscriptions. The shutdown of 2G and 3G networks will accelerate VoLTE adoption and VoLTE roaming agreements. VoLTE will support subscribers and roamers with voice services, 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, 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 CSFB of voice from 5G. 5G voice will be deployed stepwise in 4G and 5G networks, using LTE-NR dual connectivity, Evolved Packet System fallback and voice over New Radio (VoNR). Successful end-to-end testing of 5G voice (VoNR) and 5G video calling with network infrastructure and the device ecosystem has been conducted.

Figure 14: VoLTE subscriptions by region (billion)



Device availability and use case uptake

There are over 2,650 VoLTE-enabled 4G devices, of which around 85 percent are phones.[2] More than 40 5G phones include VoLTE support.[3] VoLTE-enabled smartphones also have enhanced functionalities, such as the latest voice codecs and native video calling. There are more than 165 models supporting HD Voice+ (Evolved Voice System, or EVS), and more than 400 devices capable of video calling over LTE (ViLTE).[4]

The latest 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 90 service provider networks support cellular smartwatches enabled with voice services.

Other VoLTE-based services include additional phone lines on the same phone, shared phone lines, video calling, enterprise collaboration services in combination with mobile HD voice, and voice for IoT devices. 5G-related service innovations for consumers, enterprises and industries are being explored, including combinations with AR and VR. 5G interactive calling – combining 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 – could become a radically improved, mainstream 5G voice service in the future.

VoLTE usage and performance in times of crisis

Analysis of VoLTE usage across Europe during the weeks before and after the recent global lockdowns began revealed a significant increase in traffic, mainly due to longer call times. Due to reduced mobility of users across networks, the retainability of voice calls was improved. The VoLTE traffic increase varied by 20–50 percent across different markets in Europe.[5] In some other markets, service providers experienced up to a 90 percent increase in Voice over Wi-Fi calls as people spent more time at home.

[1] GSA (May 2020)
[2] GSA (May 2020) modules, smartphones and other types of devices, supporting different regions and frequencies
[3] GSA (May 2020)
[4] GSA (May 2020)
[5] Based on data from a selection of representative countries in Europe

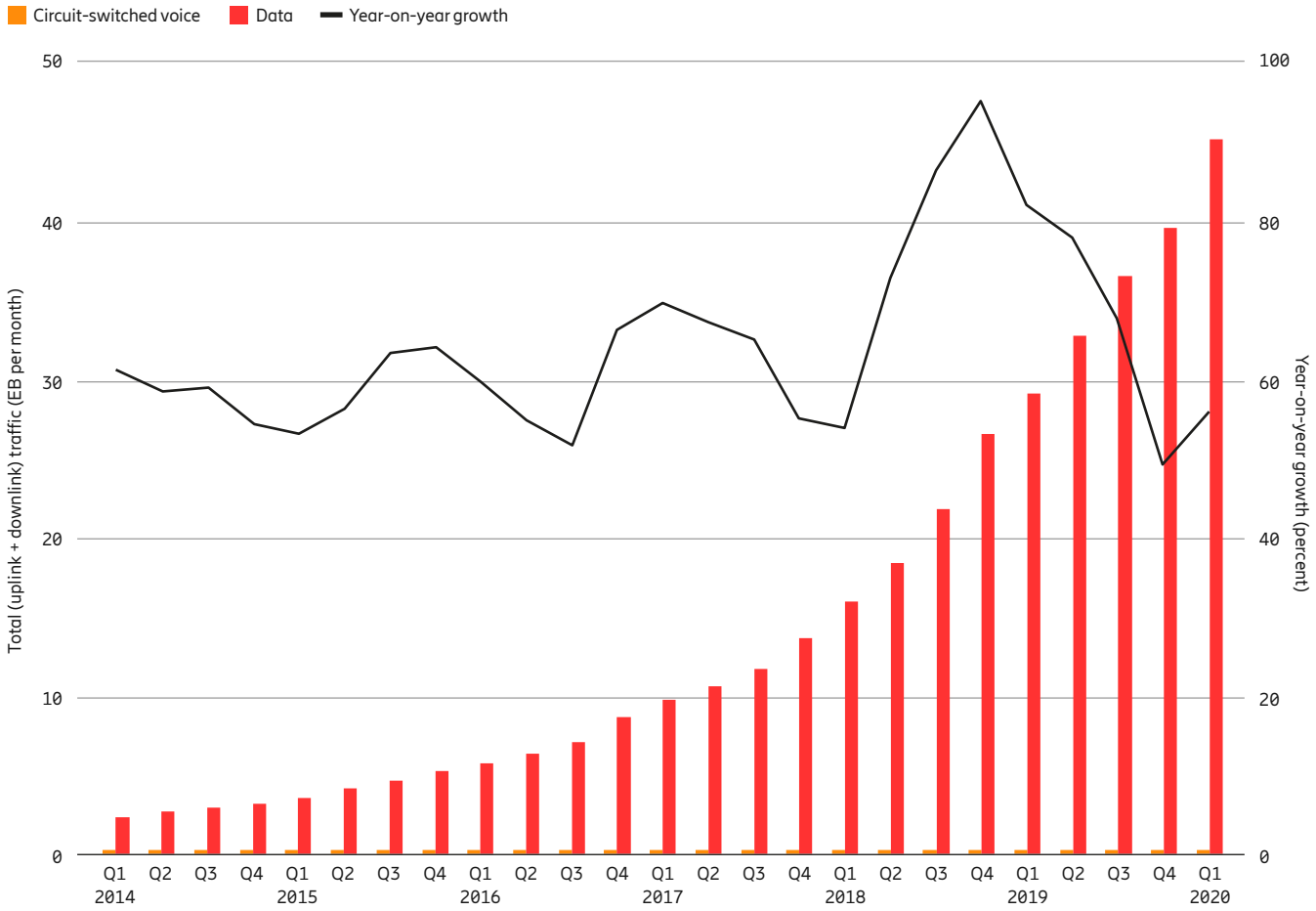
Mobile network traffic Q1 2020

Mobile network data traffic grew 56 percent between Q1 2019 and Q1 2020.

Following the extraordinary peak in traffic growth seen in 2018 and the first part of 2019, the growth rate has returned to a more normal level. The quarter-on-quarter growth for Q1 2020 was 14 percent. A change in consumer behavior caused by COVID-19 lockdown restrictions impacted mobile networks by geographically shifting traffic loads; for example, daytime loads moved, to a degree, from city centers to suburban residential areas due to home-working guidance. This effect was most pronounced in areas with limited penetration of fixed residential broadband connections. Generally, the traffic volumes were only modestly affected in mobile networks in markets where fixed network connections are common.

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 15 shows total global monthly network data and voice traffic from Q1 2014 to Q1 2020, along with the year-on-year percentage change for mobile network data traffic.

Figure 15: 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 traffic by application category

Mobile traffic is expected to grow by 31 percent annually between 2019 and 2025. Continuing recent trends, most of this will come from video traffic.

Video traffic in mobile networks is forecast to grow by around 30 percent annually up to 2025. It will account for nearly three-quarters of mobile data traffic, which is up from just over 60 percent in 2019. Mobile video traffic growth is driven by the increase of embedded video in many online applications, growth of video-on-demand (VoD) streaming services in terms of both subscribers and viewing time per subscriber, and the evolution towards higher screen resolutions on smart devices. All of these factors are influenced by the increasing penetration of video-capable smart devices. Social network traffic is also expected to rise by around 20 percent annually over the next 6 years. However, its relative share of traffic will decline from 10 percent in 2019 to around 8 percent in 2025, because of the stronger growth of video.[1]

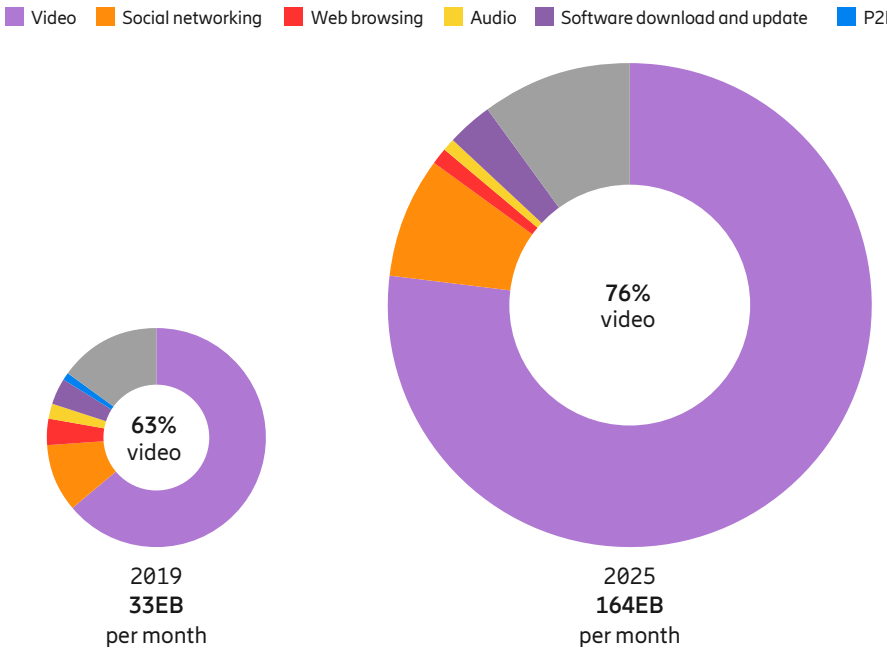
Immersive formats contribute to traffic growth

Users are increasingly streaming and sharing video. The most common resolution for video streamed over cellular networks is estimated to be 480p (varying from network to network). With smartphones and networks improving constantly, streaming in HD (720p) and Full HD (1080p) is becoming more common. More immersive media formats and applications are expected to become a significant factor contributing to mobile data traffic growth, as 5G networks will provide the performance needed for a good user experience. For example, watching a streamed e-sports event in multi-view would consume about 7GB per hour, while a high-quality AR/VR stream with a media (bit) rate of 25Mbps would consume as much as 12GB per hour.

Calculate the traffic impact of different application categories
www.ericsson.com/en/mobility-report/mobility-calculator

Explore the relationship between the usage of various app types and monthly traffic per subscription. Fill in your app usage figures and benchmark the resulting data consumption against six pre-set data consumption profiles.

Figure 16: Mobile traffic by application category per month (percent)



Main drivers for video traffic growth

- Video is part of most online content (news, ads, social media, etc.)
- Video sharing services
- Video streaming services
- Changing user behavior – video being consumed anywhere, any time
- Increased segment penetration, not just early adopters
- Evolving devices with larger screens and higher resolutions
- Increased network performance through evolved 4G deployments
- Emerging immersive media formats and applications (HD/UHD, 360-degree video, AR, VR)

[1] Traffic from embedded video in web browsing and social media is included in the application category "Video"

Gaming on the move

In countries with lockdown measures in place and limited outdoor entertainment, applications for video streaming, video calling and gaming experienced significantly increased usage.

Driven by both new users with more time to explore and increasing usage among those already using the services, rising use of video services and game downloads resulted in a traffic increase in networks. Given this, some providers of video streaming services took a cautious approach and reduced the video quality to ensure they could maintain delivery over strained networks.

The popularity of many online games has increased, with millions around the world playing every week. Online games are designed to minimize the exchange of data traffic over the network in order to reduce latency. Traffic generated while playing a traditional online game consists primarily of small packets of information about each player's position and activity on the game map. Hence, even a large increase in players will not have a substantial impact on the amount of online traffic. For multiplayer games that are executed in the device, the demands on the network are for low latency. The biggest traffic impact on networks occurs when millions of players download or update a game at the same time, as this may amount to a few tens of gigabytes. A full download can even be 100–150GB. Many such simultaneous downloads could cause short-term capacity challenges for any fixed or mobile network.

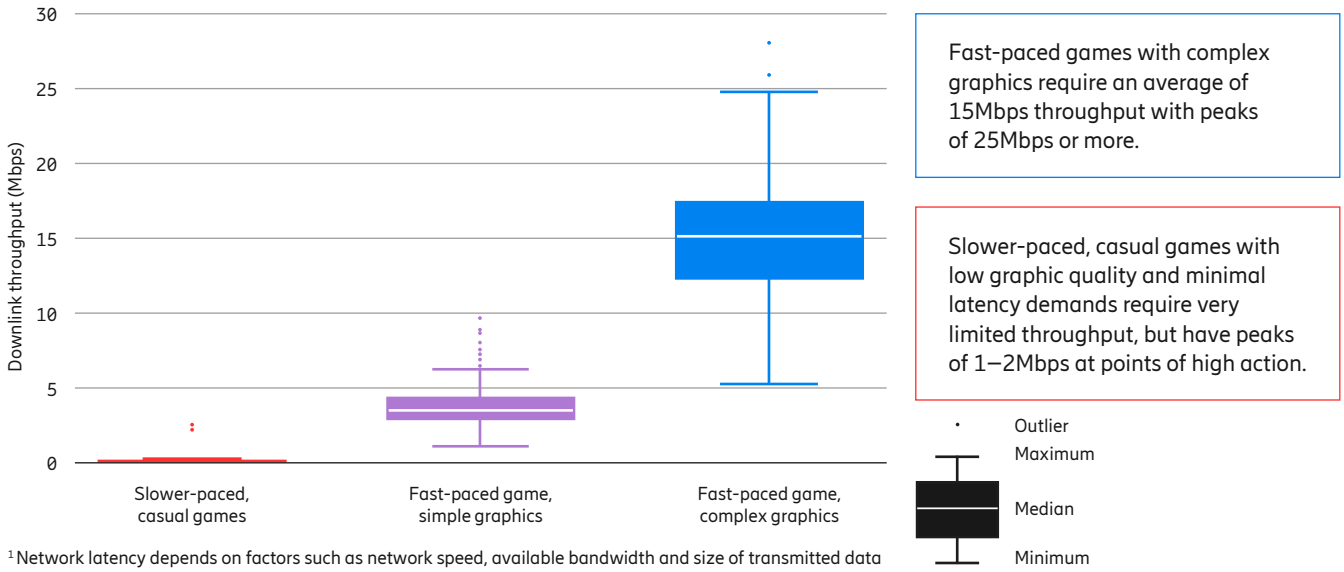
Streaming video games

Streaming games from remote datacenters is now a reality for smartphone users. This trend is gaining momentum, as it enables games to run on a wide range of devices due to reduced hardware requirements. A number of services have already launched and more are under development. Streaming video game services, unlike traditional PC or console games, stream the whole game live over the network. Presently, some service providers with a 5G mobile broadband offering are partnering with cloud-based gaming providers to offer service-based packages on top of or within their 5G price plans.

Streaming different types of games can have varying impacts on the network, as illustrated in Figure 17. The required downlink throughput depends on the game's speed and complexity. 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. Current cloud-based gaming platforms require sub-60–100ms network latency as a minimum for the services to run.[1] As games become more complex, even lower network latency will be required. Today's deployed 5G networks already have an average latency of 20–30ms, and are developing towards sub-10ms latencies.

Network performance becomes increasingly important when games are developed for a streaming architecture executed in the cloud. Network capabilities provided by 5G and edge compute technologies will better equip service providers with an optimized architecture for these services. Once deployed, more gaming packages are expected to launch that can both differentiate offerings and deliver the required user experience.

Figure 17: Variation in downlink throughput requirements of one cloud-based mobile gaming platform



[1] Network latency depends on factors such as network speed, available bandwidth and size of transmitted data

Mobile data traffic outlook

In 2025, 5G networks will carry nearly half of the world's mobile data traffic.

Global total mobile data traffic reached around 33EB per month by the end of 2019, and is projected to grow by a factor close to 5 to reach 164EB per month in 2025. This figure represents the mobile data that will be consumed by over 6 billion people using smartphones, laptops and a multitude of new devices at that time.

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.

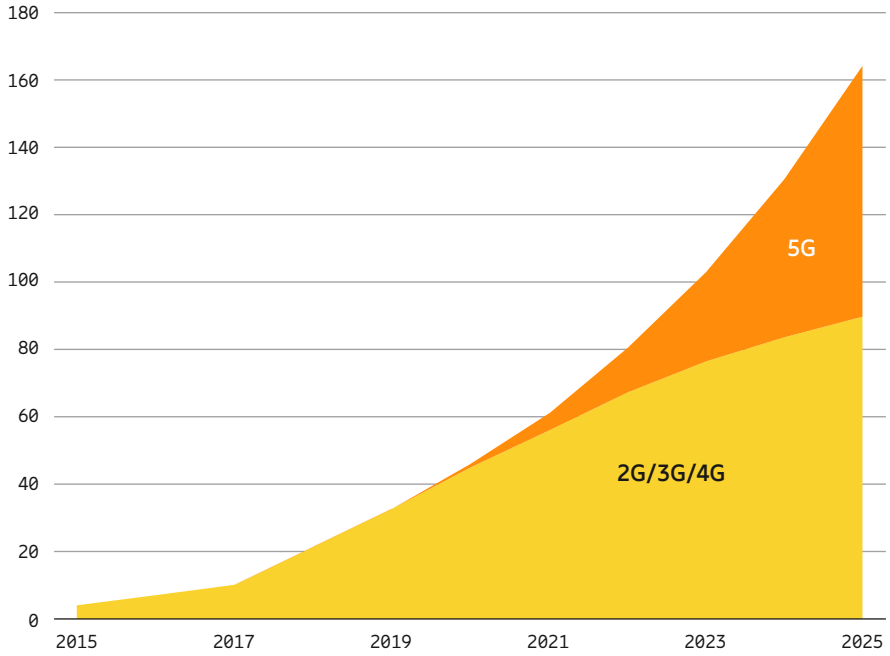
Populous markets that launch 5G early are likely to lead traffic growth over the forecast period. By 2025, we expect that 45 percent of total mobile data traffic will be carried by 5G networks.

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. In the US, the traffic growth rate declined slightly during 2018 but recovered to previously expected rates during 2019. In China, 2018 was a year of record traffic growth. India's traffic growth continued its upward trajectory and it remains the region with the highest usage per smartphone and per month.

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 affordable data plans.

Figure 18: Global mobile data traffic (EB per month)



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

45%

By 2025, 5G will account for an estimated 45 percent of total mobile data.

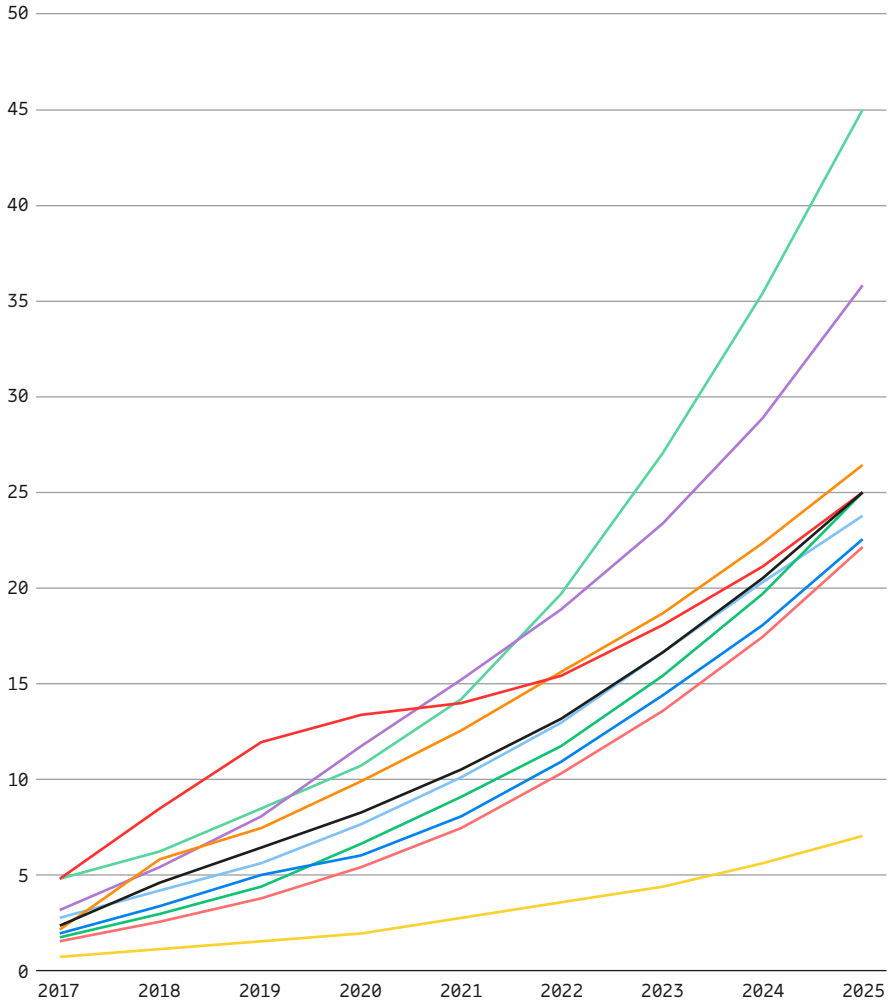
Around 410 million additional smartphone users are expected in India by 2025

In the India region, the average monthly mobile data usage per smartphone continues to show robust growth, boosted by the rapid adoption of 4G. Low prices for mobile broadband services,[1] affordable smartphones and people's changing video viewing habits have continued to drive monthly usage growth in the region. Only 4 percent of households have fixed broadband, making smartphones the only way to access the internet in many cases.[2]

Total traffic is projected to triple, reaching 21EB per month in 2025. 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. A total of around 410 million additional smartphone users are expected in India by 2025. Even if the traffic per existing smartphone user continues to grow significantly over time, the increase in average traffic per smartphone is expected to moderate as more consumers in India acquire smartphones. The average traffic per smartphone is expected to increase to around 25GB per month in 2025.

[1] www.cable.co.uk/mobiles/worldwide-data-pricing
[2] GlobalData, India Telecom Operators Country Intelligence Report (2019)

Figure 19: Mobile data traffic per smartphone (GB per month)



Regions	2019	2025	CAGR 2019–2025
North America	8.5	45	32%
Western Europe	8.2	36	28%
North East Asia	7.5	27	23%
India	12	25	13%
South East Asia and Oceania	4.6	25	33%
Global average	7.0	25	25%
Central and Eastern Europe	5.8	24	27%
Latin America	3.9	22	34%
Middle East and North Africa	5.0	23	28%
Sub-Saharan Africa	1.6	7.1	28%

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 45GB per month per smartphone by 2025. 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. By 2025, 5G subscription penetration is set to be the highest of all regions at 74 percent.

The **Western Europe** traffic growth rate follows a similar pattern to that expected in North America. However, the more fragmented market situation is expected to lead to later mass-market adoption of 5G, and therefore somewhat lower traffic per smartphone in 2025 than North America, at 36GB per month.

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

Attractive data plans, as well as innovative mobile apps and content, have pushed up monthly mobile data usage across North East Asia, particularly in China. The rapid growth in smartphone subscriptions is expected to continue, with China alone set to add around 170 million smartphone subscriptions between 2019 and 2025, further driving data traffic growth. With 5G set to capture a great number of early adopters, we continue to expect high growth numbers in the region. The data traffic per smartphone is expected to reach 27GB and 25GB per month respectively in North East Asia and China.

The **Middle East and North Africa** region is expected to have one of the highest growth rates during the forecast period, increasing total mobile data traffic by a factor of almost 9 between 2019 and 2025. The average data per smartphone is expected to reach 23GB per month in 2025. **Sub-Saharan Africa** also has a very high growth rate, but from a relatively small base, with total traffic increasing from 0.33EB per month to 4EB by 2025. Average traffic per smartphone is expected to reach 7.1GB over the forecast period.

South East Asia and **Latin America** are expected to follow similar trends over the forecast period on a regional level, while the individual countries can show very different growth rates for traffic per smartphone, especially in markets deploying 5G. Traffic growth is driven by coverage build-out and continued adoption of 4G, linked to a rise in smartphone subscriptions and increases in average data usage per smartphone. The data traffic per smartphone is expected to reach 25GB and 22GB per month respectively in South East Asia and Latin America.

In **Central and Eastern Europe**, growth is also fueled by 4G adoption, but the region has a somewhat higher traffic per subscriber starting point. Over the forecast period, the monthly traffic per smartphone is expected to increase from 5.8GB to 24GB 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.

Network coverage

5G could cover up to 65 percent of the world's population in 2025.

Momentum continues in the build-out of 4G (LTE) networks. Global 4G population coverage was around 80 percent at the end of 2019 and is forecast to reach over 90 percent in 2025. 4G networks are also evolving to deliver increased network capacity and faster data speeds. There are currently 797 commercial 4G networks deployed. Of these, 315 have been upgraded to LTE-Advanced, and 37 Gigabit LTE networks have been commercially launched.

5G launch and deployment momentum continues

To date, there have been more than 75 5G commercial launches across the world. Initially, networks have mainly been deployed in larger cities. Global 5G population coverage was around 5 percent at the end of 2019, with the most extensive coverage build-out 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. Switzerland's 5G population coverage reached over 90 percent at the end of 2019 and is expected to continue to grow during 2020.

Technology advancements enabling rapid 5G population coverage build-out

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

1. Radio deployments in new bands in the sub-6GHz range
2. Deployments in millimeter wave frequency bands
3. Deployments in existing LTE bands

Looking at the first two categories combined, 5G population coverage is forecast to reach 55 percent in 2025. For the third category, a significant proportion of 4G networks are already prepared for 5G and can be upgraded to support 5G services in existing LTE bands by utilizing spectrum sharing. Given this option, an estimated additional 10 percentage points of 5G population coverage is achievable, creating a potential of up to 65 percent coverage in 2025.

Increased uncertainty in 5G population coverage forecast due to COVID-19

There are drivers indicating an accelerated build-out of 5G networks, particularly looking forward to 2025. However, short-term factors point to a slower pace in certain countries, for example delays in the licensing of 5G spectrum due to COVID-19. The exact impact on 5G population coverage in both the short (2020–2021) and medium terms (2022–2025) remains to be seen. 5G is still expected to be the fastest deployed mobile communication technology in history.

Figure 20: World population coverage by technology[1]

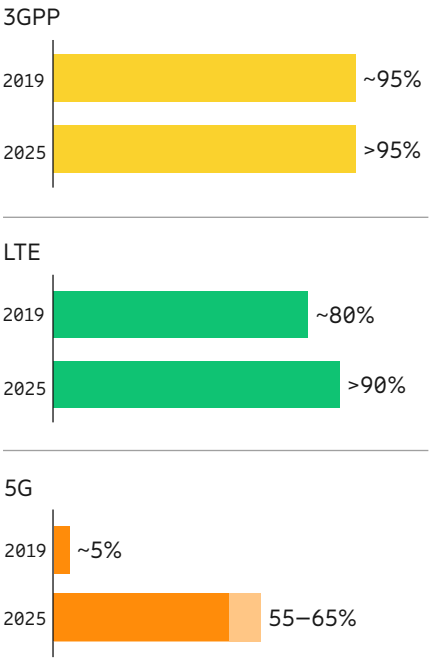
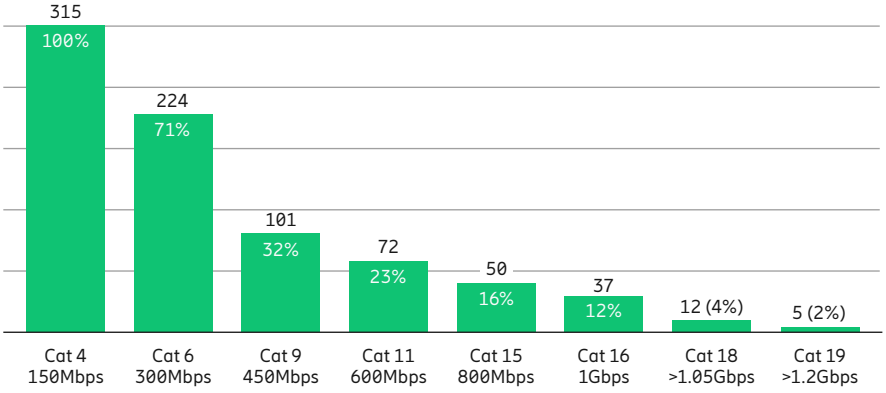


Figure 21: Percentage and number of LTE-Advanced networks supporting various categories of devices



Source: Ericsson and GSA (May 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

IoT connections outlook

The number of Massive IoT connections increased by a factor of 3 during 2019, reaching close to 100 million.

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 2019, the number of Massive IoT connections increased by a factor of 3, reaching close to 100 million connections at the end of the year.

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. NB-IoT and Cat-M technologies complement each other; out of the 123 service providers[2] identified as having launched at least one of these, 25 percent have launched both. At the end of 2025, NB-IoT and Cat-M are projected to account for 52 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 2025, 34 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 used 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. Deployment of the first modules supporting Critical IoT use cases is expected in 2021. 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.

North East Asia is leading in terms of the number of cellular IoT connections. At the end of 2019, the region accounted for 54 percent of all cellular IoT connections, a figure set to increase to 67 percent by 2025.

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 22: Cellular IoT connections by segment and technology (billion)

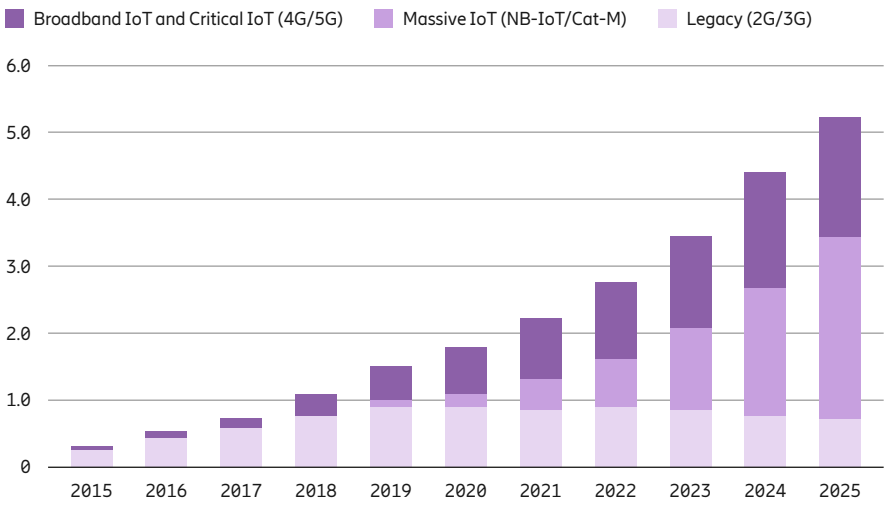


Figure 23: IoT connections (billion)

IoT	2019	2025	CAGR
Wide-area IoT	1.6	5.5	23%
Cellular IoT[3]	1.5	5.2	23%
Short-range IoT	9.1	19.1	13%
Total	**10.7**	**24.6**	**15%**

[1] Cat-M includes both Cat-M1 and Cat-M2. Only Cat-M1 is being supported today
[2] GSA (April 2020)
[3] These figures are also included in the figures for wide-area IoT

Verizon is transforming fixed and mobile broadband with 5G

5G in millimeter-wave spectrum redefines user experiences.

Verizon is in the second year of delivering 5G services in the US using millimeter-wave spectrum. A journey starting with the launch of 5G Home for fixed wireless access (FWA) in 2018 was followed by 5G mobility services in 2019 with both running on Verizon's 5G Ultra Wideband network.

The 5G millimeter-wave opportunity

The use of the millimeter-wave spectrum for wireless services represents a new opportunity for service providers. The enhancement that 5G connectivity provides changes the game for applications leveraging artificial intelligence, robotics, augmented/virtual reality and/or IoT.[1] This represents a leap in performance compared to what was possible for the first four mobile network generations.

In October 2018, 5G Home was released in select neighborhoods of four cities to provide an alternative to wired broadband. The initial deployments used the TF specification of 5G to enable early field evaluations of performance. These insights provided the foundation for network planning of further 5G millimeter-wave based services.

Verizon's 5G network was launched for mobile services to both consumers and business customers in the spring of 2019. Initial deployments focused on enhancing 5G mobility at outdoor locations primarily in dense urban areas such as commercial zones, parks and landmarks. Sports and concert venues have been a special focus. To date, the build-out includes parts of 17 stadiums and 7 indoor arenas. As of June 2020, Verizon's 5G network mobility services are available in parts of 35 markets/cities across the US.

The 5G user experience will not be limited to the millimeter-wave band and coverage. The service has been designed to use both 4G and 5G and will leverage capabilities such as dual connectivity, carrier aggregation and dynamic spectrum sharing (DSS). This approach has the advantage of minimizing the experience of coverage white spots as millimeter-wave 5G is built out in steps.

Principles for building 5G with millimeter-wave spectrum

The build-out of networks using 5G in the millimeter-wave spectrum required the reinvention of both network design and operational models. To develop these new opportunities, a strategy built on five principles was adopted:

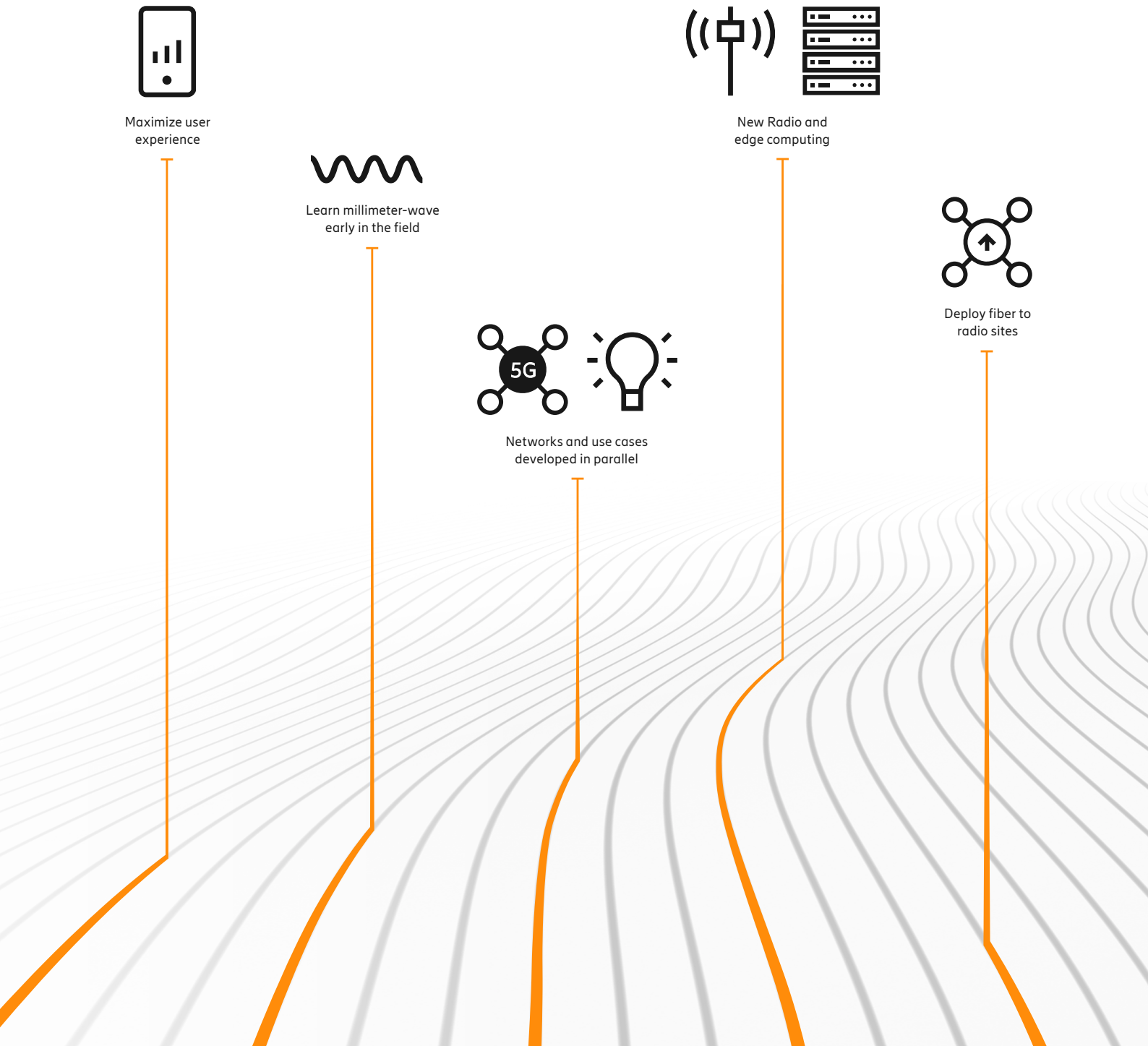
1. Focus on differentiated user experiences, deploying 5G with millimeter-wave spectrum.
2. Learn about building with millimeter-wave characteristics by experiencing real-life network conditions as early as possible.
3. Develop use cases together with enterprises in different industries while building out 5G networks.
4. Combine New Radio capabilities with edge computing.
5. Deploy fiber infrastructure to 5G sites.

This article was written in cooperation with Verizon, a market-leading communications service provider in the US delivering innovative communications and technology solutions to a wide range of customers.

verizon

[1] Verizon, "When we say '5G', we mean 5G" (January 7, 2019): www.verizon.com/about/news/when-we-say-5g-we-mean-5g

Figure 24: Overview of five Verizon principles for 5G in millimeter-wave spectrum



Use case innovation in parallel with network deployment

Verizon's 5G Ultra Wideband network was built to support innovative use cases beyond enhanced mobile broadband. Verizon has established six 5G labs in the US and one in London where the company partners with startups, universities and established companies to develop 5G use cases.[2] Each lab has a core focus in areas such as financial services, robotics, public safety, entertainment and information technology. The goal of the labs is to support and foster the next great 5G innovation for the marketplace.

Today, with social distancing due to COVID-19, the public debate concerns how to stepwise reopen economies and when it will be possible to attend large events. The various alternatives offered by 5G, streaming video and augmented reality could play a part in experiencing sports and music events on the way to the new normal.

Verizon is further collaborating with various enterprises to explore how 5G Ultra Wideband could transform industries ranging from manufacturing to healthcare. For example:

- **Corning Inc.**: Verizon partnered with Corning to help create the 5G factory of the future. Initial use cases focus on factory automation, zero touch quality assurance and supply chain tracking in near real-time. Efficient use of automated guided vehicles (AGV) and inventory tracking with 5G-connected cameras will also be explored.
- **Emory Healthcare**: Verizon provided Emory's Innovation Hub with 5G Ultra Wideband service to explore ways to accelerate the development of 5G healthcare applications. Use cases will focus on AR/VR-based medical training, remote physical therapy, patient monitoring and emergency room readiness. The pandemic has put the value of "remote anything" in the spotlight.
- **The Walt Disney Company**: At the premiere of "Star Wars: The Rise of Skywalker", the companies explored how 5G and motion capture technology could enable fans to interact with virtual Sith jet troopers at the movie afterparty. Further, the red carpet action was captured and streamed over 5G and key moments were incorporated into the live broadcast.

The development of use cases in parallel with network roll-outs reduces the time to market for both activities. Network builds can focus on addressing roll-out related challenges without distracting innovation activities. Use case innovations take place in an environment enabling rapid prototyping where projects can evolve stepwise into applications ready for commercial launch. These parallel processes are vital for a timely expansion of use cases beyond mobile broadband.

Performance measurements in commercial networks

The first performance measurements, comparing downstream data rates for 5G and 4G, have emerged. Figure 25 describes the differences between maximum and median downstream measures for two Verizon markets where 5G Ultra Wideband service is available.

Increasing 5G coverage and focusing on the network edge

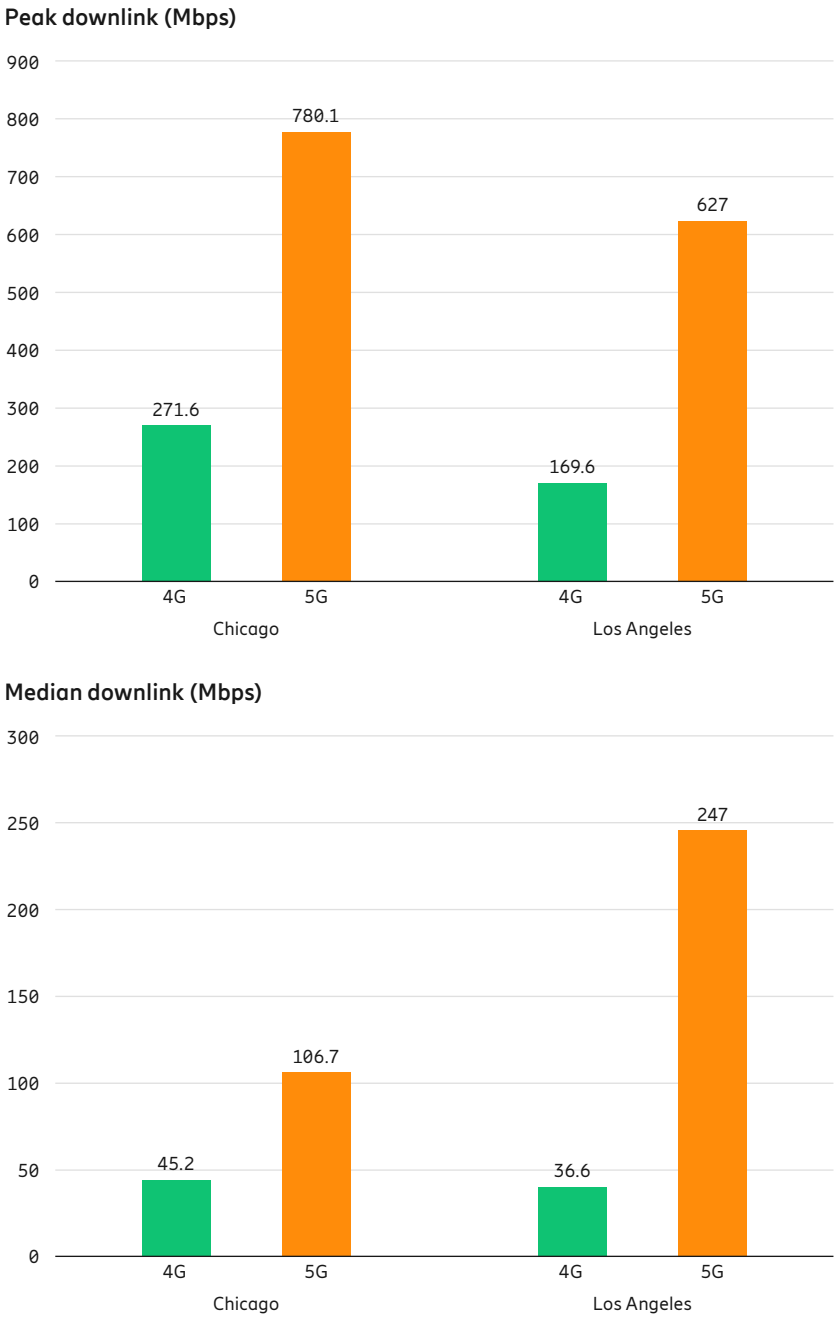
The 5G Ultra Wideband network roll-out continues. The plan includes increasing the market footprint from 35 to over 60 cities during 2020. The number of small cells is slated to grow by a factor of five times, both through expansion in the initial cities and through the addition of new cities.

The 5G Home service (FWA for the consumer market) is planned to be expanded from 5 to 10 markets. In addition, there are plans to launch 20 new 5G devices in 2020 with smartphones as the biggest device category.

As Verizon continues to expand the footprint of its 5G network, it is also working to locate edge computing capabilities at the selected edge sites. These mobile edge computing (MEC) sites will allow Verizon to substantially reduce the end-to-end latency for enterprise applications that are currently being rendered from a centralized cloud from approximately 100ms to 20ms or less. In addition, enterprises that are leveraging the Verizon deployed MEC sites will benefit from being able to offload compute-intensive applications from their end devices to the local MEC compute element. This will enable locally cached data associated with the application, substantially reducing not only the physical size and power consumption of the end devices, but also reducing the backhaul bandwidth required to transport data to a centralized public cloud.

[2] Verizon 5G labs (2020): www.verizon5glabs.com

Figure 25: 5G vs. 4G performance in commercial networks



Source: RootMetrics by IHS Markit (March 2020)

Summary
Verizon is a pioneer in 5G services using millimeter-wave spectrum for both mobile and fixed purposes. The 2020 plan includes expansion to new cities, increased coverage in initial cities and a broader portfolio of devices. Network build and use case innovation take place in parallel to accelerate time to market for both. The plans also include edge computing to move performance-critical applications closer to the user, to take full advantage of the reduced network latency.

Dedicated networks for industrial connectivity

As manufacturers address modernization, automation and digitalization, dedicated networks offer a way to support multiple use cases, retain control of network resource allocation and ensure that critical data remains on-site.

New choices for industrial connectivity

The process of integrating the networks of one or more manufacturing sites can be triggered by a need to replace legacy networks or the increasing mobility requirements of their operations. Focus has been on improving network performance in lighthouse sites for a few notable use cases. Many sites currently run multiple connectivity platforms (LMR, cables, Wi-Fi etc.) for specific functions. This has been a challenge for enterprise digitalization efforts, which essentially need to pull together and structure diverse data sets. A unified platform is required which integrates voice, data, video and IoT.

Attention is now broadening from lighthouse cases to operational mainstream, and the next steps include standardized connectivity across company sites globally, and improved visibility across end-to-end supply chains.

Manufacturers that see 5G as a new platform for their operational technology (OT) often state that they need dedicated resources to ensure critical manufacturing processes are guaranteed the connectivity resources they require. There are various ways to implement this, but the early adopters have concluded that they require dedicated networks.

Industry digitalization is setting requirements and driving demand for dedicated networks

Enterprises provided key input to 3GPP in the development of the IMT-2020 (5G) standards, resulting in cellular networks designed for their needs. Industry bodies now combine membership from both manufacturing and ICT companies, for example with 5GAA in automotive, and 5G-ACIA in industry. The Critical Communications Association (TCCA) pulls together stakeholders in the public safety arena. These three organizations are Market Representation Partners to 3GPP, providing input on their industry needs.

In the newly emerging field of air traffic management for beyond line-of-sight (BVLOS) drones, bodies such as NASA and FAA in the US, EASA in the EU, and the Global Unmanned Aircraft Systems Traffic Management Association (GUTMA) work on standards, and 3GPP follows with work items to align.

For live broadcast production (e.g. news gathering, sports coverage) the European Broadcasting Union (EBU) has a working group for 5G in Content Production (5GCP), while 3GPP studies the requirements of audio and video production.

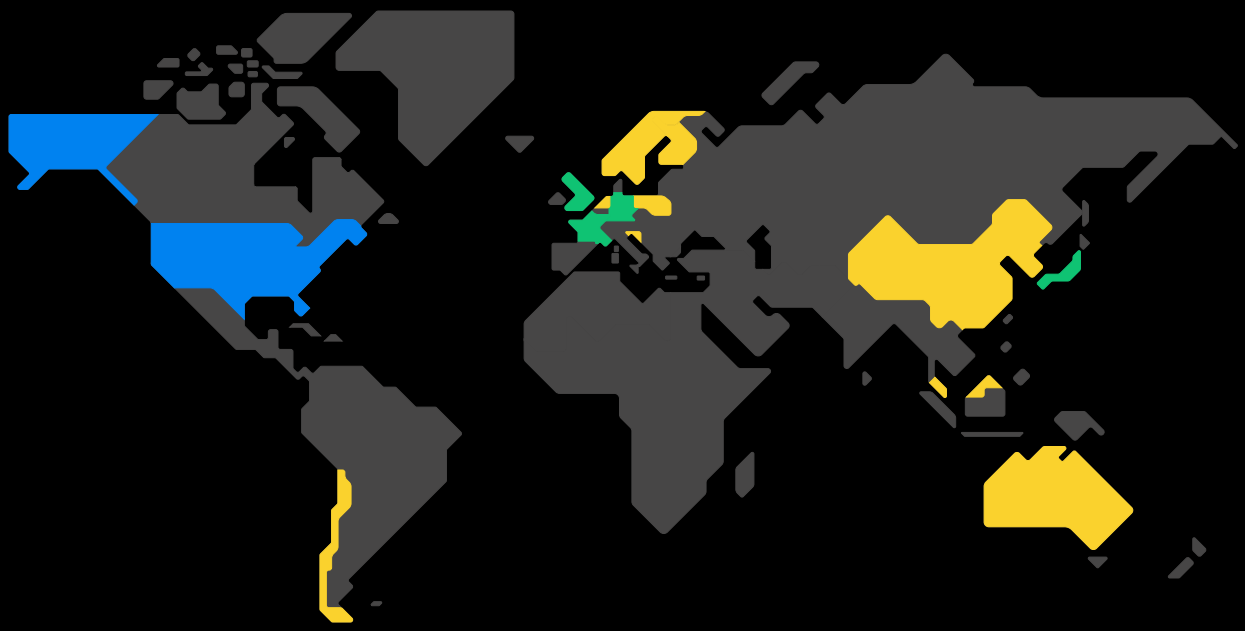
These are examples of industries now taking steps to incorporate connectivity and cellular into their standards, as many industrial enterprises are defining 5G as their primary connectivity platform for both IT and OT systems to reach new levels of productivity, security and safety.

Spectrum considerations

Choosing the frequency bands with which to build their connectivity platform presents a set of strategic issues for manufacturing enterprises: low-band (e.g. 700–900MHz) provides great coverage while high-band (e.g. 25GHz and above) trades off coverage for greater capacity over much shorter distances. Mid-band offers a compromise between the two. Beyond the significantly different performance characteristics, a specific band that is globally or regionally harmonized is attractive, while those which are country-specific may not be. Multinationals will want to know which bands will work for their specific sites, and which will work for them globally for future expansions and integration with suppliers and customers.

One new parameter at play is the release of locally licensed spectrum by national regulators for industry use. Regulatory authorities in the US, Europe, Japan and other markets are making available new spectrum dedicated for local use, on top of the spectrum already provided to service providers for national networks. Countries differ, but most of the focus is on releasing additional 5G spectrum (mid-band and mmWave high-band) because 5G is seen as a key enabler of industrial competitiveness. Germany was an early mover, announcing spectrum reserved for use in dedicated networks with fees based on bandwidth, geographical area covered and duration of the license.

Figure 26: Countries which have, or are considering to make, spectrum available for industry (as of April 2020)



Local licenses
(France, Germany, Japan, UK)

Considering local licenses
(Australia, Chile, China, Finland, Hong Kong, Luxembourg, Malaysia, Netherlands, Norway, Poland, Slovenia, Sweden)

CBRS – Citizens Broadband Radio Service
(US)

Manufacturers – and other businesses that operate big facilities – have a range of choices to secure 5G spectrum as it is being assigned in different countries using a number of different models. The choices vary from signing a traditional SLA with a nationally licensed service provider to investing in dedicated spectrum delimited by bandwidth, time and geographical area then building – or contracting – a dedicated network.

The map indicates countries that have already assigned 5G spectrum for private networks (in green) and those that are currently considering it (in yellow).

The US (in blue) is a special case which has identified 150MHz in the 3.5GHz band for Citizens Broadband Radio Service (CBRS). It will be administrated in a three-tiered model: Incumbent Access (mostly US Navy and satellites), Priority Access (to be auctioned in June 2020), and General Authorized Access (unlicensed).

The role of service providers in dedicated networks

Historically, many manufacturers have built, owned and operated one or more elements of their communications infrastructure in-house, but over time this has gradually changed to outsourcing more elements, driven by the growing complexity of the technologies. Making the jump from analog to digital was manageable for many industries; however, through successive digital technologies it has become increasingly challenging. With the advent of LTE, and now 5G, for many industries it no longer makes sense to build, own and operate infrastructure that is not a core business. That said, a service provider that is willing and able to release sufficient spectrum and deliver the service required by an industrial enterprise is not always available, so enterprises have requested regulators give them an option of acquiring spectrum directly for their purposes and potentially building networks themselves.

Industrial enterprises are experienced in running their own connectivity networks for OT in-house, but a dedicated LTE or 5G network needs to be designed, integrated, optimized and managed. Service providers are skilled in this area and comfortable managing frequent 3GPP new releases of functionality.

A service provider can bring value by offering a service that combines locally licensed and public spectrum. This could include adding spectrum in low-band or the lower mid-band, and frequency division duplex (FDD) for Massive IoT. The service provider's low/mid-band spectrum (e.g. 1800 or 2600MHz) could host VoLTE services or Massive IoT devices with LTE-M and/or NB-IoT, and the remainder of the carrier capacity can be used for LTE or New Radio (NR) operation with dynamic spectrum sharing (DSS) which dynamically allocates radio resources between the two. With FDD, coexistence with the outdoor public network is straightforward, and it could migrate over time increasingly from LTE to NR. The industry licensed spectrum (e.g. 3.7–3.8GHz band in Germany) can be used for NR, with focus on ultra-reliable low-latency communication (URLLC).

In an early phase, DSS could be considered with a combined LTE/NR operation on the carrier. Over time, the LTE devices can be migrated to the low/mid-band carrier, and the carrier becomes a clean NR carrier that can be optimized for URLLC operation. In contrast to the situation of local license only as described above, the phasing out of LTE on the carrier requires only moving the devices to another lower LTE band, without a need to replace the devices.

While industry licensed spectrum can be employed in the site, the site will still need public network mobile coverage for staff personal use, worker productivity tools and contractors on-site.

The coexistence of public and private networks needs careful consideration to avoid interference.

Integrating the end-to-end supply chain adds another dimension, as logistic hubs such as airports and seaports are host to multiple service companies operating on-site. Digitalization projects depend upon securing wider access to data, shared within sites, between sites and between parties. In the case of critical national infrastructure, public safety workers may need on-site roaming access for emergencies. These factors drive a need for a capable connectivity platform rather than the legacy of incompatible networks.

The use of multi-operator core networks (MOCN) and radio resource partitioning (RRP) is one way for public and private networks to efficiently coexist, splitting the traffic generated from the same radio units on-site. This can be an effective model, provided it fulfills the enterprise's requirements.

As the complexity of networking grows, manufacturers are outsourcing more of their communications infrastructure.

While it is evident for many industries that data is a highly prized competitive asset, it is an exception rather than a rule that an industrial site requires to work in complete isolation from other sites or indeed from upstream/downstream supply chain partners and customers. Secure mobility for both local and wide area communications is a growing requirement of many industries.

Service providers are able to offer advanced mobility solutions that combine local spectrum with their own national spectrum assets.

Summary

This data-driven environment is what drives industrial enterprises to evolve their operations with an embedded connectivity platform for the future. Spectrum can be obtained in different ways, e.g. by an SLA with a service provider or through dedicated locally licensed spectrum. These solutions may be complimentary.

Example 1: Dual-slice campus networks for Osram, provided by Deutsche Telekom

A private LTE network has been deployed on the Osram factory campus by Deutsche Telekom, leveraging the existing publicly available LTE mobile network infrastructure.

Osram and Deutsche Telekom are prototyping and testing a mobile robotics solution at the Osram factory in Schwabmünchen. A flexible production environment is being developed where automated guided vehicles (AGV) will be used to transport goods throughout the factory. The AGV scans its environment in the factory and sends the data through the campus network to an application in the cloud edge, enabling autonomous control of the transport system.

Deutsche Telekom is deploying the campus network solution based on a dual-slice approach. This solution combines and integrates public and private LTE connectivity on Deutsche Telekom spectrum, where it can be enhanced with a local IT edge cloud deployment.

The network is achieving latencies of <20ms and sufficient capacity for the factory use cases. Going forward, 5G will bring even lower latency and more capacity in both uplink and downlink when needed. Applications such as AGVs are assured priority with the use of quality-of-service class identifier (QCI) priority classes.

The use of network features such as MOCN and RRP, where the radio splits traffic resources between private and public, provides Osram with dedicated network resources and capacity while benefiting from the existing mobile infrastructure footprint and coverage.

It also ensures that private and public radio is built in coordination on FDD spectrum to avoid interference. Deutsche Telekom is able to provide Osram with the dedicated on-site connectivity it needs, while coordinating public and private radio resources effectively.

Example 2: Dedicated network on industry spectrum for Groupe ADP and Air France-KLM

In January 2020, the French regulatory body granted a 10-year 4G/5G license to Hub One, a subsidiary of Groupe ADP (Aéroports de Paris), to launch a high-speed private mobile network covering the Paris airports of Charles de Gaulle, Orly and Le Bourget. The license grants 40MHz of time division duplex (TDD) spectrum on the 2570–2620MHz band (2.6GHz, B38A).

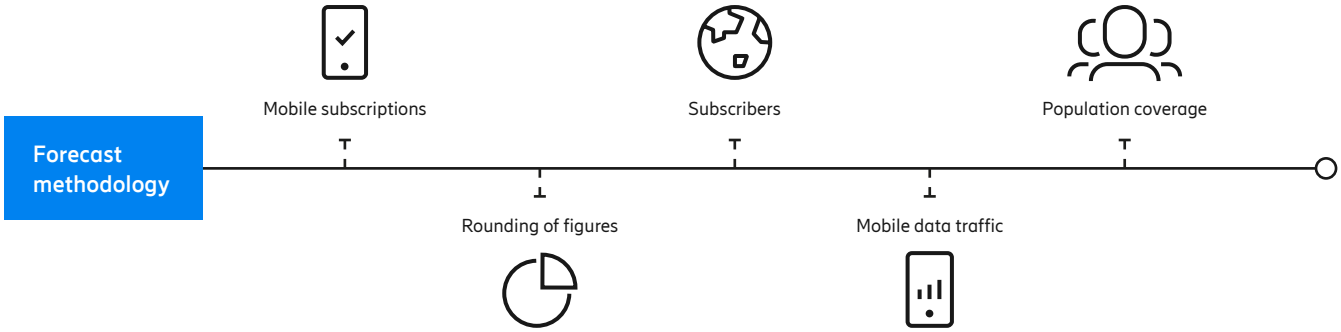
The 3 airports collectively host approximately 120,000 employees from around 1,000 companies daily. Hub One is a telecommunications service provider delivering network services to many of the companies operating on-site. One of the largest is Air France-KLM, which requires high-performance networking for ground service engineering teams and for retrieving aircraft telematics data.

A dedicated network with both micro cells on gates and macro cells for wide area coverage is currently being installed. Initial use case testing has included ramp and ground staff activities including tablet/mobile telephony, LTE broadcast push-to-talk (PTT) and luggage tracing. The private mobile radio (PMR) systems currently in place have low data rates, and Hub One and Air France-KLM chose an LTE-based system for high data capacity allowing applications such as AR video sharing to enhance site worker productivity.

Future uses include telematics data transfer during taxiing for predictive and preventive maintenance, as well as improved efficiency of software and content updates for onboard data servers.

Quality and security are prerequisite factors in aircraft operations, which influenced the decision to implement a 3GPP cellular network based on LTE and 5G.

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.

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)

5G TF: A pre-3GPP NR technical forum open specification

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

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: Millimeter waves are radio frequency waves in the extremely high frequency range (30–300GHz) with wavelengths between 10mm and 1mm. In a 5G context, millimeter waves refer to frequencies between 24 and 71GHz (the two frequency ranges 26GHz and 28GHz are included in millimeter range by convention)

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	2018	2019	Forecast 2025	CAGR* 2019–2025	Unit
Worldwide mobile subscriptions	7,670	7,920	8,860	2%	million
• Smartphone subscriptions	4,980	5,530	7,500	5%	million
• Mobile PC, tablet and mobile router subscriptions	240	270	390	6%	million
• Mobile broadband subscriptions	5,570	6,110	7,820	4%	million
• Mobile subscriptions, GSM/EDGE-only	1,950	1,660	840	-11%	million
• Mobile subscriptions, WCDMA/HSPA	2,020	1,880	820	-13%	million
• Mobile subscriptions, LTE	3,550	4,290	4,390	0%	million
• Mobile subscriptions, 5G	0	12	2,790	-	million
• FWA connections	0	55	160	21%	million
Mobile data traffic					
• Data traffic per smartphone	4.7	7.0	25	25%	GB/month
• Data traffic per mobile PC	12	15	25	9%	GB/month
• Data traffic per tablet	5.7	6.9	16	15%	GB/month
Total data traffic**					
Mobile data traffic	22	33	164	31%	EB/month
• Smartphones	20	31	160	31%	EB/month
• Mobile PCs and routers	0.7	0.8	1.0	3%	EB/month
• Tablets	0.7	0.9	2.8	22%	EB/month
Fixed wireless access	4.3	6.3	53	43%	EB/month
Total fixed data traffic	110	140	440	21%	EB/month
Fixed broadband connections	**1,080**	**1,160**	**1,440**	**4%**	**million**

Regional key figures

Mobile subscriptions	2018	2019	Forecast 2025	CAGR* 2019–2025	Unit
North America	380	390	440	2%	million
Latin America	660	670	730	1%	million
Western Europe	510	510	530	0%	million
Central and Eastern Europe	580	570	580	0%	million
North East Asia	1,970	2,050	2,200	1%	million
China[1]	1,540	1,600	1,680	1%	million
South East Asia and Oceania	1,060	1,130	1,280	2%	million
India, Nepal and Bhutan	1,090	1,120	1,280	2%	million
Middle East and North Africa	720	730	880	3%	million
Sub-Saharan Africa	700	750	950	4%	million

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

Regional key figures

Smartphone subscriptions	2018	2019	Forecast 2025	CAGR* 2019–2025	Unit
North America	310	310	360	3%	million
Latin America	480	510	590	2%	million
Western Europe	380	390	480	4%	million
Central and Eastern Europe	340	350	480	5%	million
North East Asia	1,630	1,820	2,070	2%	million
China[1]	1,290	1,440	1,610	2%	million
South East Asia and Oceania	650	770	1,100	6%	million
India, Nepal and Bhutan	530	620	1,030	9%	million
Middle East and North Africa	340	380	740	12%	million
Sub-Saharan Africa	320	390	650	9%	million
LTE subscriptions					
North America	330	350	110	-17%	million
Latin America	280	340	490	6%	million
Western Europe	300	350	230	-7%	million
Central and Eastern Europe	190	240	390	8%	million
North East Asia	1,580	1,800	820	-12%	million
China[1]	1,230	1,410	560	-14%	million
South East Asia and Oceania	280	390	810	13%	million
India, Nepal and Bhutan	410	550	820	7%	million
Middle East and North Africa	120	170	450	18%	million
Sub-Saharan Africa	50	90	270	21%	million
5G subscriptions					
North America	0	1	320	-	million
Latin America	0	0	90	-	million
Western Europe	0	0	290	-	million
Central and Eastern Europe	0	0	160	-	million
North East Asia	0	10	1,320	-	million
China[1]	0	5	1,080	-	million
South East Asia and Oceania	0	0	270	-	million
India, Nepal and Bhutan	0	0	230	-	million
Middle East and North Africa	0	1	80	-	million
Sub-Saharan Africa	0	0	30	-	million
Data traffic per smartphone					
North America	6.3	8.5	45	32%	GB/month
Latin America	2.7	3.9	22	34%	GB/month
Western Europe	5.4	8.2	36	28%	GB/month
Central and Eastern Europe	4.2	5.8	24	27%	GB/month
North East Asia	5.9	7.5	27	23%	GB/month
China[1]	6.1	7.5	25	22%	GB/month
South East Asia and Oceania	3.1	4.6	25	33%	GB/month
India, Nepal and Bhutan	8.5	12	25	13%	GB/month
Middle East and North Africa	3.4	5.0	23	28%	GB/month
Sub-Saharan Africa	1.1	1.6	7.1	28%	GB/month
Mobile data traffic					
North America	2.1	2.8	16	34%	EB/month
Latin America	1.1	1.7	11	37%	EB/month
Western Europe	2.2	3.2	15	30%	EB/month
Central and Eastern Europe	1.0	1.5	8	33%	EB/month
North East Asia	8.6	12	50	26%	EB/month
China[1]	7.1	10	37	24%	EB/month
South East Asia and Oceania	1.8	3.2	25	40%	EB/month
India, Nepal and Bhutan	3.6	6.0	21	23%	EB/month
Middle East and North Africa	1.0	1.7	15	43%	EB/month
Sub-Saharan Africa	0.21	0.33	4.0	52%	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.

www.ericsson.com

Ericsson
SE-164 80 Stockholm, Sweden
Telephone +46 10 719 0000
www.ericsson.com

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