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Ericsson Mobility Report

June 2019

Letter from the publisher

5G switched on

As market after market switches on 5G, we are at a truly momentous point in time. No previous generation of mobile technology has had the potential to drive economic growth to the extent that 5G promises. It goes beyond connecting people to fully realizing the Internet of Things (IoT) and the Fourth Industrial Revolution.

Digital infrastructure can make distance less relevant than ever. 5G is the key to making it all work – driving economic value from enhanced mobile broadband to industry digitalization. That, in turn, will require an ecosystem of technology, regulatory, security and industry partners to deliver on the potential. Smart cities, Industrial IoT, augmented reality, autonomous transport and digital health are just some of the exciting prospects that can be made real with the support of the 5G ecosystem.

In this edition of the Ericsson Mobility Report, we go beyond the forecast numbers and, in three co-written articles, present a glimpse of the impressive progress happening in markets on the verge of deploying 5G:
- With Telstra in Australia, we explore how to manage the ever-growing demand for data and video, while maintaining consumer experience, particularly for live content streaming.
- With MTS in Russia, we describe how mobile networks must evolve to ensure network performance that meets customer experience expectations, as well as enabling new services when preparing for 5G.
- With Turkcell in Turkey, we look into managing network performance and service offerings in a successful fixed wireless access (FWA) implementation.

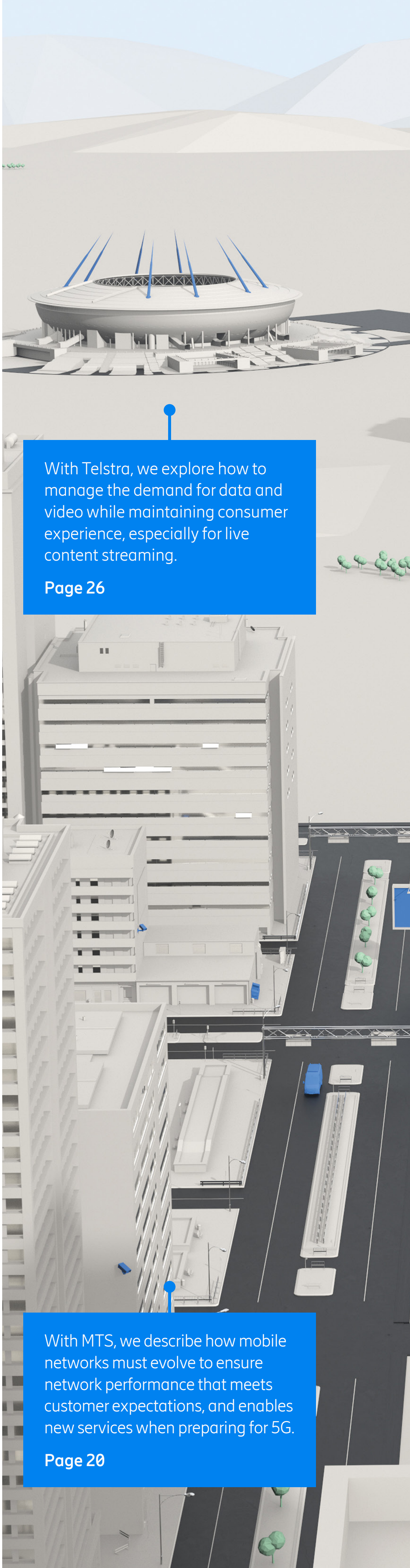
As 5G is switched on in country after country, the significance of this technology for all sectors of society will become increasingly apparent.

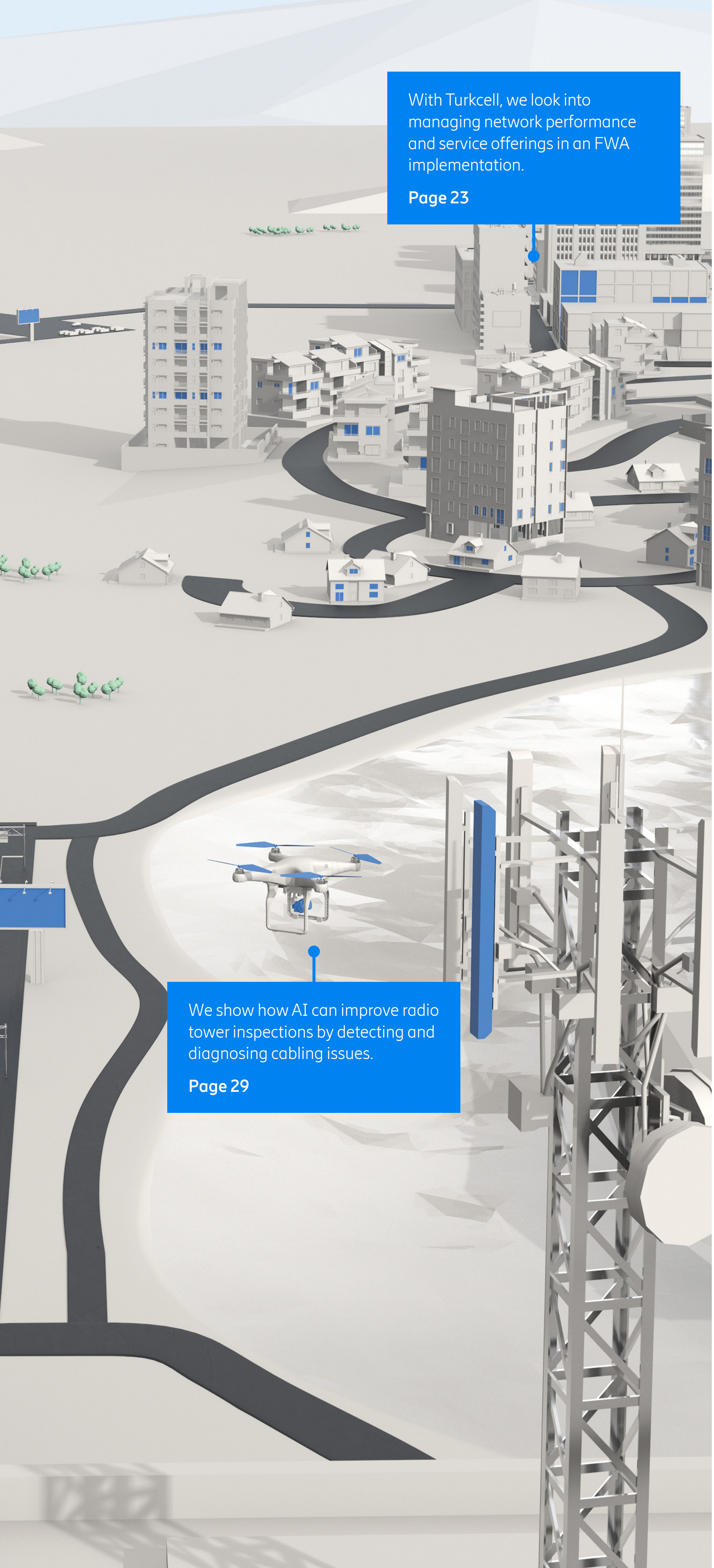
I hope you find the report engaging and useful!

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, Andres Torres, Per Lindberg, Kati Öhman, Athanasios Karapantelakis
Co-written articles:	Shamil Bajgin, Elena Purtova, MTS (Russia) Saliha Sezgin Alp, Mustafa Karakoc, Gulay Yardim, Turkcell (Turkey) Jenni Barbour, Telstra (Australia)





With Turkcell, we look into managing network performance and service offerings in an FWA implementation.

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We show how AI can improve radio tower inspections by detecting and diagnosing cabling issues.

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Mobile subscriptions Q1 2019

The total number of mobile subscriptions was around 7.9 billion in Q1 2019, with 44 million new subscriptions added during the quarter.

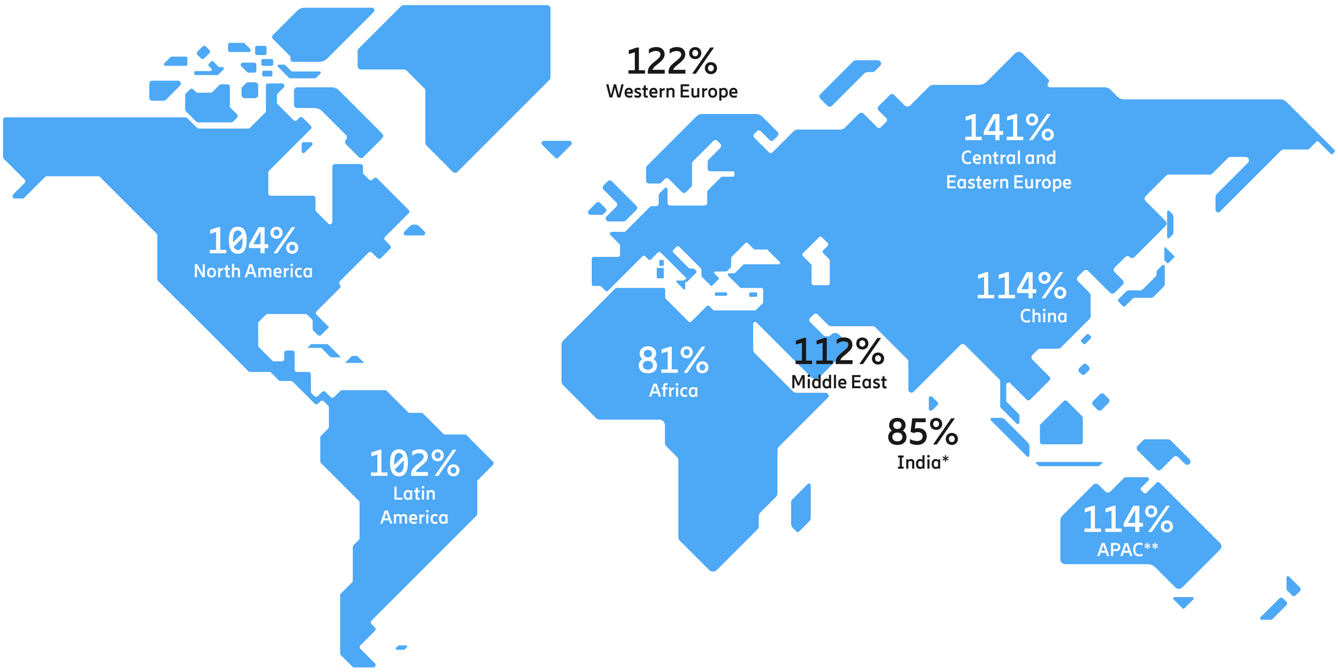
The number of mobile subscriptions grew at 2 percent year-on-year and currently totals around 7.9 billion. China had the most net additions during the quarter (+30 million), followed by Nigeria (+5 million) and the Philippines (+4 million). The high subscription growth in China continues from last year, and is likely the result of intense competition among communications service providers in the country. In India, the number of subscriptions declined by 14 million. This was mainly due to the introduction of a minimum regular recharge amount by some large operators, to tackle low-paying users and increase average revenue per user (ARPU).

The number of mobile broadband subscriptions[1] grew at 15 percent year-on-year, increasing by 140 million in Q1 2019. The total is now 6 billion, equaling 76 percent of mobile subscriptions. The number of LTE subscriptions increased by 160 million during the quarter to reach a total of 3.7 billion, and 47 percent of all mobile subscriptions are now for LTE. The net addition for WCDMA/HSPA was around 20 million subscriptions.

GSM/EDGE-only subscriptions declined by 80 million. Other technologies[2] declined by around 30 million.

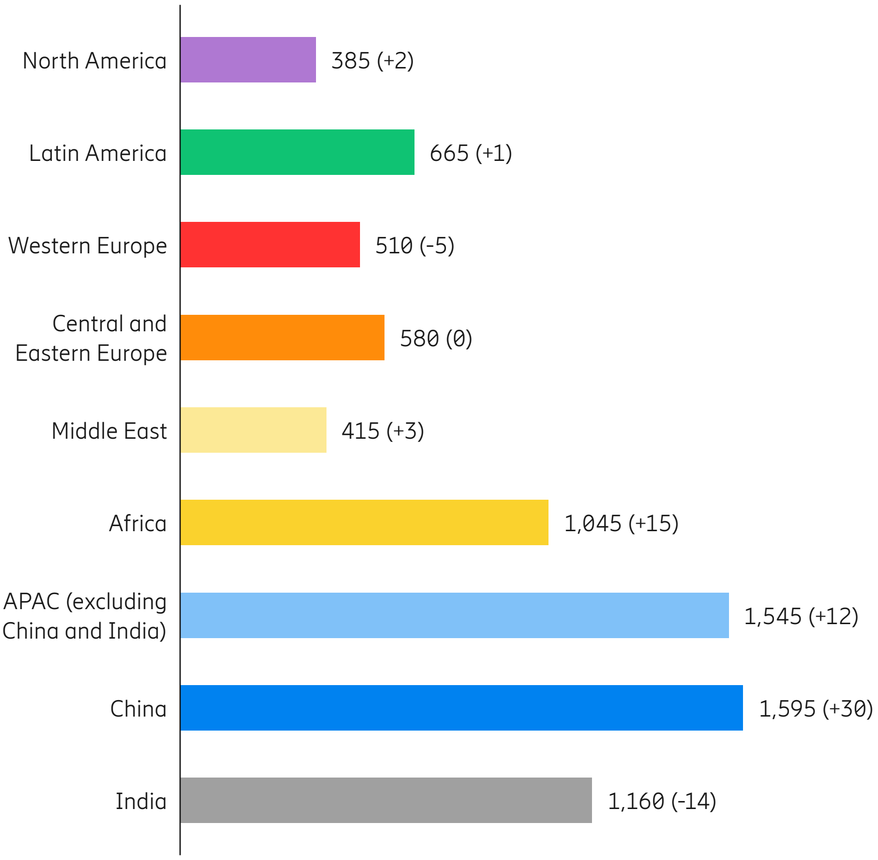
Subscriptions associated with smartphones account for more than 60 percent of all mobile phone subscriptions. The number of mobile subscriptions exceeds the population in many countries, which is largely due to inactive subscriptions, multiple device ownership or optimization of subscriptions for different types of calls. As a result, the number of mobile subscribers is lower than the number of mobile subscriptions. Today, there are around 5.7 billion subscribers globally compared to 7.9 billion subscriptions. Global mobile subscription penetration is now at 104 percent.

Subscription penetration Q1 2019 (percent of population)

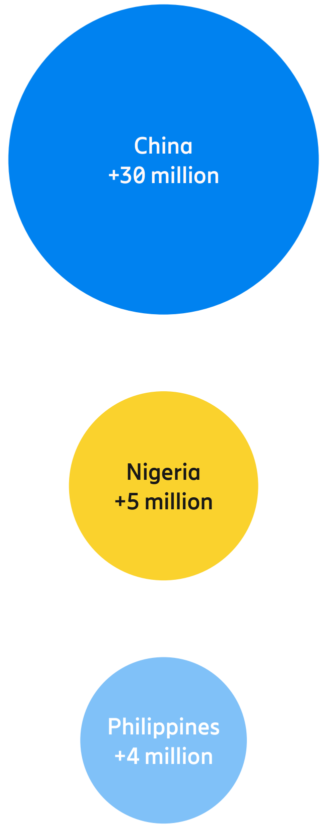


[1] Mobile broadband includes radio access technologies HSPA (3G), LTE (4G), 5G, CDMA2000 EV-DO, TD-SCDMA and Mobile WiMAX
[2] Mainly CDMA2000 EV-DO, TD-SCDMA and Mobile WiMAX
* India region includes India, Nepal and Bhutan
** Excluding China and India

Total and new mobile subscriptions Q1 2019 (million)



Top countries by net additions Q1 2019



6bn

There are now 6 billion mobile broadband subscriptions.

104%

Global subscription penetration is at 104 percent in Q1 2019.

47%

47 percent of all mobile subscriptions are now for LTE.

Mobile subscriptions outlook

The strong momentum for 5G continues.

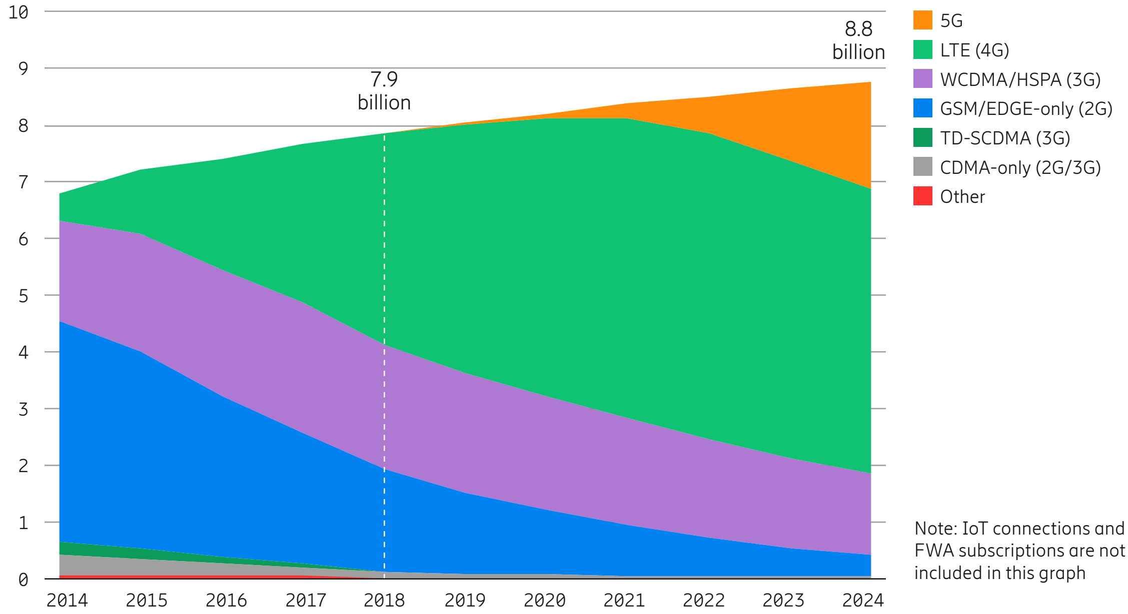
5G is on a roll. During the second quarter of 2019 several markets switched on 5G following the introduction of new 5G-compatible smartphones. Some communications service providers have set ambitious targets of reaching up to 90 percent population coverage within the first year. As 5G devices increasingly become available and more service providers launch 5G, over 10 million 5G subscriptions[1] are projected worldwide by the end of 2019. Looking ahead, in the first five years, 5G subscription uptake is expected to be significantly faster than that of LTE, following its launch back in 2009.

On a global level, 5G network deployments are expected to ramp up during 2020, creating the foundation for massive adoption of 5G subscriptions. Most new 5G subscribers will be users trading up their 4G handsets to 5G-compatible devices following 5G services launching in their market. By the end of the period, it is also likely that many young users in mature markets will get a 5G smartphone as their first device.

Given the momentum in the market, we have increased our forecast for 5G subscriptions, and now expect there to be 1.9 billion 5G subscriptions for enhanced mobile broadband by the end of 2024. This will account for over 20 percent of all mobile subscriptions at that time. The peak of LTE subscriptions is projected for 2022, at around 5.3 billion subscriptions, with the number declining slowly thereafter. However, LTE will remain the dominant mobile access technology by subscription for the foreseeable future, and it is projected to have nearly 5 billion subscriptions at the end of 2024.

Cellular IoT connections and fixed wireless access (FWA) subscriptions supporting new use cases will come in addition to the mobile subscriptions shown in the graph below.

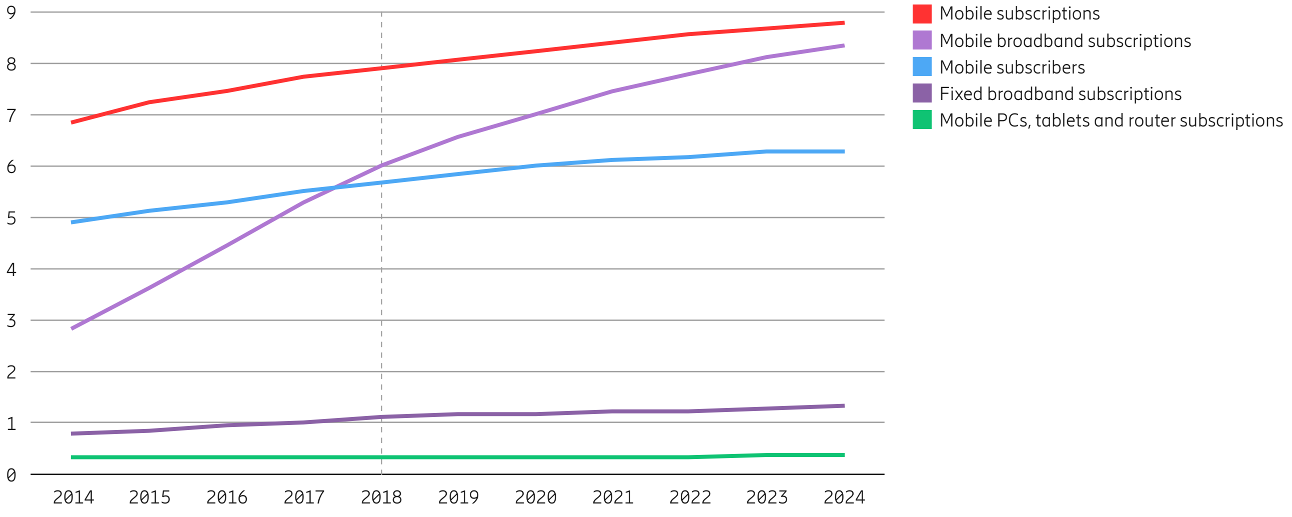
Mobile subscriptions by technology (billion)



Note: IoT connections and FWA subscriptions are not included in this graph

[1] 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

Subscriptions and subscribers (billion)



By the end of 2024, 95 percent of all subscriptions will be for mobile broadband

We estimate that there will be 8.8 billion mobile subscriptions by the end of 2024. Out of this, around 95 percent will be for mobile broadband. The number of unique mobile subscribers is estimated to reach 6.2 billion by the end of our forecast period.

Over the last couple of years, we have slightly reduced our forecast for mobile subscriptions due to a number of factors beginning to decline in importance. The number of users having multiple SIMs has started to reduce, and prepaid subscriptions have been fewer than anticipated because many markets now require all prepaid SIMs to be registered.

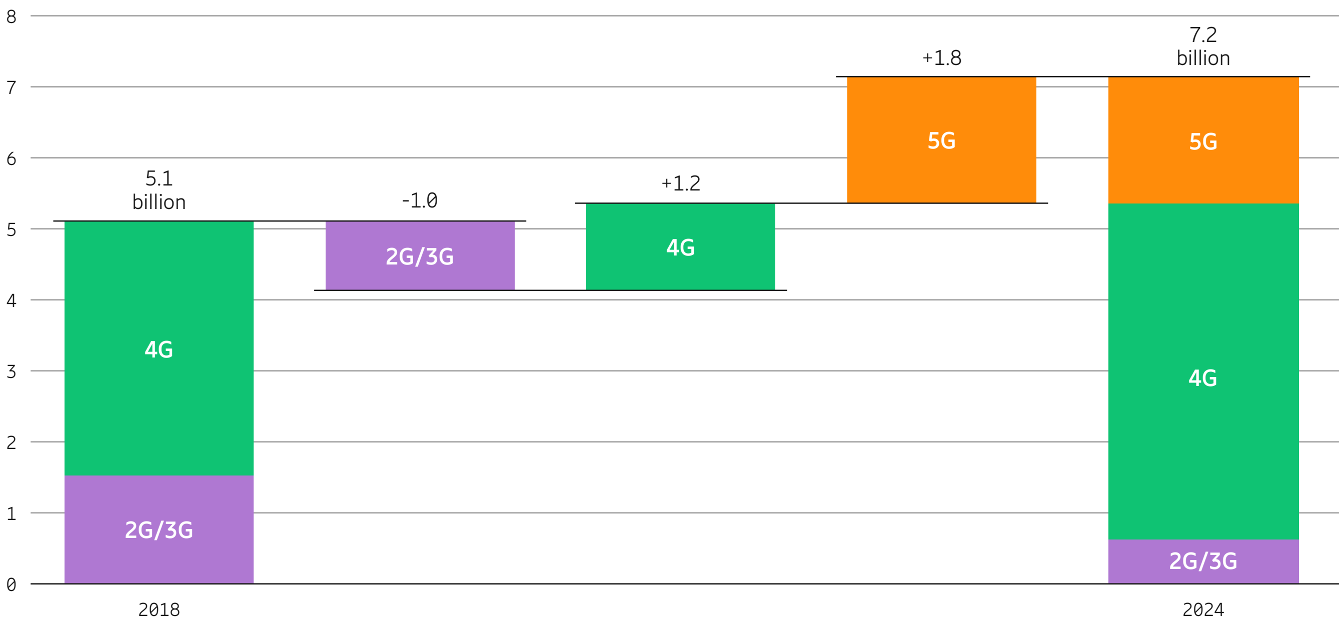
On the other hand, smartphone penetration continues to rise. At the end of 2018, there were 5.1 billion smartphone subscriptions, 99 percent of which were for 3G and 4G. The number of smartphone subscriptions is forecast to reach 7.2 billion in 2024.

Subscriptions for fixed broadband are expected to show limited growth of around 3 percent per year through 2024.[2] Subscriptions for mobile PCs, tablets and routers are expected to show moderate growth, reaching 330 million in 2024.

8.3bn

In 2024, there will be 8.3 billion mobile broadband subscriptions.

Smartphone subscriptions by technology (billion)



[2] 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. This is the opposite for mobile phones, where subscription numbers exceed user numbers. FWA subscriptions are not part of the fixed broadband subscription estimate

IoT connections outlook

NB-IoT and Cat-M technologies will account for close to 45 percent of cellular IoT connections in 2024.

To date, 2G and 3G connectivity has enabled many cellular IoT applications. In recent years, support for large volumes of devices has been enabled by the Massive IoT technologies NB-IoT and Cat-M[1] deployed on top of LTE networks.

Cellular IoT use cases will have differing connectivity requirements. A heat sensor in a basement will need deep coverage and have low throughput, whereas a connected robot on a production line may require ultra-low latency, high reliability and high throughput. Cellular IoT use cases can be divided into four segments based on their connectivity requirements.

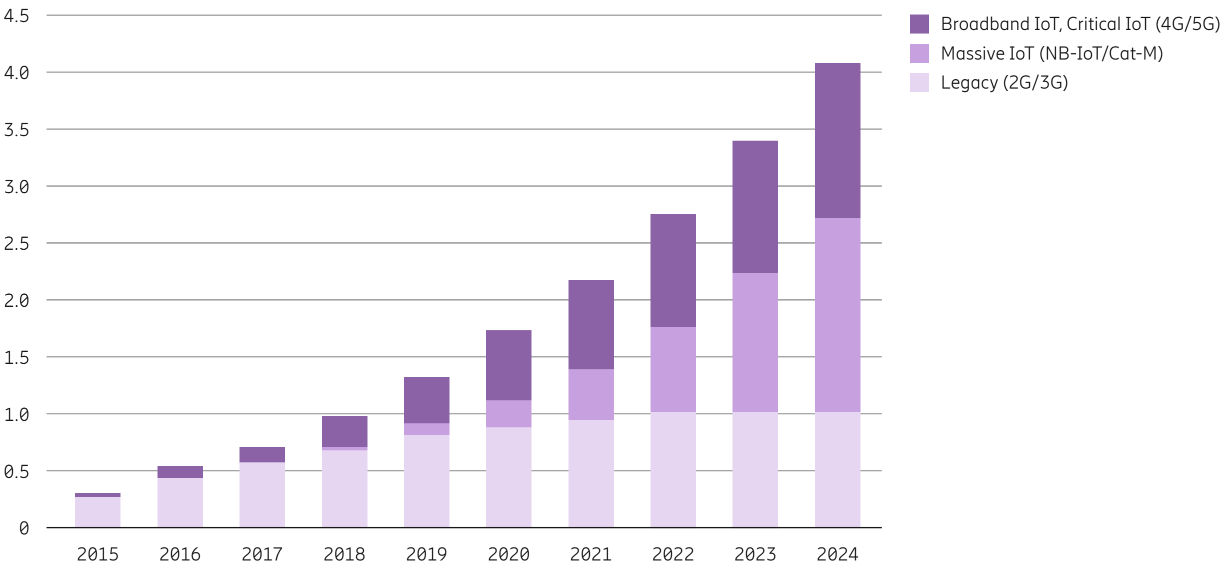
Massive IoT
This segment primarily includes wide-area use cases, connecting massive numbers of low-complexity, low-cost devices with long battery life and relatively low throughput. Support for these is already being provided in today's LTE networks with NB-IoT and Cat-M. These technologies complement each other and there is an emerging trend towards service providers deploying one common network supporting both technologies. Cat-M is suited to use cases that require relatively higher throughput, lower latency and voice support, whereas NB-IoT is suited to use cases with very low throughput that are tolerant of delay but require extended coverage.

IoT connections (billion)

IoT	2018	2024	CAGR
Wide-area IoT	1.1	4.4	27%
Cellular IoT[2]	1.0	4.1	27%
Short-range IoT	7.5	17.8	15%
Total	**8.6**	**22.3**	**17%**

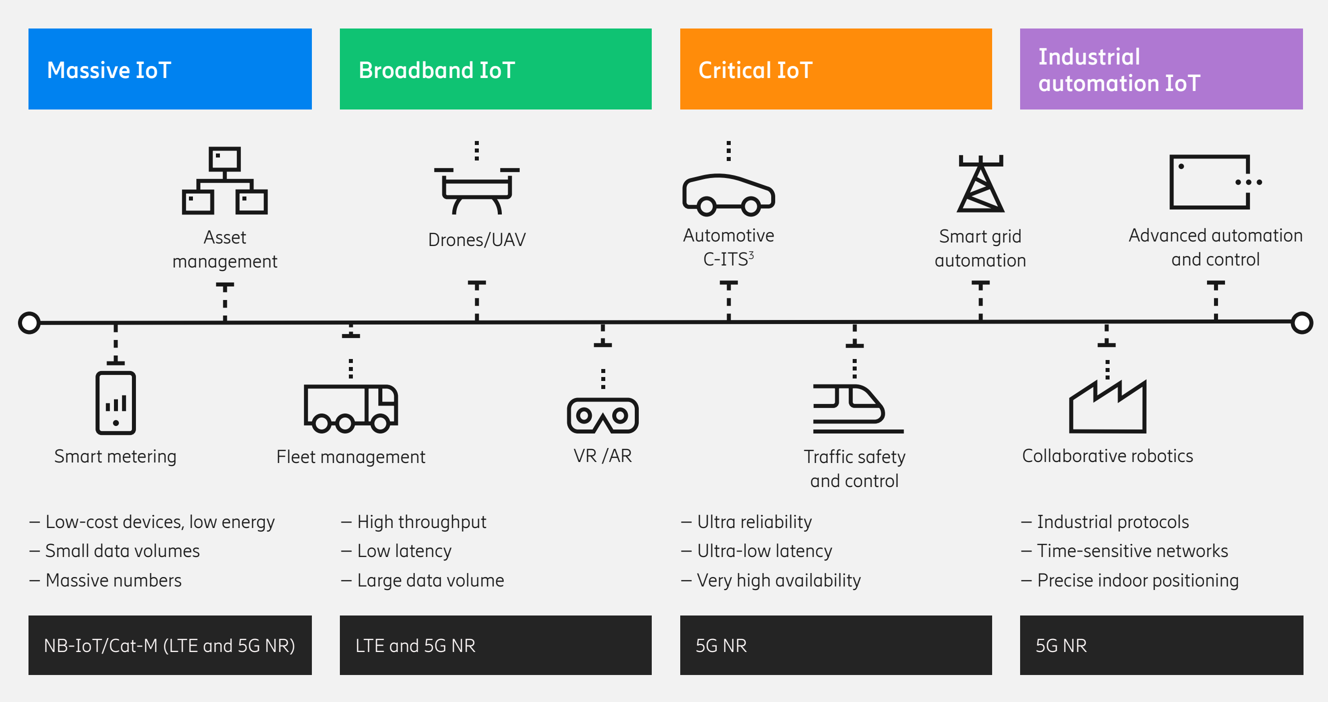
Verticals using Massive IoT include utilities with smart metering, healthcare in the form of medical wearables and transport with tracking sensors. At the end of 2024, NB-IoT and Cat-M are expected to account for close to 45 percent of all cellular IoT connections. In the future, NB-IoT and Cat-M will be able to fully co-exist in spectrum bands with 5G NR.

Cellular IoT connections by segment and technology (billion)



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

Cellular IoT use case segments



Broadband IoT
This segment mainly includes wide-area use cases that require higher throughput, lower latency and larger data volumes than Massive IoT technologies can support. LTE networks are well prepared to support use cases in this segment, as the technology can provide peak data rates in the multi-Gbps range and radio interface latency as low as 10ms. LTE is already connecting millions of modern cars, and there are LTE-capable smart watches.

By the end of 2024, nearly 35 percent of cellular IoT connections will be Broadband IoT, with 4G connecting the majority. When moving to 5G, with higher speed, lower latency and other capabilities, even more advanced use cases can be supported. Throughputs in the tens of Gbps and latency as low as 5ms will be possible.

Critical IoT
This segment includes both wide-area and local-area use cases that have requirements for extremely low latency and ultra-high reliability. 5G NR networks with support for Ultra-Reliable Low-Latency Communication (URLLC) as defined in 3GPP will be needed and will enable complex use cases such as interactive transport systems in the automotive industry, smart grids with real-time control and distribution of renewable energy in the utilities industry, and real-time control of manufacturing robots in the manufacturing industry.

The first modules supporting Critical IoT use cases are expected to be deployed in 2020. Only a small fraction of total cellular IoT connections will be Critical IoT in 2024.

Industrial automation IoT
This segment consists of very specific use cases, with the most demanding requirements coming from the manufacturing and industrial sites. Time-sensitive networks, industrial protocols running over ethernet, and very precise positioning will be needed.

Functionality to support this segment is currently being defined in 3GPP, influenced by Industry 4.0 initiatives and industry bodies such as 5G-ACIA. It will be a 5G-specific segment valid for local area use cases and private network deployments. As standardization is still ongoing, no forecast is included for this segment.

Legacy
Today, the majority of cellular IoT devices are connected via 2G and 3G technologies (GPRS, EDGE and HSPA). The number of legacy connections is expected to increase slightly until 2022, and then remain stable throughout the rest of the forecast period.

[3] Co-operative Intelligent Transport System

5G device outlook

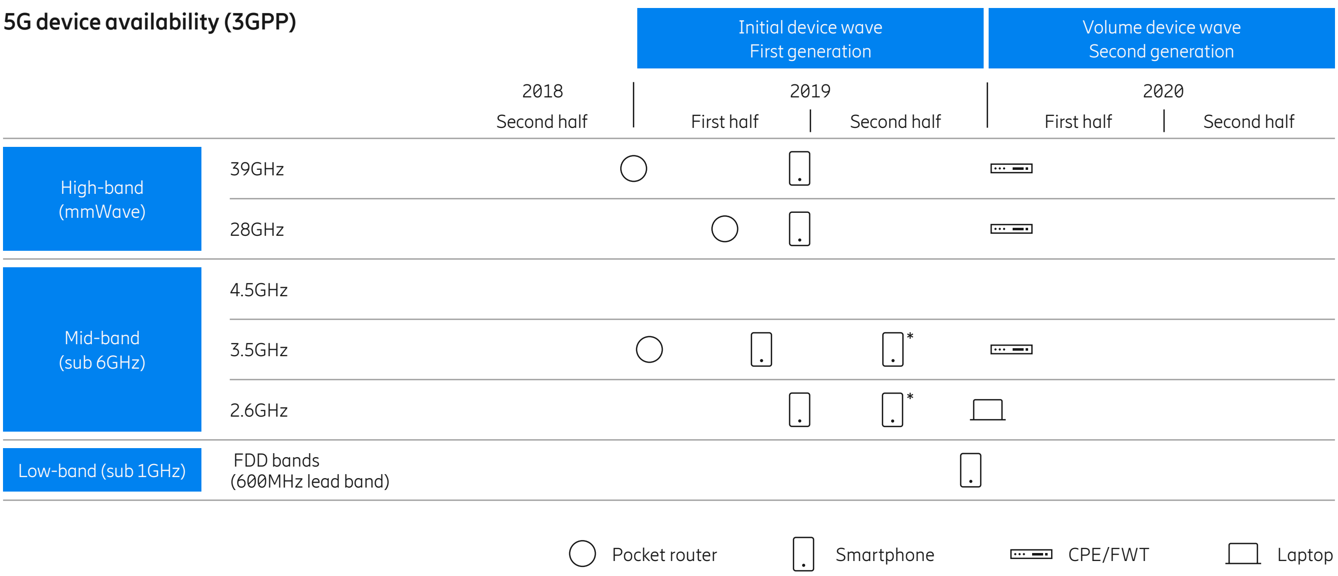
5G smartphones in all three spectrum bands are expected to be available in 2019.

There is a strong commitment and an increasing 5G focus from chipset and device vendors. The first 5G devices, launched in 2018, were pocket routers. The first 5G smartphones were launched in early Q2 2019 in line with the first commercial 5G service launches in Asia Pacific, North America and Europe. Despite challenging 5G timelines, device suppliers are expected to be ready with different band and architecture support in a range of devices during 2019. For example, due to increased interest in deploying 5G network-wide coverage, first devices in low-band (below 1GHz) are now expected at the end of this year. Given the device availability, over 10 million 5G subscriptions are projected worldwide by the end of 2019, and more substantial volumes of 5G devices in different bands are expected from 2020 onwards.

Chipsets for Standalone (SA) architecture expected in the second half of 2019
The first wave of 5G service and device launches will be based on Non-Standalone (NSA) architecture, which means 5G networks will be supported by existing 4G infrastructure. Due to initial limited 5G network coverage, fallback to 4G networks for service continuity will be important. Communications service providers in North America, Asia Pacific and Europe are launching NSA, which has influenced China to shift its focus to NSA deployments first, with SA to follow. Suppliers are already working on the first chipsets supporting SA architecture and devices are expected to be available in the second half of 2019.

Spectrum sharing can support faster 5G network coverage build-out
New spectrum assets available for 5G service providers include wide bandwidths in higher frequencies, allowing significant increases of capacity. However, this requires tighter network grids to build coverage, which is both time and resource-consuming. While this is happening, a fast way to build coverage is to utilize existing frequency bands used by today's LTE networks. By implementing spectrum sharing, service providers can run LTE and 5G traffic on the same bands. This enables them to provide 5G network coverage quickly but requires device chipset support. Chipsets are currently in development and are anticipated to be in 5G commercial devices in late 2019.

5G device availability (3GPP)



* Standalone

Voice and communication services outlook

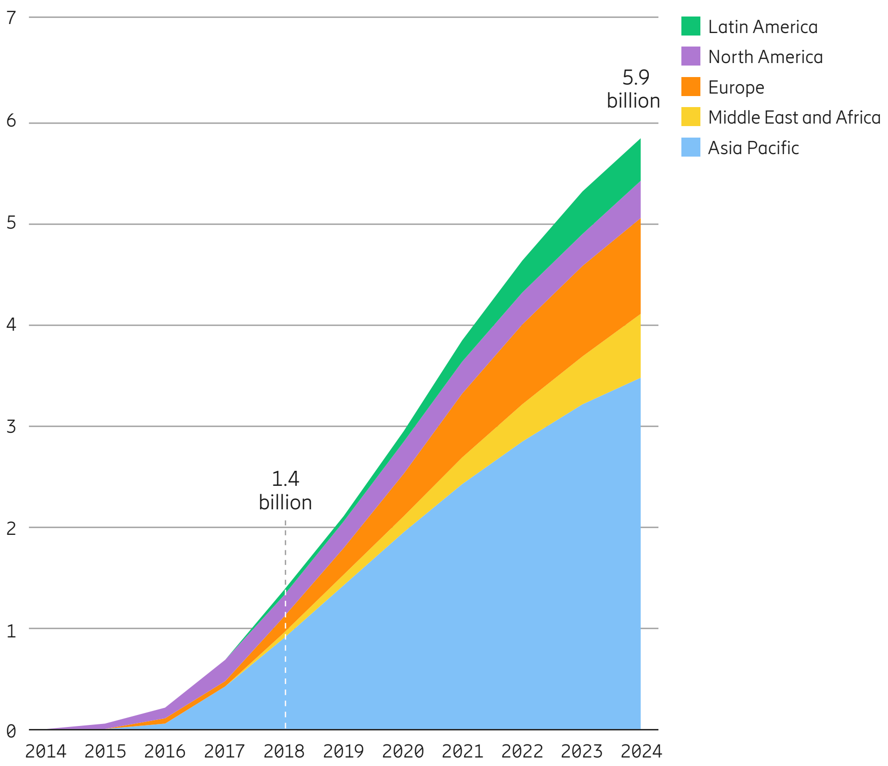
VoLTE is the foundation for enabling voice and communication services on 5G devices. Subscriptions are expected to reach 2.1 billion by the end of 2019.

Communications service providers continue to evolve their voice services and build IP-based networks founded upon VoLTE. These have now been launched in more than 170 networks in over 85 countries.[1] VoLTE is being deployed using cloud/NFV technologies in order to support more cost-efficient network operations, enabling easier capacity scaling and faster deployment of new services.

The building of globally connected VoLTE services is ongoing, with more than 20 service providers having signed VoLTE roaming agreements, mainly across North America and Asia Pacific, and over 10 holding interconnect agreements nationally or internationally.[2]

The number of VoLTE subscriptions is projected to reach 5.9 billion by the end of 2024, accounting for more than 85 percent of combined LTE and 5G subscriptions. VoLTE technology will be the foundation for enabling 5G voice calls, SMS over IP and new types of communication services on various 5G devices. This will be deployed in several network evolution steps in the LTE and 5G networks in different markets, using LTE-NR dual connectivity, Evolved Packet System fallback and voice over NR.

VoLTE subscriptions by region (billion)



New use case uptake and device availability

There are more than 2,100 VoLTE-enabled device models.[3] HD voice+[4] (Enhanced Voice Services, or EVS) provides improved audio and music quality within calls on VoLTE-capable devices, as well as better reliability across LTE and Wi-Fi. There are 150 HD voice+ devices available and the service has been deployed by 20 service providers.[5]

Cellular smartwatches with VoLTE-based voice calls have gained market traction, with 70 service provider launches. Video calling over LTE (ViLTE) has been launched by over 20 service providers, and there are more than 290 device models[6] available.

Wi-Fi calling is starting to become a mainstream service as part of service providers' VoLTE offering, and has launched in more than 70 networks in over 40 countries, mainly in North America and Europe.[7]

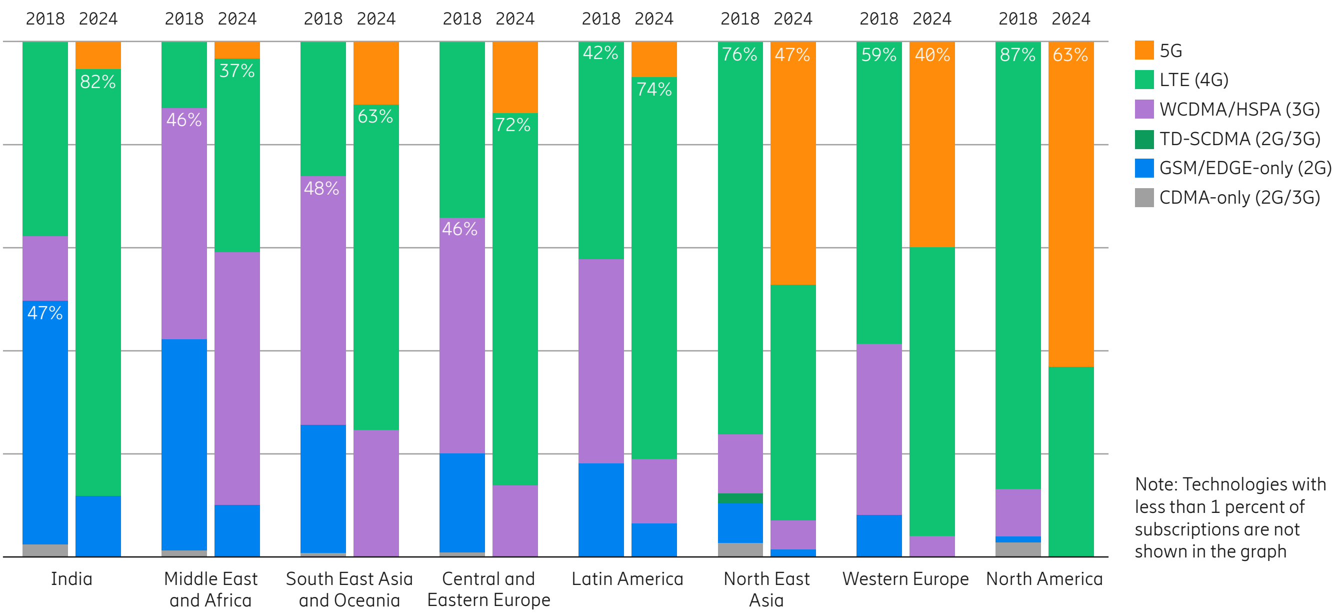
Service providers that have launched VoLTE can start adding other new IP-based communication services, such as multi-device (including phones, smartwatches and smart speakers sharing a phone number), multi-number (a single phone using several phone numbers), different types of enterprise collaboration services in combination with mobile HD voice, and voice in IoT devices. 5G-related service innovations for consumers, enterprises and industries are being explored, including combinations with augmented and virtual reality, and real-time interaction.

1 GSMA (April 2019)
2 Ericsson and GSMA (April 2019)
3 GSA (March 2019), supporting different regions and frequencies
4 GSMA trademark
5 GSA (April 2019)
6 GSA (March 2019)
7 GSMA (April 2019)

Regional subscriptions outlook

All regions now have mobile broadband subscription penetration of 50 percent or higher.

Mobile subscriptions by region and technology (percent)



In the **India** region, GSM/EDGE-only remained the dominant technology during 2018, accounting for 47 percent of mobile subscriptions at the end of the year. However, the country has experienced strong growth in LTE subscriptions over the last couple of years and, at the end of 2018, it accounted for 38 percent of mobile subscriptions. Mobile broadband[1] technologies now make up more than 50 percent of subscriptions.

As the transformation towards more advanced technologies continues in India, LTE is forecast to represent 82 percent of mobile subscriptions by the end of 2024. 5G subscriptions are expected to become available in 2022 and will represent 6 percent of mobile subscriptions at the end of 2024.

The **Middle East and Africa** comprises over 70 countries and is a diverse region. It varies from advanced markets with 100 percent mobile broadband subscription penetration, as well as emerging markets, where around 40 percent of mobile subscriptions are for mobile broadband. At the end of 2018, close to 20 percent of mobile subscriptions were for LTE in the Middle East and North Africa, while in Sub-Saharan Africa, LTE accounted for around 7 percent of subscriptions. The region is anticipated to evolve over the forecast period and, by 2024, 90 percent of subscriptions are expected to be for mobile broadband. Driving factors behind this shift include a young and growing population with increasing digital skills, as well as more affordable smartphones.

76%

On a global level, mobile broadband subscriptions make up 76 percent of all mobile subscriptions.

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

In the Middle East and North Africa, we anticipate commercial 5G deployments with leading communications service providers during 2019, and significant volumes in 2021. In Sub-Saharan Africa, 5G subscriptions, in discernible volumes, are expected from 2022. For the region as a whole, around 60 million 5G subscriptions are forecast for the end of 2024, representing 3 percent of total mobile subscriptions.

South East Asia and Oceania is a very diverse region, comprising developed markets with some of the world's most advanced networks, as well as developing economies that have only recently launched LTE. Today, WCDMA/HSPA is still the region's dominant technology, at 48 percent of subscriptions. However, LTE subscriptions grew by about 40 percent during 2018, and are expected to account for 63 percent of mobile subscriptions by the end of 2024.

Early 5G launch plans have been announced in Australia with communications service providers upgrading their networks to 5G NR, both for enhanced mobile broadband and fixed wireless access use cases. Initial 5G commercial devices are expected in the region during the first half of 2019. By the end of 2024, it is anticipated that almost 12 percent of subscriptions in the region will be for 5G, as more markets launch 5G services.

In **Central and Eastern Europe**, transition from WCDMA/HSPA to LTE is continuing. LTE is forecast to become the dominant technology during 2019. It is expected to account for 72 percent of mobile subscriptions in 2024, with WCDMA/HSPA forecast to decline from 46 percent (at end of 2018) to just 13 percent by the end of 2024. The first 5G subscriptions are expected in 2019, and will make up 15 percent of subscriptions in 2024.

In **Latin America**, LTE became the dominant radio access technology in 2018, accounting for 42 percent of subscriptions, just above WCDMA/HSPA with a 39 percent share. The distribution of technology is expected to change over the forecast period, with LTE projected to represent three-quarters of all subscriptions in 2024, while WCDMA/HSPA accounts for only 13 percent. The first 5G deployments will be possible in the 3.5GHz band during 2019. Argentina, Brazil, Chile, Colombia and Mexico are anticipated to be the first countries in the region to deploy 5G, with increased subscription uptake forecast from 2020. By the end of 2024, 5G is set to make up 7 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.

In **North America**, 5G commercialization is moving at a rapid pace. In the region, service providers have already launched commercial 5G services, both for fixed wireless access and mobile. North America's LTE penetration is currently 87 percent, which is the highest share globally. By the end of 2024, we anticipate close to 270 million 5G subscriptions in the region, accounting for more than 60 percent of mobile subscriptions.

63%

63 percent of North American mobile subscriptions are expected to be for 5G in 2024.

In **North East Asia**, the share of LTE subscriptions is high at 76 percent, with China alone having close to 1.2 billion LTE subscriptions at the end of 2018. In South Korea, communications service providers launched commercial 5G services in the beginning of April this year, and Japan and China are expected to follow with commercial 5G services. By the end of the forecast period, the region's 5G subscription penetration is projected to reach 47 percent.

In **Western Europe**, LTE is the dominant access technology, accounting for 59 percent of all subscriptions. WCDMA/HSPA continues to decline and will represent only 4 percent of subscriptions in 2024. The momentum for 5G in the region was highlighted by the first commercial launch in April. By the end of 2024, 5G is expected to account for around 40 percent of mobile subscriptions.

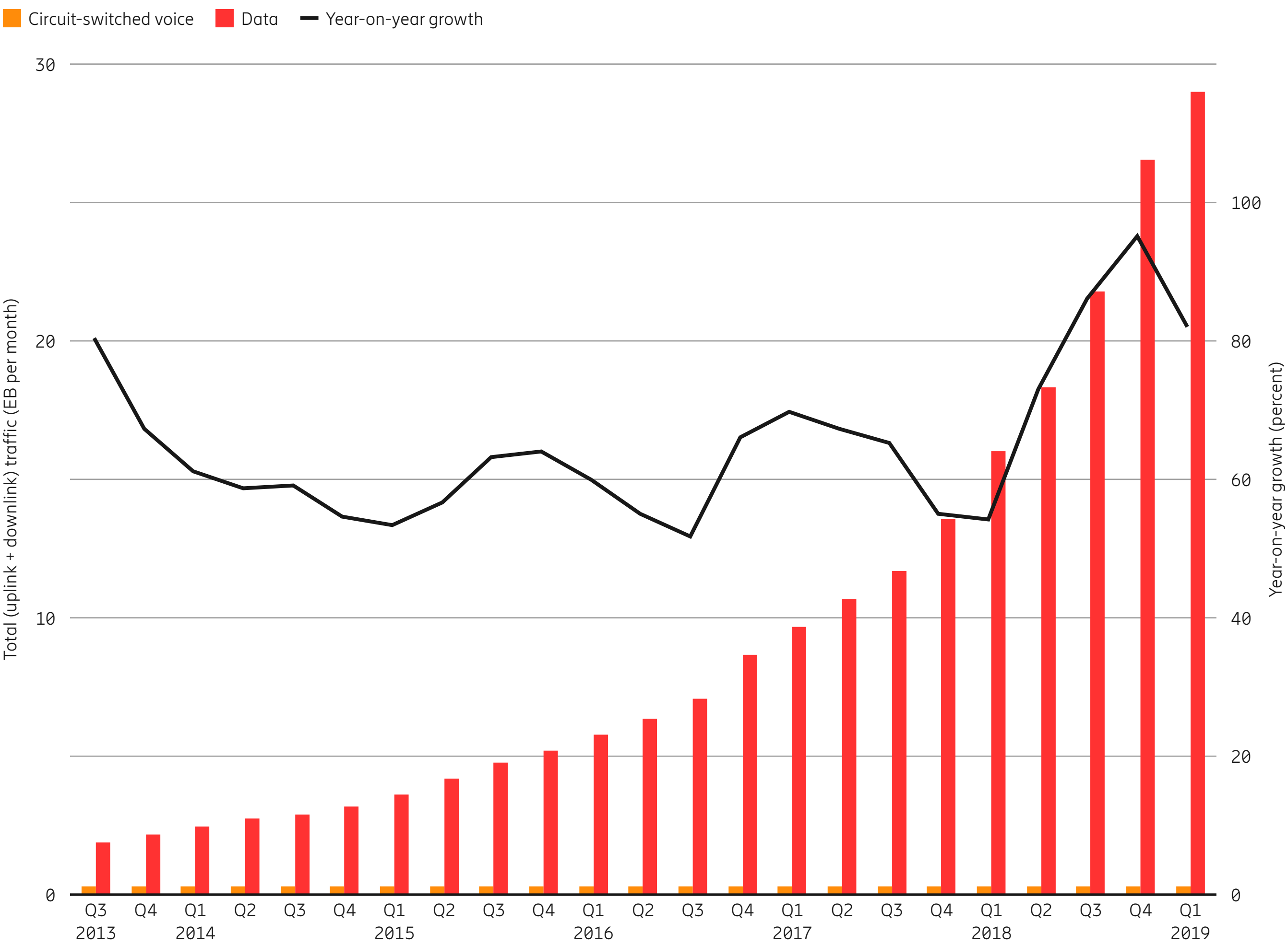
Mobile traffic Q1 2019

Mobile data traffic grew 82 percent between Q1 2018 and Q1 2019.

Traffic[1] growth is being 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. The graph below shows total global monthly data and voice traffic from Q3 2013 to Q1 2019, along with the year-on-year percentage change for mobile data traffic.

In Q1 2019, mobile data traffic grew 82 percent year-on-year. The high growth rate was mainly influenced by the increased number of smartphone subscriptions in India and increased data traffic per smartphone per month in China. The quarter-on-quarter growth for Q1 was 9 percent.

Global mobile data traffic and year-on-year growth (EB per month)



Source: Ericsson traffic measurements (Q1 2019)

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

Mobile traffic by application category

Mobile traffic is expected to grow by 30 percent annually between 2018 and 2024. Continuing recent trends, most of this should come from video traffic.

Video traffic in mobile networks is forecast to grow by around 34 percent annually up to 2024 to account for nearly three-quarters of mobile data traffic, from approximately 60 percent in 2018.

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 perpetual evolution towards higher screen resolutions on smart devices. All of these factors have been influenced by the increasing penetration of video-capable smart devices.

Social network traffic is also expected to rise 22 percent annually over the next 6 years. However, its relative share of traffic will decline from 11 percent in 2018 to around 8 percent in 2024, because of the stronger growth of video.[1]

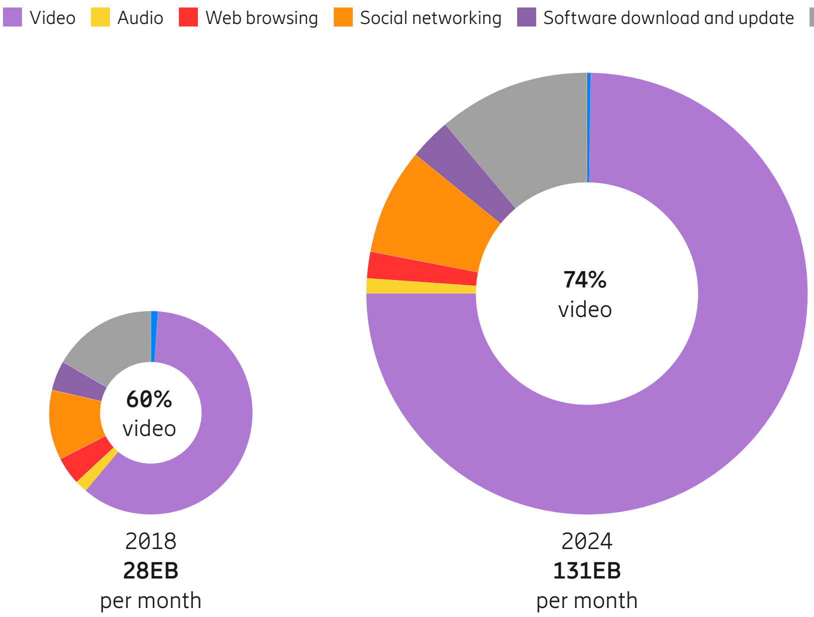
Video is everywhere

Users are spending more time streaming and sharing video. This is expected to continue, as video is embedded in all types of online content. In addition, surveys of smartphone users worldwide indicate that they expect 5G to bring the network performance needed for immersive media formats and applications.[2] Streaming 360-degree video and augmented/virtual reality should start to be a significant factor in mobile traffic growth while enhancing user experience as 5G is rolled out, and compatible devices are successively introduced.

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

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

Mobile data traffic by application category per month (percent)



Main drivers for video traffic growth

- Video part of most online content (news, ads, social media, etc.)
- Growth of VoD 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"
[2] Ericsson ConsumerLab, 5G consumer potential study (May 2019)

Mobile data traffic outlook

In 2024, 5G networks will carry 35 percent of mobile data traffic globally.

Total mobile data traffic continues to increase globally and is predicted to reach 131 exabytes (EB) per month by the end of 2024. This means a 30 percent compound annual growth rate (CAGR) between 2018 and 2024. This is slightly lower than previously reported and comes as a result of the strong growth seen in 2018.

However, this is not evenly distributed, as we anticipate large variations in traffic growth across regions. Populous markets that are early with 5G are likely to lead in traffic growth over the forecast period. By 2024, we expect that 35 percent of total mobile data traffic will be carried by 5G networks. Our 5G traffic forecast does not include traffic generated by fixed wireless access (FWA) services, as it is not yet possible to estimate this traffic. However, as FWA is one of the early use cases planned for 5G in some regions, it could significantly impact the overall traffic, depending on market uptake.

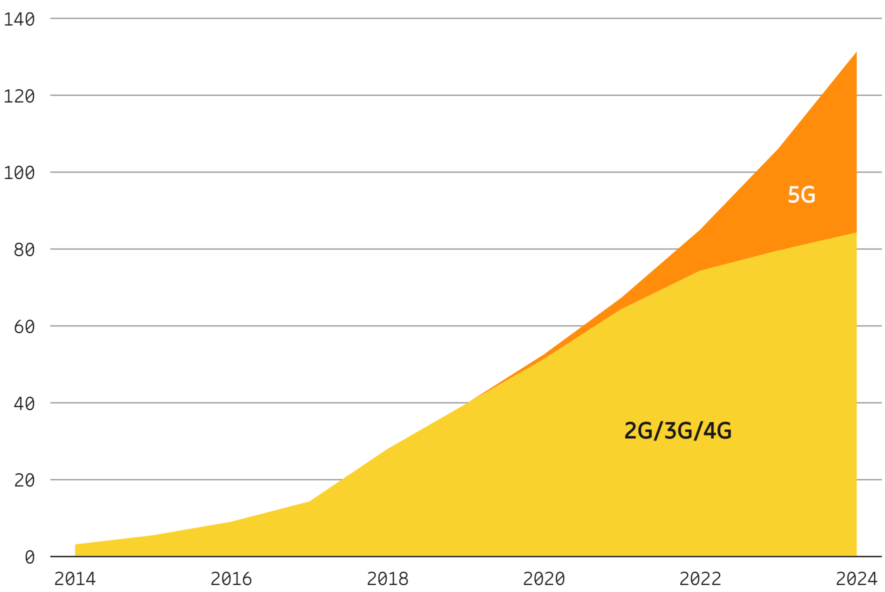
Smartphones continue to generate most of the mobile data traffic – close to 90 percent today and projected to reach 95 percent at the end of 2024. In this forecast period, this means that only new or evolved smartphone-based services are likely to have the ability to significantly affect the global traffic growth curve.

India region has the highest average usage per smartphone

India has the highest average monthly usage, reaching 9.8 gigabytes (GB) by the end of 2018. Increased numbers of LTE subscriptions, attractive data plans being offered by service providers and young people's changing video viewing habits have driven monthly usage growth.

In North East Asia, traffic per smartphone also grew strongly during 2018, and the region has the second-highest monthly usage, averaging 7.1GB. Attractive data plans, as well as innovative mobile apps and content, have pushed up monthly mobile data usage, particularly in China.

Global mobile data traffic (EB per month)



During 2018, we have seen a slightly slower traffic growth in North America than anticipated. Nevertheless, the average usage of mobile data traffic is expected to reach 39GB per month per smartphone by 2024. This will be driven by the financial strength of consumers, fast deployment of 5G with a high proportion of subscriptions at the end of the forecast period, and also innovative apps and content.

Globally, the increase in monthly mobile data traffic per smartphone can mainly be attributed to three drivers: improved device capabilities, more affordable data plans and an increase in data-intensive content.

The largest share of mobile data traffic is in North East Asia

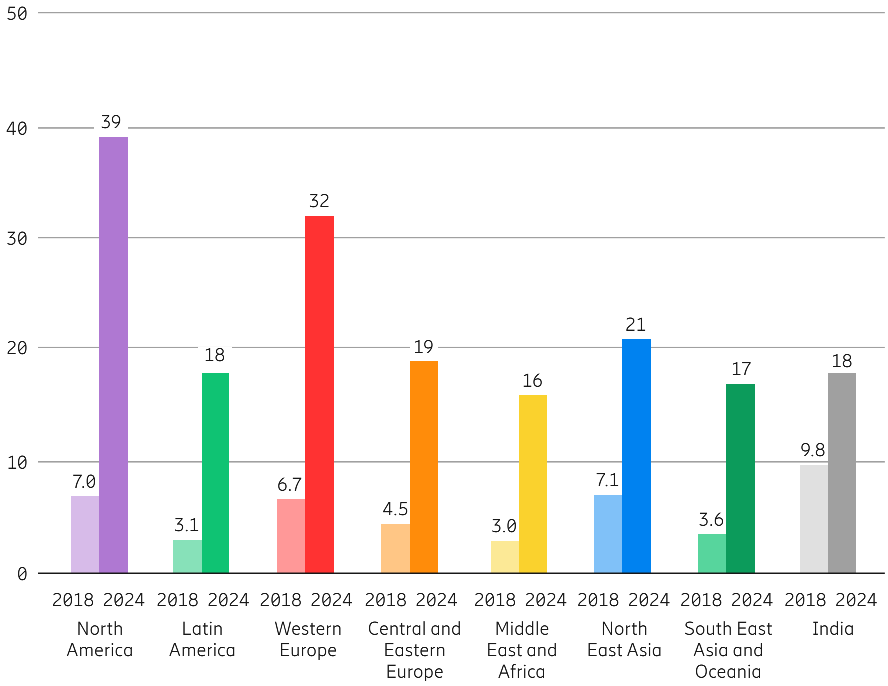
North East Asia is the world's most populous region and, as such, has the largest share of global mobile data traffic. In 2024, total mobile data traffic in the region is estimated to reach 39EB per month, equaling 30 percent of the world total. The rapid growth in mobile broadband subscriptions is expected to continue, with China alone set to add around 190 million mobile broadband subscriptions between 2018 and 2024. This growth, together with increased usage per smartphone, will drive total mobile data traffic up to 30EB per month in China.

The Middle East and Africa region is expected to have the highest growth rate during the forecast period, growing total mobile data traffic by eight times between 2018 and 2024. Smartphone subscriptions are projected to almost double, increasing penetration from 46 to 63 percent of all mobile subscriptions. In 2024, total monthly mobile data traffic is expected to reach 15EB in the region.

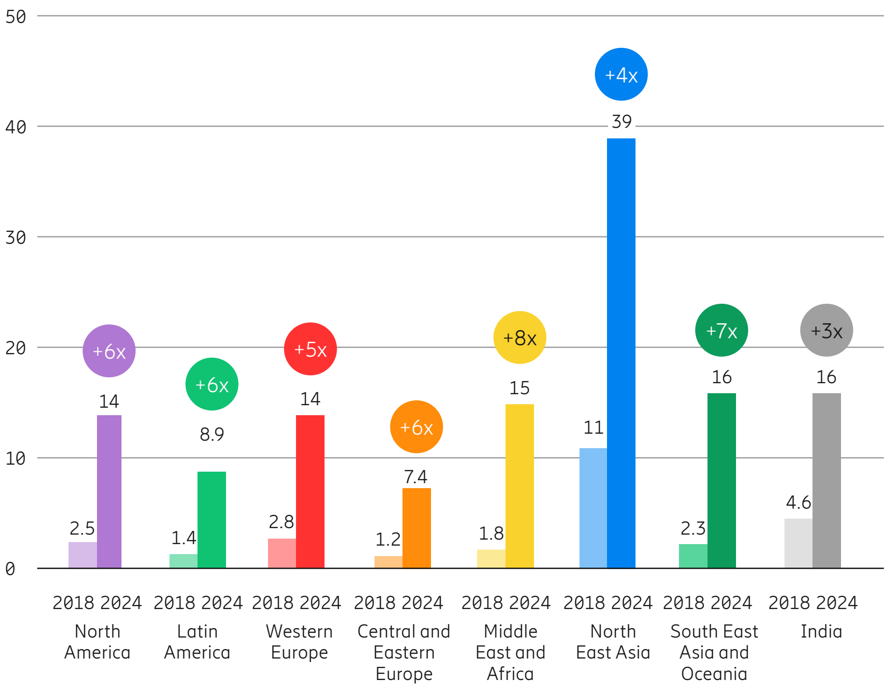
In Latin America, traffic is predicted to increase by a factor of 6 between 2018 and 2024, taking it to 8.9EB per month. The traffic growth is driven by broader coverage and adoption of LTE within the region, linked with a 16 percent rise in smartphone subscriptions and increases in average data usage per smartphone from 3.1GB to 18GB per month.

In Central and Eastern Europe, traffic is predicted to grow by a factor of 6 from 1.2EB to 7.4EB per month during the forecast period. This growth is fueled by the migration from 3G to 4G, coupled with a 46 percent growth in the number of smartphone subscriptions. Over the forecast period, the monthly traffic per smartphone is expected to increase from 4.5GB to 19GB.

Mobile data traffic per smartphone (GB per month)



Regional mobile data traffic (EB per month)



North America and Western Europe have a larger share of the total traffic volume than subscription numbers imply. This is due to well built-out LTE networks and high penetration of high-end user devices, complemented with affordable packages offering large volumes of data. The increased consumption of data-intensive services, such as video, and new applications, including virtual reality and augmented reality, are expected to become more prevalent with the introduction of 5G during the forecast period. With this, mobile data traffic is expected to reach 14EB per month in North America as well as in Western Europe by 2024.

Network coverage

5G can cover up to 65 percent of the world's population in 2024.

There is continued momentum in the build-out of LTE networks. In terms of population coverage, LTE increased by some 10 percent during 2018, creating the potential for around 750 million more people to utilize the technology. The largest share of this increase came in India, which now has around 90 percent population coverage. Global LTE population coverage was around 75 percent at the end of 2018 and is forecast to reach around 90 percent in 2024.

LTE networks are also evolving to deliver increased network capacity and faster data speeds. There are currently 720 commercial LTE networks deployed. Of these, 286 have been upgraded to LTE-Advanced, and 32 gigabit LTE networks have been commercially launched.

Initial 5G deployments during 2018

5G deployments are gaining momentum worldwide. During 2018, a few 5G launches took place, mainly in North America.

In North America and North East Asia significant 5G subscription volumes are expected early.

Technology advancements enabling a rapid 5G population coverage build-out

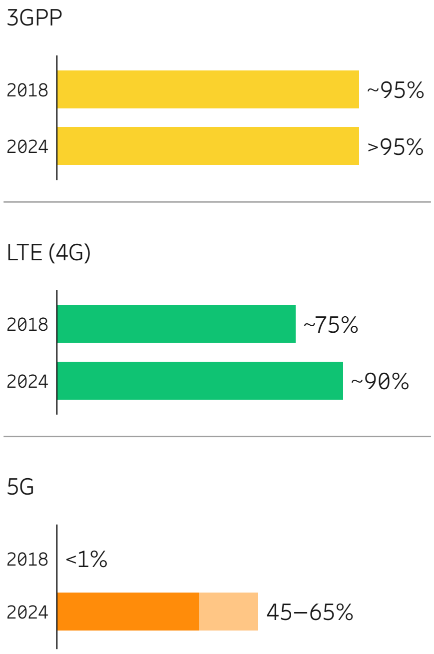
5G coverage build-out can be divided into three broad categories[1]:

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

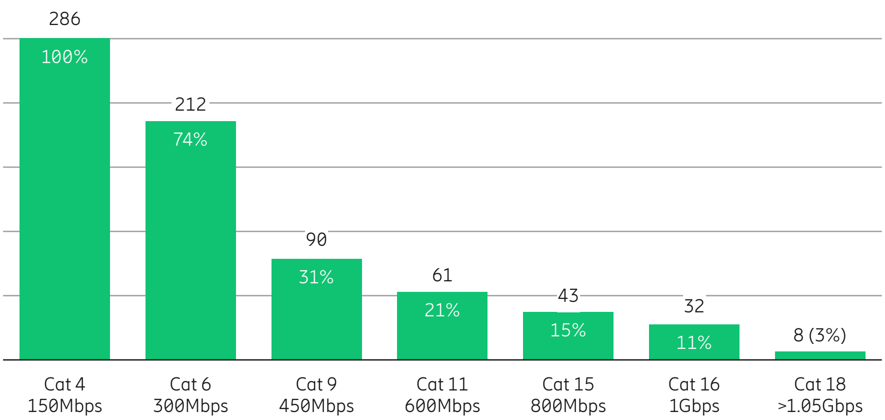
Looking at the first two categories combined, 5G population coverage is forecast to reach 45 percent in 2024.

For the third category, technology advancements have made it possible to perform rapid upgrades to support 5G services in many networks by installing new software; for example, spectrum sharing between LTE and 5G in low- to mid-bands. Given this possibility, an additional 20 percentage points 5G population coverage is achievable, creating a potential of up to 65 percent in 2024.

World population coverage by technology[2]



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



Source: Ericsson and GSA (May 2019)

[1] The coverage area for the three categories may overlap in some areas but the calculated numbers refer to the combined coverage area predicted
[2] 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

Private networks

The need for Land Mobile Radio (LMR) modernization, together with industry digitalization, are driving the market.

The continuous investments and improvements in cellular technology on a global scale are making it compelling for governments and industries to explore its use for private networks. In parallel, communications service providers are looking for new revenue streams and have identified governments and industries as addressable market segments.

The two main drivers for growth in the private networks market are:

- The need for modernization of LMR systems. These lack broadband capabilities, offer limited value for money and major deployments are nearing end of life. These conditions are driving investments, especially in public safety, utilities, public venues (e.g. airports, ports) and natural resource segments (oil and gas, mining).
- Industry digitalization (including Industry 4.0 initiatives). This is driven by new use cases that generate strong productivity improvements and/or operational efficiencies, and are the main drivers within logistics/supply and manufacturing segments among others.

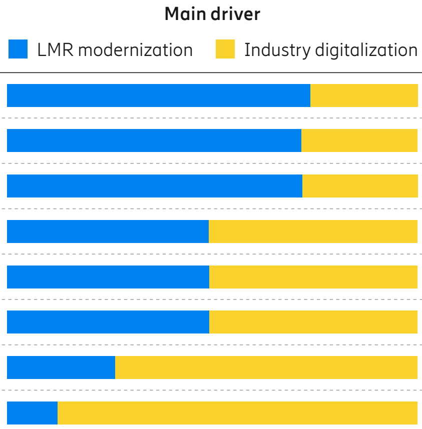
In the table below, the industry segments are listed together with key characteristics of each segment. As depicted, the public safety segment[1] is mainly driven by LMR modernization needs. These systems tend to be very large and, for example over the next few years, focused on a handful of nationwide opportunities, with more planned beyond that. For the manufacturing segment, it is the opposite. In these cases, potential deployments tend to be relatively small in terms of the number of radio sites. However, the potential value is expected to be significant over the long term, with the number of deployments driven by Industry 4.0 and digitalization.

Today, the adoption of cellular technology varies across market segments. However, these segments all have similar needs, with up to 90 percent of network connectivity requirements in common. This makes cellular technologies attractive and is a key reason why LTE/5G is already the chosen technology for many industry segments. Others are still evaluating alternatives (fixed, Wi-Fi or LTE/5G).

A key challenge for these deployments is how to access suitable spectrum when using cellular technologies for private networks. There are three main alternatives: via service providers, direct allocation by regulators to industries, or by using shared licensed spectrum with local allocation.[2] Which option is best will depend on the conditions in each market.

The mobile broadband communication needs of industries and governments, where network connectivity requirements are common throughout, are set to lead to more private network deployments over the coming years. The early adopters in this market, including major public safety and utility organizations, have chosen 3GPP LTE (and by inference 5G), and are now in the process of implementing these solutions globally. Many more industries are expected to follow shortly, all of which will drive the wider market adoption of 3GPP cellular technologies.

Industry segments evaluating private LTE/5G networks

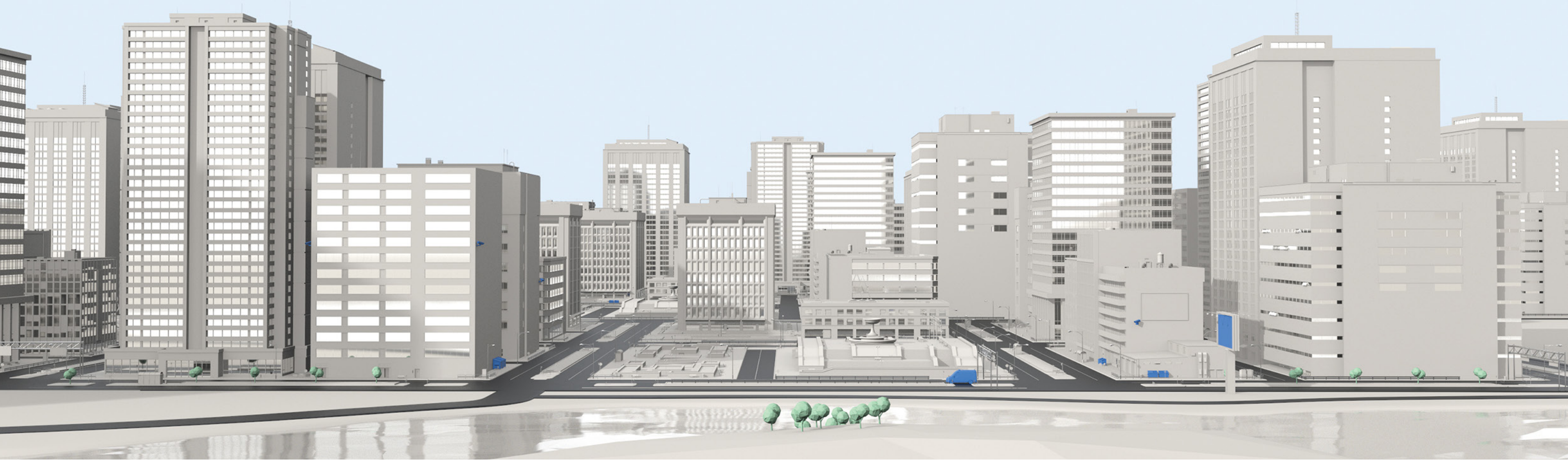


Private network industry segment	Main driver	Typical size of network (coverage area)	Number of networks delivered in 2023
Public safety		Very large	Low
Utilities		Large	Medium
Oil and gas		Medium	Medium
Rail		Large	Medium
Mining		Medium	Medium
Public/enterprise venues		Small	High
Logistics and supply, warehousing		Small	High
Manufacturing		Small	High

[1] Public safety is the main segment within the public protection and disaster relief area
[2] For example, Citizens Broadband Radio Service (CBRS), 3550MHz to 3700MHz on the 3.5GHz band, will be available with a three-tiered sharing model for wireless carriers and enterprises in the US

Network evolution strategies towards 5G

Evolving networks today will ensure a smooth 5G switch-on tomorrow.



Among the world's capital cities, Moscow ranks highly for digital development, according to various research institute reports. The 2018 United Nations E-Government Survey ranked Moscow highest among the world's capital cities regarding digital technology development[1] in electronic governance.[2] It was also ranked second in Europe for its number of transportation, health and personal services apps, and among the top five cities in the world prepared to introduce digital technology of the future. Although digital maturity varies across different geographical locations in Russia, these rankings indicate strong customer demand for digital services where there is network support.

In conjunction with vendors and regulators, communications service providers in Russia have ensured mobile networks are built-out and modernized to support this development. Around 75 percent of the Russian population over 16 years old uses the internet (90 million), with a growing mobile internet penetration that reached 61 percent in early 2019.[3] It is a highly competitive market, in which mobile service price levels are among the lowest in the world, with monthly average revenue per user (ARPU) at USD 4.8 in 2018. In this market environment, MTS (Russia) is embracing new revenue opportunities through active development of its portfolio of digital services for existing and new customer segments. A key strategic priority to enable MTS to reach this goal is evolution of its existing 4G mobile network and investment in new technology within areas such as 5G, IoT, Cloud, big data, automation and artificial intelligence.

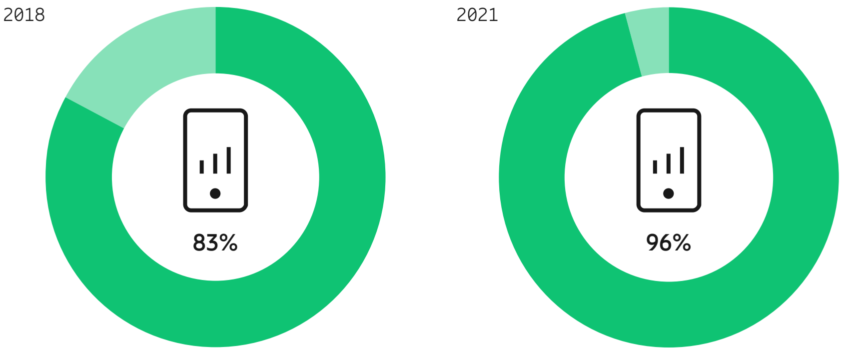
Service providers need to ensure their 4G networks continually evolve to cope with growing mobile traffic demands, and to continue addressing and monetizing existing use cases, while preparing for the future by having an evolutionary path to 5G in place today. It is important to both meet short-term business objectives and have a longer-term strategic direction planned.

This article was written in cooperation with MTS, a market-leading telecommunications group, providing a range of mobile and fixed-line communications-based services in Russia and the Commonwealth of Independent States (CIS).

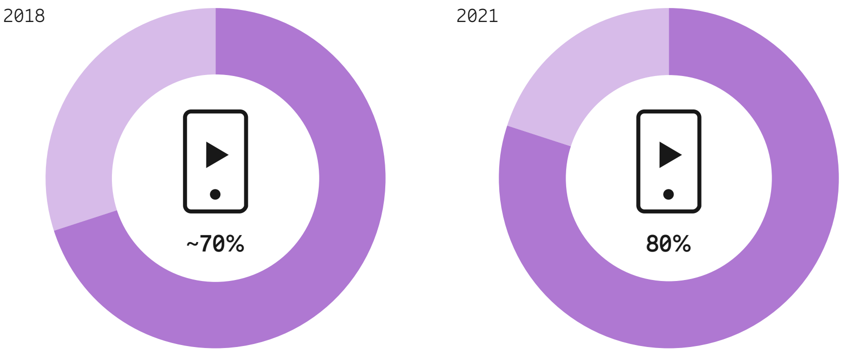
[1] https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2018-Survey/E-Government%20Survey%202018_FINAL%20for%20web.pdf
[2] Electronic governance or e-governance is the application of information and communication technology (ICT) for delivering government services
[3] Mobile subscription penetration in Russia is higher than 100 percent due to use of multiple SIM cards

MTS (Russia) – indicators of traffic growth

4G smartphone penetration among MTS data users



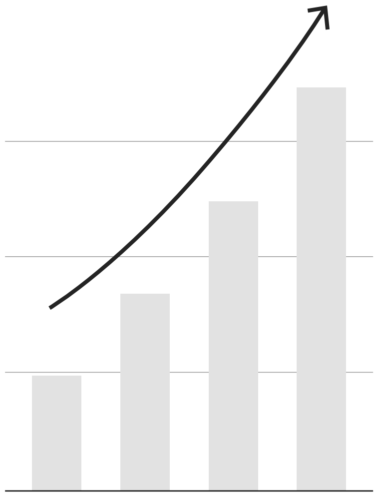
Video traffic share



3.5x

Mobile data traffic is predicted to increase by up to 3.5 times from 2018 to 2021.

Mobile data traffic growth



Managing strong traffic growth
Mobile data traffic growth in MTS networks has been strong since the introduction of 4G. This is related to increased penetration of 4G subscribers, improved device capabilities and an increase in subscriber consumption of data-intensive content. By late 2018, 4G smartphone penetration among MTS data users had reached 83 percent, and is forecast to reach 96 percent in 2021. In the same period, traffic in MTS networks is expected to grow by a factor of 3–3.5 times according to the most conservative estimates.

Content is increasingly data-intensive. For example, the size of a standard web page has significantly increased in the last five years. Today, an ordinary web page among the number of top-100 visited pages by MTS subscribers can be up to 15MB in size, which is comparable to a small video clip. Five years ago, the average size was only 1.6MB.

For a typical MTS subscriber, video accounts for nearly 70 percent of all traffic, and this is expected to rise to about 80 percent by 2021. The use of 2K and 4K video content is gaining momentum, which requires higher network throughput and capacity. Average data consumption per subscriber has grown by a factor of 7 during the last 3 years, with data consumption by 4G subscribers 3.5 times higher than for 3G subscribers.

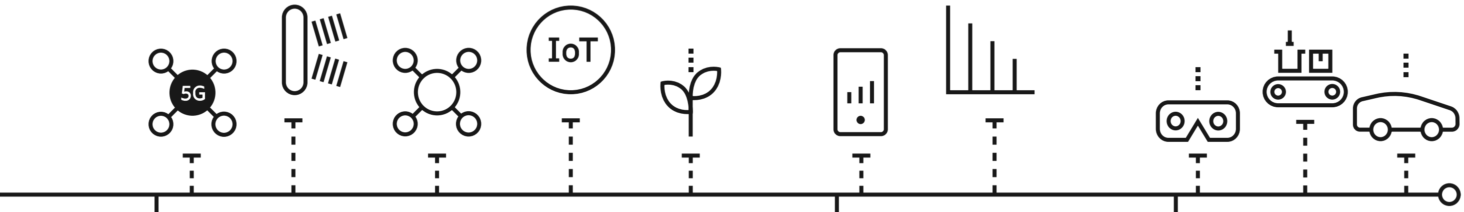
Total mobile data traffic in the MTS network has increased fivefold during the last 3 years, whereas 4G traffic has increased by 12 times.

Handling growth in video consumption depends on the capacity and performance of the mobile network. For MTS, ensuring the network evolves to cope with increasing data consumption is vital, and addressing this is considered a priority.

Strategies for network evolution to 5G
MTS is modernizing its network and is currently engaging with vendors on testing 5G technology. 5G-ready base stations, which can be switched on with 5G software, have already been deployed in many areas. However, deployment of 5G networks is not only dependent on the preparedness of the operator. There are also external factors that affect deployments, including regulatory decisions on frequency allocations, availability of devices, and preparedness of network equipment vendors. Based on the current situation, the most probable time for launching the first 5G commercial networks in Russia is 2020.

Preparation for introduction of 5G technology includes modernization of the existing mobile network infrastructure for radio, core and transport networks. Today, MTS is deploying 5G-ready, multi-standard base stations for seamless activation of 5G in the future. This includes the use of spectrum sharing which enables deployment of 5G in the same spectrum as 4G. There is also utilization of higher-order MIMO (4x4/8x8) in the higher frequency bands. Massive MIMO is deployed in traffic-congested areas to increase network capacity and provide higher data throughput. To increase capacity, available frequency resources for LTE can also be expanded with Licensed Assisted Access (LAA) functionality, for use of spectrum in the 5GHz band.

Examples of MTS network evolution-related deployments 2019–2021/22



2019

- The first pre-commercial 5G NR pilot
- Commercial gigabit LTE networks, with functionalities such as Massive MIMO and LAA, achieving peak data rates close to 1 gigabit per second (Gbps)
- A private network solution based on LTE, mission-critical Push-To-Talk (PTT), Enterprise LTE Core and associated services
- Further development of IoT use cases for industry, agriculture, city infrastructure and utilities

2020

- 5G networks for enhanced mobile broadband use cases in Russian regions
- Further LTE evolution of network technology for low latency and Short TTI

2021/22

- Realize commercial products based on virtual reality (VR)
- Private LTE within industry sectors for smart manufacturing
- Create a test zone for autonomous transport

Introducing new technologies

MTS is planning to test and introduce technologies such as URLLC-Short Transmission Time Interval (TTI), mobile edge computing, and network slicing[4] in the existing LTE network. Parallel modernization of the transport network with XGS-PON and TWDM-PON and multi-level hierarchic architecture will enable the substantial lowering of latency for latency-critical applications, and will bring the LTE network closer to the future 5G network.

In the next three years, introduction of 5G New Radio (NR) will be done on the basis of a modernized LTE network by use of non-Standalone (NSA) architecture, facilitating a smooth evolution from LTE to 5G. This is more efficient, as it provides the benefits of using LTE equipment as an anchoring point. Network evolution directly based on Standalone (SA) deployment would require significantly more investment to deploy for coverage, as it lacks functionality such as downlink/uplink decoupling and dual connectivity that can leverage the LTE network to efficiently increase coverage, as is the case in NSA deployment. However, for some projects, like important high-profile use cases for verticals, business-to-business (B2B) and business-to-government (B2G), SA 5G deployments may be an option.

A strategic plan for an evolutionary path to 5G

MTS has created a strategic plan for 4G/5G deployments during the period 2019 to 2022. During 2019, MTS will deploy 5G networks in pilot areas and commercial clusters as well as build out a nationwide LTE-Advanced network, by using re-farmed spectrum. Furthermore, MTS will deploy "gigabit LTE zones" in city, industrial and business clusters with high data usage and demand for new digital services. MTS estimates that, after modernization, its LTE network will have similarities to a 5G network, reaching peak speeds of about 1 gigabit per second (Gbps), with lower latency in the radio access network as well as providing extensive IoT network coverage. The graph illustrates examples of deployments and use cases in the strategic plan, but their realization depends upon 5G spectrum allocation by Russian regulators.

Innovation strategy for development of new digital services

5G is an enabler for existing business growth as well as a platform for business innovation. MTS has a threefold innovation strategy for bringing new services to the market:

- Fostering own innovation efforts by establishing an IoT laboratory and acting as an innovation incubator through the MTS start-up hub, supporting teams with mentoring, training and expert support to prepare a product idea for pilot
- Investing in innovation through mergers and acquisitions (purchasing assets or solutions)
- Innovating in conjunction with partners

Initially, commercial use cases will be for enhanced mobile broadband, with services based on technology such as 360-degree video, UHD TV, VR/AR, holographic services, cloud gaming, and fixed wireless access (FWA).

Further development of new services will be on a case-by-case basis for vertical industries, enterprises and governments, based on customer demand as well as possibilities for equipment to realize them at a specific time. Business models will also be developed case-by-case, and in many instances mainly as integrated go-to-market models in terms of turnkey projects. Other promising, but more difficult, use cases such as complete solutions for Cellular Vehicle-to-Everything (C-V2X)[5], will probably be realized in about five years' time.

[4] Division of the network into virtual layers to ensure end-to-end quality of service

[5] Vehicles can communicate with each other and everything around them, such as providing 360-degree non-line-of-sight awareness and a higher level of predictability for enhanced road safety and autonomous driving

Experiences from smart fixed wireless access deployment

Fixed wireless access (FWA) service deployment in a 4G (LTE) network can pave the way for a successful 5G FWA market introduction.

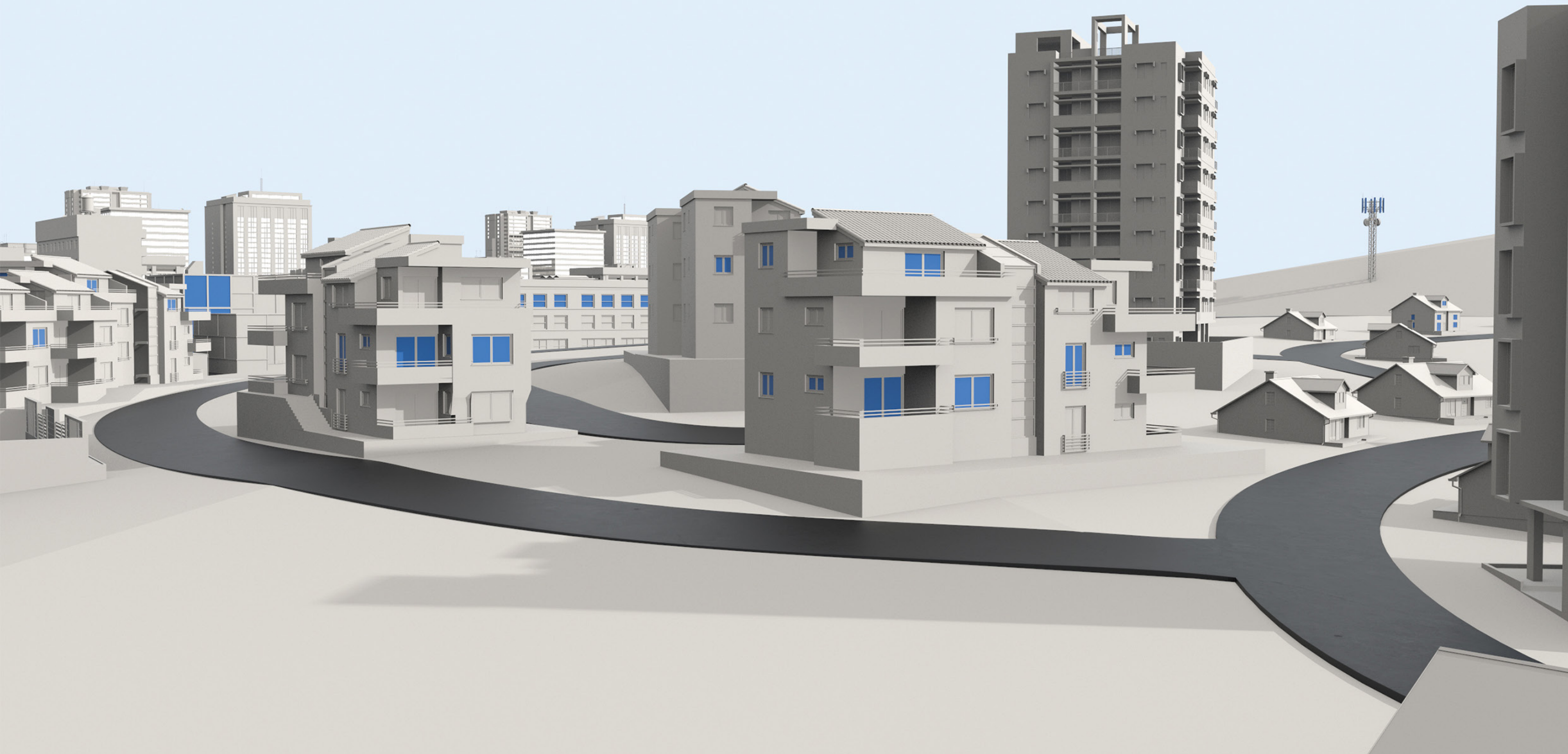
Based on LTE technology – currently capable of providing downlink peak rates of over 1 gigabit per second – FWA offerings have been on the market for several years, from many communications service providers worldwide. With 5G due to provide 10 to 100 times more capacity and higher data throughput rates than 4G, it has the potential to enable cost-efficient FWA solutions on an even larger scale. 4G and 5G FWA solutions are complementary, and can be used to address requirements of different customer segments.

In conjunction with the country's centennial in 2023, the government of the Republic of Turkey has a strategy to ensure the availability of broadband access of at least 100Mbit/s to every home and workplace. Wireless broadband is a key alternative to fixed broadband to help achieve this goal. As its broad holding of Frequency Division Duplex (FDD) spectrum enables Turkcell to deliver both high throughput and capacity through its mobile network, it is in a strong position to support this strategy by its implementation of FWA.

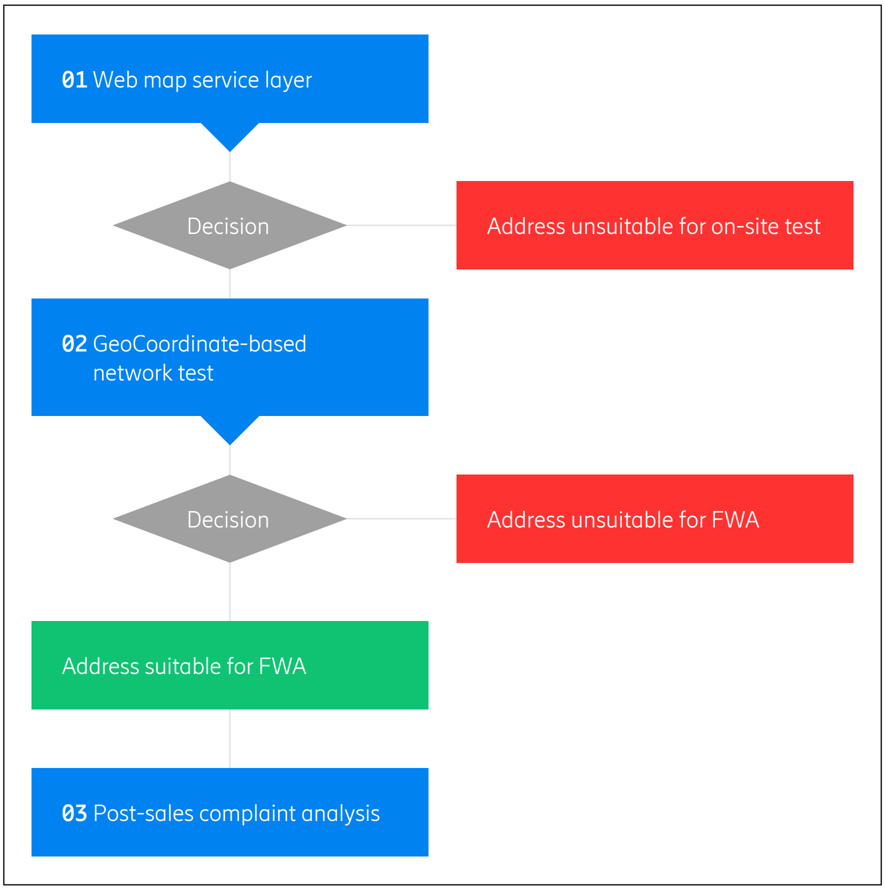
Turkcell launched the 4G FWA service Superbox in August 2017 to offer a premium service using Cat-11, 4x4 MIMO-capable Customer Premises Equipment (CPE). Superbox is a cost-efficient, converged home broadband service aimed at customers who have no access to fiber-based fixed broadband or who are dissatisfied with the performance of their copper-based ADSL connection.

Turkcell recently launched another 4G service, based on a Cat-6 CPE implementation, Superbox EKO (economic), to reach a wider range of users and facilitate mass deployment. Positive experiences for 4G FWA subscribers should create a foundation for introducing customers to 5G FWA. Due to the higher capacity offered by the wide spectrum bandwidth of 5G, it is also an opportunity to offer 5G FWA solutions in locations where household density is high.

This article was written in cooperation with Turkcell, a market-leading converged telecommunications and technology service provider, offering a portfolio of digital services on its mobile and fixed broadband networks in Turkey.



Location-based predictive analysis



>2x

Average revenue per user (ARPU) of the FWA service is more than twice that of mobile broadband.

Targeting the right market segments

FWA delivered over a 4G or 5G network is a cost-efficient alternative to providing broadband in areas with limited access to fixed broadband services such as DSL, cable or fiber. Turkcell has an LTE-Advanced network with more than 90 percent population coverage and considerable capacity available in the radio network, with a total of 2 x 64.8MHz FDD spectrum bandwidth in 3 bands (800, 1800 and 2600MHz). These assets have been utilized to offer the 4G FWA service Superbox.

The business case for Superbox is underpinned by the ability to make use of available network capacity, by increasing utilization at locations with spare capacity. Since the customer expectation of FWA services is similar to that of fixed broadband, it is essential to ensure network performance meets the defined FWA quality of service levels. To date, more than 60,000 customers have subscribed to Superbox. Based on Turkcell's marketing strategy, the service was initially selectively aimed at the premium customer market segment. However, high demand from additional customer segments has resulted in new customer acquisition averaging 8,000 subscribers per month.

There is a range of service packages with different monthly data plans available: 50GB, 100GB, 200GB and unlimited. Average data consumption for subscribers is currently 100GB/month. The average revenue per user (ARPU) of the service is more than two times that of mobile broadband.

Location-based predictive analysis to ensure quality of service

To meet coverage and capacity requirements, Turkcell developed a location-based predictive analysis tool, consisting of three network-aware digital services (see diagram above). These are:

1. A web map service layer, depicting suitable and unsuitable areas implemented in the Turkcell location intelligence platform to manage marketing and sales activities. The selection algorithm is based on an analytical hierarchy process (AHP) model using some network and sales key performance indicators (KPI) as input parameters.
2. A mobile application developed by Turkcell for use by technical staff to measure the service suitability at a given address. The application is also integrated with the customer relationship management (CRM) platform for sales approval. The results are reported to the sales team as suitable or unsuitable for FWA sales.
3. A location-based web service integrated with the CRM platform to analyze customer complaints relating to temporary coverage loss or capacity problems, in order to respond to the customer automatically.

The tool helps to determine availability of FWA service for any given address, whether in an urban, suburban or rural area, by using network coverage and utilization data. The main goals are to maximize customer satisfaction and eliminate complaints, thereby increasing sales and reducing deployment costs. It is an end-to-end solution which relies upon location-based analytics of network data, as well as radio site measurements performed over a mobile application.

The sales process starts by recording and geocoding the address given by the prospective FWA customer. The address coordinates are used to calculate coverage and capacity of the 4G network, in order to evaluate the type of FWA package that can be offered to the address.

Results achieved using the analytical tools when deploying FWA services have been highly satisfactory. Service availability data based upon coverage and capacity figures from serving LTE cells has mostly been in alignment with measured results from the mobile application, resulting in a deployment success rate of 98 percent. Furthermore, a very low customer complaints rate (0.7 percent) has been achieved.

The process has also resulted in reduced operating costs. The average cost for each site visit is EUR 13, and there is an estimated opex saving for next year of EUR 1.95m due to fewer projected visits. Due to the success of the mobile application, it is planned to implement a customer version of the on-site measurements (mobile application test step) to further save the cost of address visits.

The predictive analysis tool is flexible and customizable to adapt to the requirements of different services, and current criteria sets are configurable to cover changing needs. It can also be used to analyze new technologies such as 5G and IoT. This kind of location-based service deployment and management will be necessary to use resources efficiently and get the most return from 5G investments.

Analysis of the network with intelligent algorithms has significant benefits in sales success, customer satisfaction rate and opex savings and plays a key role in the success of the service's deployment.

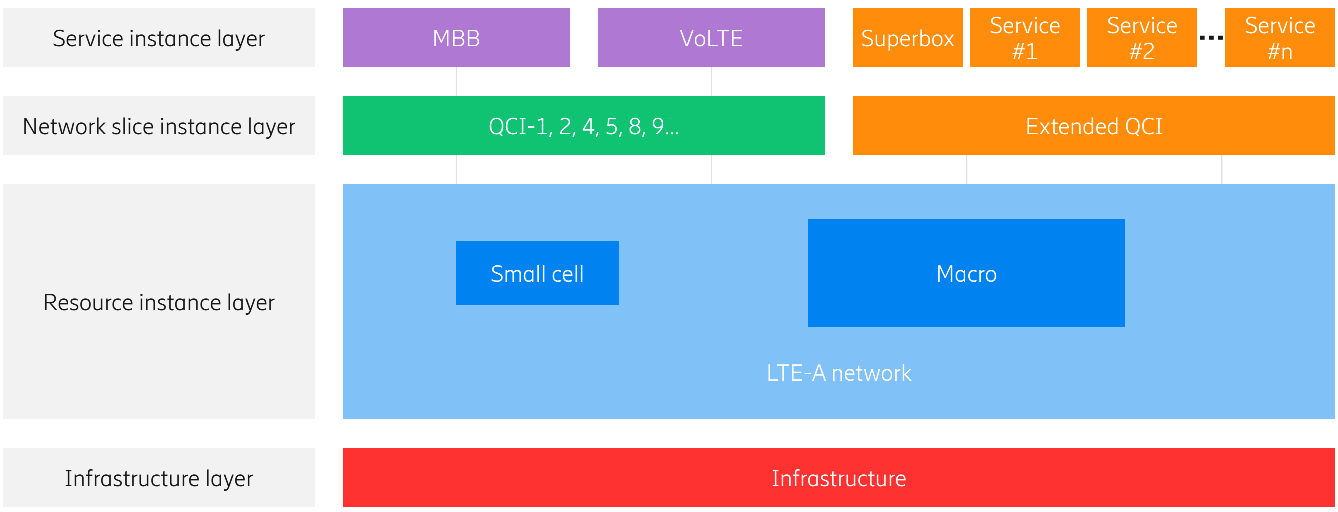
KPI management and service assurance

To ensure successful deployments and the quality of the end-to-end service, some additional integrations have been made:

- Separate quality of service class identifier (QCI) parameter definition. Although a QCI is used to determine the quality thresholds of services, a separate QCI is defined for FWA services in radio and core networks to differentiate the FWA traffic from other data traffic, so that all key performance indicators (KPIs) and statistics for FWA subscribers can be tracked separately. It can be considered a first step towards network slicing, which will be common in 5G.
- KPI collecting-management protocol (TR-069 and variants) is integrated to monitor and remotely control the CPE, e.g. auto-configuration, service provisioning and software upgrade.
- A SIM-CPE matching functionality is activated to prevent inappropriate usage of the SIM with other mobile devices.

In conclusion, FWA enhances the return on investments from the 4G network while playing an important role as a forerunner to the upcoming 5G FWA service. It is an opportunity to provide a high-quality FWA service before the arrival of 5G, which becomes integral to the lifestyles of subscribers. Given the success of the current FWA service coupled with applications for customer self-provisioning and KPI management, Turkcell is now both taking steps to broaden its 4G offering and planning for a 5G FWA roll-out.

Extended quality of service class identifiers (QCIs) defined for Turkcell Superbox services



Source: Turkcell (2019)

Superior media experiences by broadcasting content

A mobile radio network can switch on a broadcast service, enabling new use cases and improving both user experience and network efficiency.

An ongoing challenge for communications service providers around the world is managing the growing demand for video and other types of data while maintaining high-quality customer experience, particularly for live content streaming. LTE Broadcast (LTE-B), based on the Evolved Multimedia Broadcast Multicast Services (eMBMS)[1] standard, is a key part of the solution implemented by Telstra – a market-leading communications service provider in Australia – to address this challenge.

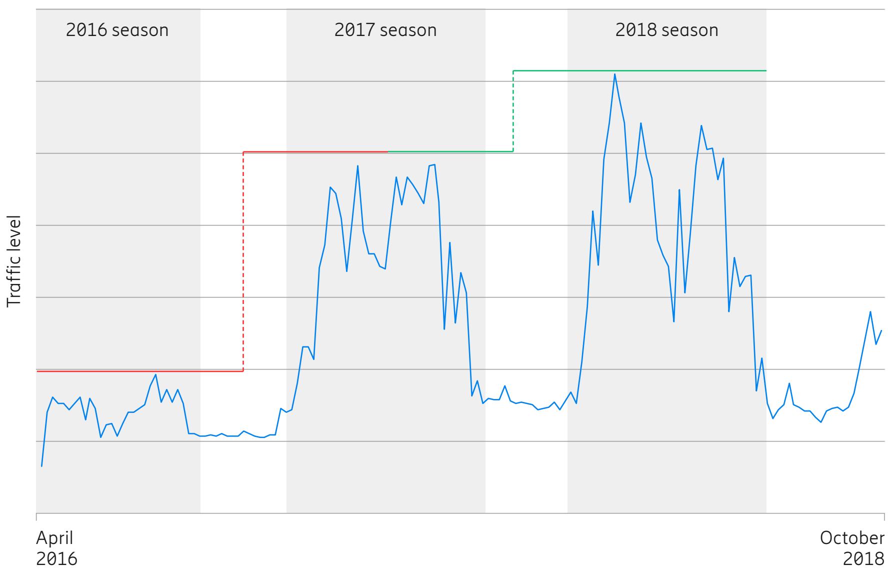
More content delivered, less network strain
Telstra's first commercial product offering based on LTE-B was launched in 2018. A year on, Telstra has quantified the network efficiency benefits of this technology. As the technology reaches widespread adoption and a compatible device ecosystem develops, use cases can be expected to multiply, further enhancing end-user experience.

LTE-B is a cost-efficient mechanism for delivering large amounts of data while increasing network efficiency and improving customer experience. Previously, when a large group of subscribers in one area wanted to watch the same content on their smartphones or tablets simultaneously, individual streams of data were sent to each individual device (i.e. one-to-one). With LTE-B, content is sent via a single stream of data to many mobile users in one area (i.e. one-to-many), making content scheduling and delivery more efficient. The same mechanism could also be used for broadcasting a software update, traffic information or emergency alerts to a large group of users in a specific geographic area.

This article was written in cooperation with Telstra, a market-leading telecommunications and technology company in Australia offering a full range of communications services.

Streaming live sports events
One of the early use cases for LTE-B that Telstra identified was streaming live sports, a popular online activity in Australia. LTE-B technology was switched on nationally across the Telstra network on July 11, 2018 as part of an end-to-end service streaming live Australian Football League (AFL) games. Telstra offers the AFL Live Official app for free (unmetered content) to its existing mobile subscriber base, but it is also available to others for a monthly subscription fee.

Weekly live sport traffic level via the AFL Live Official app



2.5x
Seasons 2016–2017 saw a 2.5 times increase in AFL Live official app traffic.

1.25x
Seasons 2017–2018 saw an additional 1.25 times increase in AFL Live official app traffic.

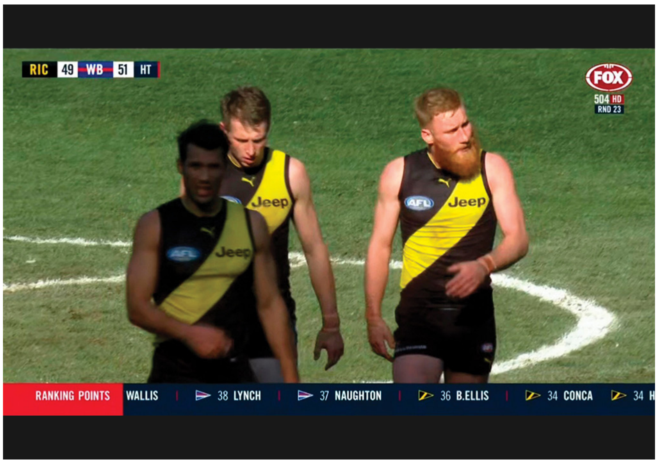
[1] eMBMS is a point-to-multipoint interface specification for 3GPP cellular networks, which is designed to provide efficient delivery of broadcast and multicast services, delivered through an LTE network. It is also known as LTE Broadcast

Difference in video quality between unicast and multicast content streams

Unicast without LTE-B (576p SD)

Non-LTE-B users had an inconsistent viewing experience with fluctuations in video quality

Multicast via LTE-B (720p HD)



LTE-B users experienced the highest resolution (HD quality) delivered as a sustained stream

25%

LTE-B users watched a stream more than 25 percent longer than viewers watching the same content on a non LTE-B enabled device.

Increase in real-time game streaming
During the 2018 AFL season, Telstra observed a 58 percent increase overall in customers streaming games in real time and, in some instances, more than twice the number of streaming customers when compared to the same match the previous year.

Weekend traffic generated by the AFL Live Official app across Telstra's network has more than tripled since 2016. The combination of AFL, rugby and netball streaming since the 2018 season launch means Telstra is now seeing mobile network traffic peaks each weekend which regularly exceed traffic seen on weekdays. However, while sports traffic has been steadily growing on Telstra's mobile network (see graph, left), customer experience on the Telstra network has not been adversely impacted and in some cases it has even improved.

LTE-B brings network efficiencies
For Telstra, LTE-B has been an important solution to meet the ever-growing demand for mobile video while improving network efficiency and, importantly, boosting customer experience by delivering smoother streaming. Video streaming is transforming entertainment consumption, including sports viewing. LTE-B improves the video and audio experience for customers watching live content. Accessing key moments in a match and "snacking" on games are key usage trends on mobile applications, and ensuring the highest quality experience for this content consumption is important.

LTE-B kicks in once a predetermined traffic threshold is reached. This is achieved using a feature called MBMS-operation-on-Demand (MooD) which dynamically activates or deactivates LTE-B based on certain parameters, such as the number of devices in an area streaming the same video content or accessing the same data stream, and when traffic levels reach a designated threshold. In cells where LTE-B has been activated, Telstra has observed that around 12 percent of traffic is being carried via LTE-B to capable devices, which represents a tangible improvement in network efficiency as less capacity is used in the cell to carry this traffic. As more LTE-B-compatible devices join the network, it can be expected that efficiencies can be further improved within LTE-B-enabled cells.

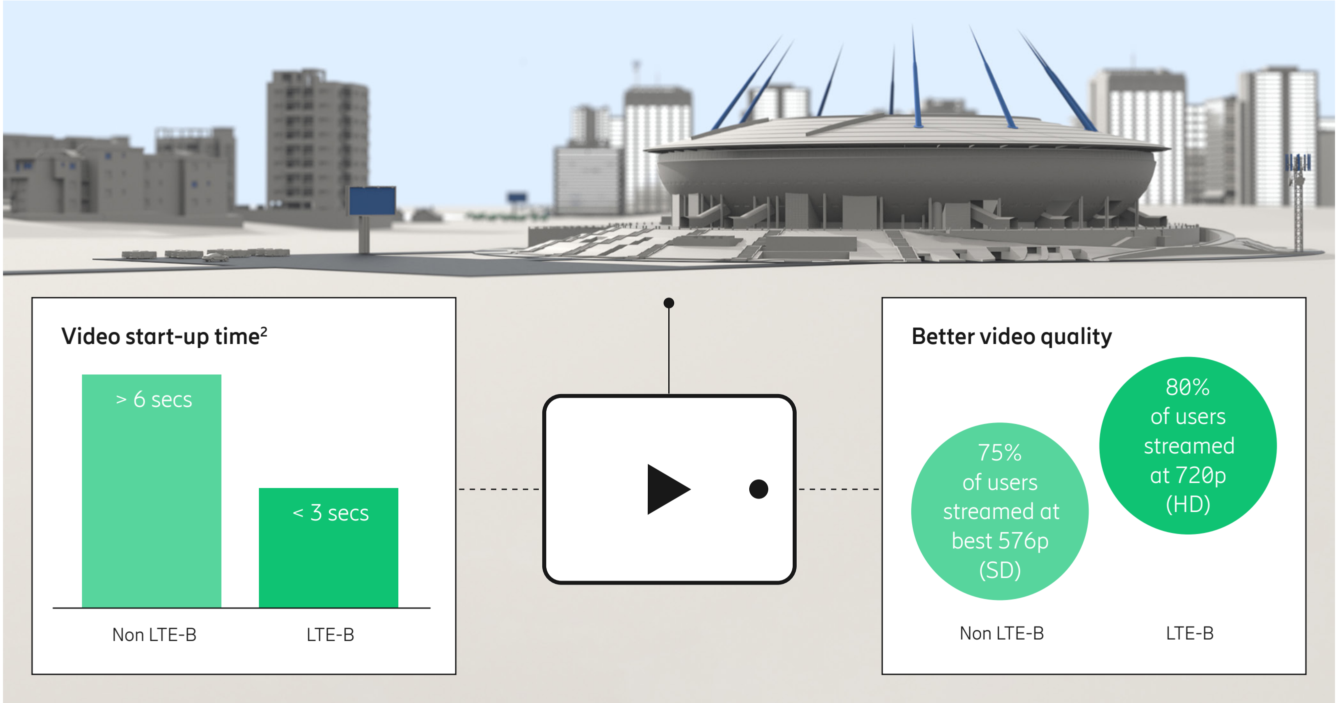
With LTE-B, the consumer experience is significantly enhanced and the operator receives cost benefits because they are not increasing capacity in their network to cater for one-off events. This technology offers myriad opportunities for broadcast app/software updates and major live, regional, and global sporting events, as well as in meeting growth in usage of live video broadcast apps.

Developing a device and application ecosystem
Live sports have been Telstra's foundational use case to accelerate the LTE-B ecosystem. In the first 3 months of the new service, Telstra broadcast more than 50 AFL games and related live events, resulting in 43,000 streams to broadcast users which equated to 4,700 hours of consumed video. After a successful introduction, it is expected several other services will follow.

In summary, LTE-B improves network efficiency in the radio access network (RAN), core and content delivery networks (CDNs), but it can also improve the coverage of high bitrate services, enhancing responsivity and reliability. It will also be an essential technology in the delivery of services in new use case areas, such as connected vehicles and mission critical services.

Support for broadcast with 5G New Radio (NR) and core is still to be defined from 3GPP Release 17 and onwards.

Comparative user video experience for non LTE-B and LTE-B users



Creating superior customer experiences
Currently, LTE-B is integrated into the Live Official app for AFL, the most widely streamed sport in Australia. Each weekend across the AFL season, Telstra streams live sports content to around 1.2 million devices, with fans consuming 37 million minutes of live content. LTE-B allows high-quality live content to be delivered, free from rebuffering and without degrading the network experience for other users. When it comes to bitrates, LTE-B users can stream with a guaranteed 720p (HD) resolution via HEVC[3] (H.265) at 1.5Mbps, while non LTE-B users can expect 576p (SD) resolutions in high-traffic situations. LTE-B users watched a stream more than 25 percent longer than viewers watching the same content on a non LTE-B enabled device, indicating that a good viewing experience can encourage increased viewing.

Meeting massive peaks in demand for live sporting content requires extensive end-to-end network design, continued network management and strategic investments. Telstra has invested in network capacity and continues to optimize its network to meet demand for video sporting content from subscribers of the AFL and other sporting apps. With an increasing number of people engaging in real-time sports consumption, the popularity of Telstra's sporting apps is a prime example of a viable LTE-B use case.

LTE-B is expected to develop and reach a truly global scale thanks to a growing ecosystem (including device support) and the increasing prevalence of broadcast content (sports, live video, software) over the mobile network.

Additionally, in developing countries, where there is a less established fixed infrastructure, LTE-B can enable large file downloads and software updates that otherwise might struggle to be efficiently delivered to end users.

Potential applications that would benefit from LTE-B include:
- evolved live sports experience: more camera angles, team statistics and telemetry information available to subscribers
- other sports events such as soccer and rugby
- delivery of software and app updates; available as an alternative for places with limited fixed broadband connectivity
- prepositioning (pre-downloads) of content for high-quality commute viewing and new media releases
- real-time traffic and navigation information for autonomous vehicles
- real-time emergency alerts
- mission-critical communications such as push-to-talk (PTT) services
- broadcast of emergency notifications, video and data to first responders

Essential to the success of LTE-B is the coordination of elements, including:
- Network evolution and coverage: the foundation for LTE-B must be a high-performing LTE network with extensive footprint
- Application development and enhancements: apps are central to the development of mobile ecosystems and represent the portal through which users consume content
- Device and middleware support: compatible devices are key to the development of the ecosystem. More devices in more frequency bands will pave the way for LTE-B global adoption
- Content rights: agreements with content providers on broadcast rights are a must to offer valuable content to users on LTE-B

[2] On average LTE-B users have < 3 secs video start-up time and 40 percent of non LTE-B users have > 6 secs video start-up time (high traffic scenario)
[3] High Efficiency Video Coding (HEVC), also known as H.265, is a video compression standard. HEVC has been an approved standard since 2013

Applying AI to mobile radio site management

A computer vision application using artificial intelligence (AI) techniques can improve radio tower inspections by detecting and diagnosing cabling problems.

Reducing tower climbs
Radio towers are crucial to communications service providers' radio access networks, as they elevate base station equipment connecting mobile devices to the network to improve cellular coverage.

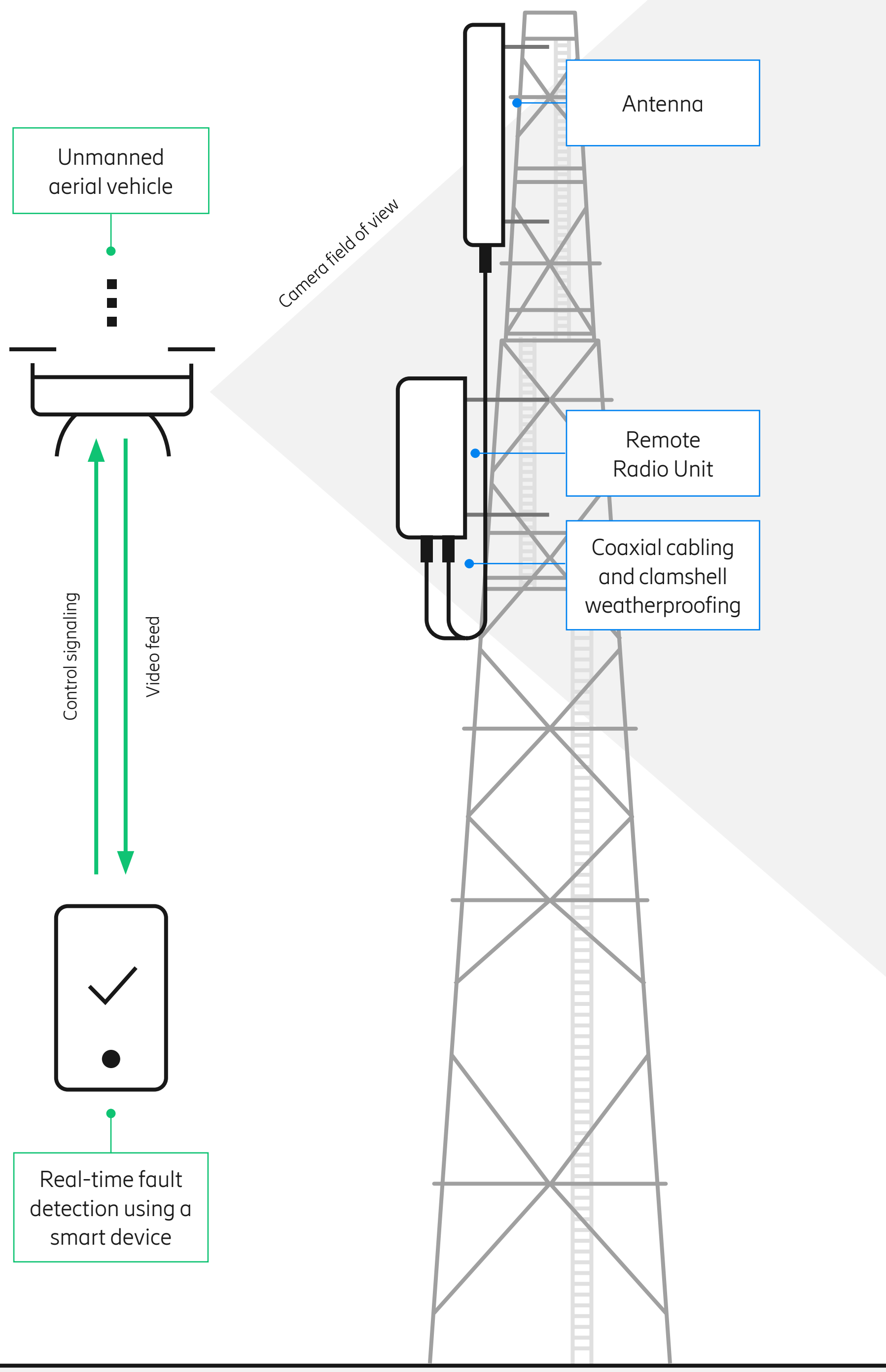
When a problem with radio performance was traced to a specific radio tower, a service technician typically climbed the tower first to assess the situation, and then again to rectify identified issues and/or to upgrade the equipment.

Recently, the use of drones, or unmanned aerial vehicles (UAVs), for tower inspections for installations and maintenance has rapidly gained favor, reducing the number of tower climbs needed. UAVs equipped with video cameras have been the core of an emerging inspection ecosystem which also includes post-processing elements such as photogrammetry (taking measurements from photographs and video images) and 3D imagery.

Ericsson Research is developing methods to enhance and improve video-based tower inspections using AI. The UAV streams video to the ground operator's mobile device, which then uses a computer vision application to process the video frames and detect issues with the radio tower installation in real time. The application can identify potential problems with coaxial feeder cable weatherproofing, color coding (to identify crossed cables) and cable bend radius measurements.

These issues can be diagnosed by utilizing the AI technique of deep learning – training a detector such as a convolutional neural network (CNN), with enough instances of "bad" versus "good" cabling installations to yield good detection results. However, unique characteristics of each case can require additional image-processing steps. In order to illustrate this, the case concerning cable weatherproofing is examined in detail overleaf.

Using AI with computer vision to enhance tower inspections



Remote detection of coaxial cable connections for faulty weatherproofing
A common maintenance task with coaxial feeder cables in radio tower installations is identifying faulty weatherproofing clamshells. Plastic clamshells (consisting of a hard-plastic casing with soft gel interior) protect coaxial feeder cables between a radio unit and an antenna from rain and humidity by forming a seal around both the cable and connector. When a plastic clamshell fails to seal properly, an exposed connector may eventually impact data traffic passing through the cable.

One approach for detecting "loose" clamshells with a video camera-equipped UAV is by analyzing video images using a neural network that addresses a dataset of "bad" examples (see image A opposite). The detector, in this case, is coded to recognize an object or "class" in machine learning (ML) terms.

An open-source CNN framework was used to configure a custom neural network as a detector to identify faulty clamshell installations. The detector was designed with very lean computational requirements, enabling it to be run on a technician's mobile device. The neural network consisted of eight convolutional layers performing feature recognition and six layers performing max-pooling operations for data consolidation.

Two practical issues affected the accuracy of this simple approach:
- First, the clamshell's distance from the connector is not fixed, as it may move down the cable or stay higher, depending on the installation and issue at hand.
- Second, the connector is reflective, which creates a number of difficulties for the detector. It reflects background colors which differ from tower to tower and it also has specular reflections. On a sunny day, an exposed connector will reflect light with higher intensity than when it is cloudy resulting in the detector not recognizing it.

One solution is to account for dataset variability by providing more training data. However, this would require an extensive data-acquisition phase, with hundreds of thousands of samples, combining clamshells in different positions with varying lighting conditions. Such data gathering is time-consuming and expensive. Instead, additional refinements can be explored using the existing dataset.

An approach to solve the problem of variable distances between clamshell and connector is to train the neural network for two classes instead of one: a class for the clamshell and another for the connector. The detector can then identify these classes and localize them on video frames by drawing bounding boxes around them. Some conclusions can then be made by comparing their relative locations. For example, if the bounding boxes are aligned horizontally but their distance on the vertical axis is greater than a defined margin, we could deduce that the weatherproofing came loose (see image B opposite).

There is still the problem of properly detecting the connector due to its reflective metal surface. A solution was to pre-process some of the dataset, replacing specular reflections with gray as a placeholder. The same substitution was subsequently used on the UAV's video frames, before executing the detector. In this way, the detector could match the connector on the video frame to the connectors it was trained with (see image C opposite).

Artificial intelligence (AI)
AI involves research into mimicking human cognition by developing algorithms for learning and reasoning. AI has existed since the beginning of digital computing, and has spawned an increasing number of sub-fields dedicated to developing techniques applicable to real-world problems in science and business.

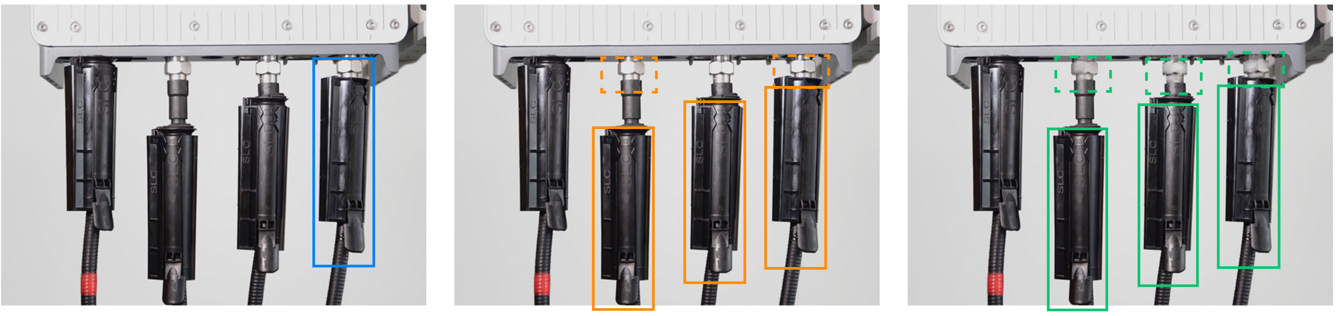
Machine learning (ML)
ML is a major field within AI, involved in applying various methods of classification to large data sets and training models to recognize patterns. Uses include aiding computer vision applications.

Deep learning
Deep learning is a class of ML algorithms that use multiple layers of processing to extract patterns or features from data sets. Each layer uses output from the previous layer as input.

Convolutional neural networks (CNNs)
A powerful deep learning method is to employ a CNN as a detector in a computer vision task such as object recognition. Over the last decade, research into CNNs and fast implementations of CNN frameworks on high-performance graphics processing units (GPUs) have dramatically improved computer vision applications.

Using video to identify faulty weatherproofing of clamshells

A B C



Loose clamshell

Single-class labeling approach: clamshell and connector class

Clamshell Connector

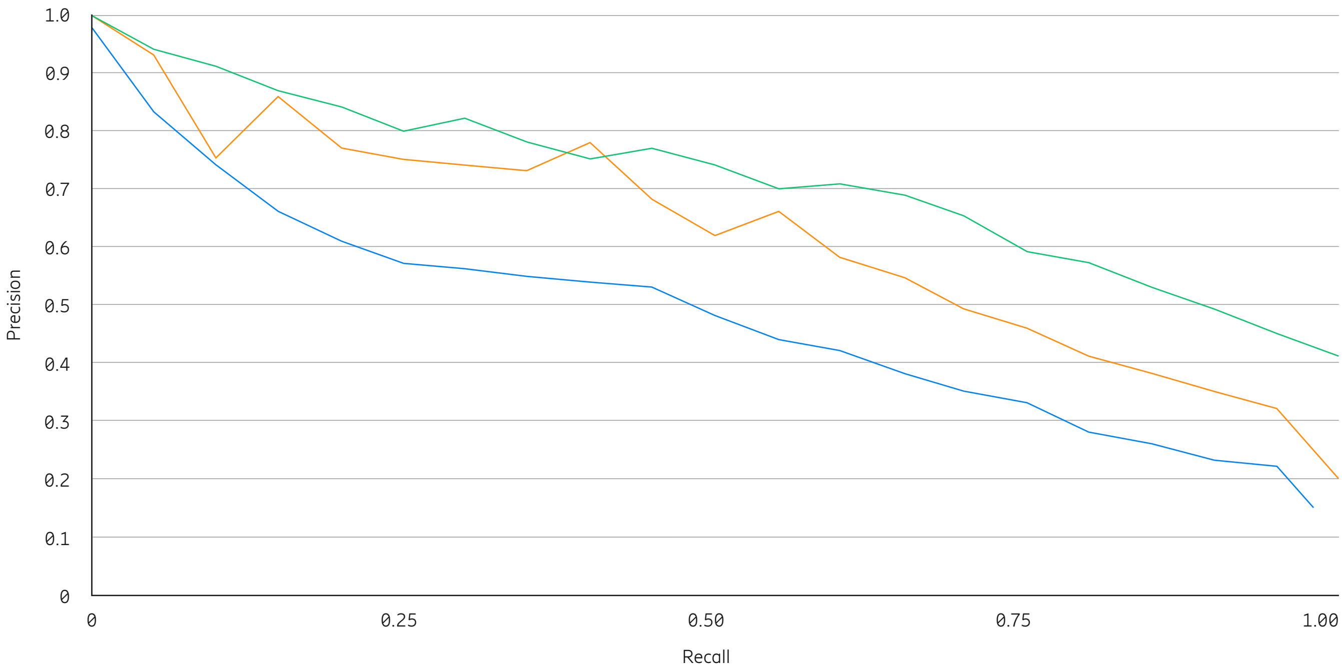
Two-class labeling approach: clamshell class and connector class

Clamshell Connector

Two-class labeling approach with specularity removal pre-processing

Precision/recall curves for the three approaches

Single-class labeling approach (Image A) Two-class labeling approach (Image B) Two-class labeling approach with specularity removal (Image C)



Benefits of removing specular highlight reflections
Precision (the rate of correct diagnosis) and recall (the ratio of objects detected out of total objects) are metrics used in assessing classifications and are standard measures of performance of an object detector in computer vision. The figure above uses these metrics to illustrate the benefits of adding an object class to the detector and then improving the results even more by removing specular highlight reflections from the dataset prior to training.

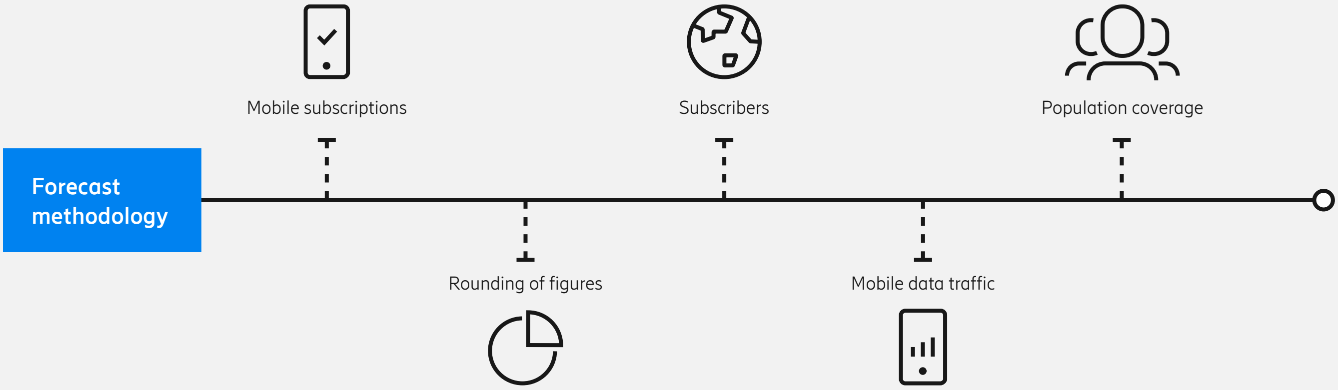
For precision close to 1 on the graph, all solutions behave the same, meaning all objects detected are actually the "real" objects (i.e. true positives). However, at the same time, the recall value is low and therefore many more undetected real objects exist. On the other side of the plot, however, solutions start to diverge.

For higher recall values, whereby more objects are actually detected, removal of specularity yields higher precision, so more of the objects detected are true positives and not false ones.

Yet, even in the refined solution there is room for improvement. An even safer deduction of which clamshell belongs to which connector could be achieved by tracing the cable from the weatherproofing to the connector, using image processing techniques like thresholding to subtract background and edge detection to identify the cable. This illustrates an attribute of working with deep learning – one can increase performance by either enlarging the dataset or introducing additional steps into the process.

Deep learning is part of a bigger picture
Deep learning using CNNs should be seen as one powerful method in a growing arsenal of computer vision techniques which collaboratively support an array of use cases. For radio tower inspection, and more precisely, inspecting coaxial cables between radio units and antennas, deep learning is used in conjunction with specularity removal. Additional image processing techniques could include morphological transformations such as dilation and erosion, edge detection and contour tracing. The cabling issues described here are examples of the applicability of deep learning to mobile radio site management. It can be applied for classification and diagnosis wherever imaging is used for inspection.

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 operators 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.

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 operator 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 data 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 WCDMA/HSPA and LTE networks with the purpose of understanding how mobile data traffic evolves. No subscriber data is included in these measurements.

Traffic refers to aggregated traffic in mobile access networks and does not include DVB-H, Wi-Fi or Mobile WiMAX traffic. VoIP is included in data traffic.

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

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 perceptual 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

EPC: Evolved Packet Core

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

MBB: Mobile broadband (defined as CDMA2000 EV-DO, HSPA, LTE, Mobile WiMAX and TD-SCDMA)

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 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

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

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

TWDM-PON: Time and wavelength division multiplexed passive optical network is the next-generation fiber access (FTTx) technology, providing an upgrade path for the current Gigabit Passive Optical Network (GPON)

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

XGS-PON: A 10 gigabit-capable symmetric passive optical network system in an optical access network for residential, business, mobile backhaul and other applications. A higher bandwidth, symmetric version of current Gigabit Passive Optical Network (GPON)

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/mobility-report/mobility-visualizer

Global key figures

Mobile subscriptions	**2017**	**2018**	**Forecast 2024**	**CAGR* 2018–2024**	**Unit**
Worldwide mobile subscriptions	7,720	7,880	8,790	2%	million
– Smartphone subscriptions	4,400	5,100	7,160	6%	million
– Mobile PC, tablet and mobile router subscriptions	270	280	330	3%	million
– Mobile broadband subscriptions	5,240	5,910	8,300	6%	million
– Mobile subscriptions, GSM/EDGE-only	2,340	1,850	410	-22%	million
– Mobile subscriptions, WCDMA/HSPA	2,370	2,300	1,490	-7%	million
– Mobile subscriptions, LTE	2,770	3,570	4,960	6%	million
– Mobile subscriptions, 5G			1,910		million
Mobile data traffic					
– Data traffic per smartphone	3.1	5.6	20	23%	GB/month
– Data traffic per mobile PC	10.2	12.5	26	13%	GB/month
– Data traffic per tablet	4.6	5.8	14	16%	GB/month
Total data traffic**					
Total mobile data traffic	14	28	131	30%	EB/month
– Smartphones	12	25	122	30%	EB/month
– Mobile PCs and routers	1.8	2.2	6.1	19%	EB/month
– Tablets	0.5	0.7	2.3	23%	EB/month
Total fixed data traffic	80	110	360	22%	EB/month
Fixed broadband connections	990	1,060	1,270	3%	million

Regional key figures

Mobile subscriptions	**2017**	**2018**	**Forecast 2024**	**CAGR* 2018–2024**	**Unit**
North America	370	380	430	2%	million
Latin America	680	680	690	0%	million
Western Europe	510	520	540	1%	million
Central and Eastern Europe	580	580	590	0%	million
North East Asia	1,840	2,000	2,130	1%	million
China[1]	1,420	1,570	1,650	1%	million
South East Asia and Oceania	1,140	1,080	1,210	2%	million
India, Nepal and Bhutan	1,200	1,190	1,410	3%	million
Middle East and Africa	1,390	1,430	1,790	4%	million
Sub-Saharan Africa[2]	670	720	950	5%	million

* 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

Smartphone subscriptions	2017	2018	Forecast 2024	CAGR* 2018–2024	Unit
North America	300	310	360	2%	million
Latin America	460	490	570	2%	million
Western Europe	380	390	490	4%	million
Central and Eastern Europe	310	330	480	6%	million
North East Asia	1,310	1,650	2,010	3%	million
China[1]	990	1,300	1,560	3%	million
South East Asia and Oceania	620	660	1,020	8%	million
India, Nepal and Bhutan	440	610	1,110	11%	million
Middle East and Africa	580	660	1,130	9%	million
Sub-Saharan Africa[2]	270	330	650	12%	million
Mobile broadband subscriptions					
North America	370	380	430	2%	million
Latin America	500	550	650	3%	million
Western Europe	450	480	540	2%	million
Central and Eastern Europe	420	470	590	4%	million
North East Asia	1,560	1,770	2,020	2%	million
China[1]	1,250	1,420	1,610	2%	million
South East Asia and Oceania	750	800	1,200	7%	million
India, Nepal and Bhutan	470	610	1,250	13%	million
Middle East and Africa	710	850	1,620	11%	million
Sub-Saharan Africa[2]	330	410	830	12%	million
LTE subscriptions					
North America	290	330	160	-12%	million
Latin America	200	280	510	10%	million
Western Europe	250	310	300	0%	million
Central and Eastern Europe	150	200	420	14%	million
North East Asia	1,280	1,530	970	-7%	million
China[1]	970	1,180	780	-7%	million
South East Asia and Oceania	210	290	770	18%	million
India, Nepal and Bhutan	270	450	1,160	17%	million
Middle East and Africa	120	180	670	24%	million
Sub-Saharan Africa[2]	30	50	250	29%	million
Data traffic per smartphone					
North America	5.7	7.0	39	33%	GB/month
Latin America	2.0	3.1	18	34%	GB/month
Western Europe	4.0	6.7	32	30%	GB/month
Central and Eastern Europe	3.4	4.5	19	27%	GB/month
North East Asia	2.9	7.1	21	20%	GB/month
China[1]	2.4	7.1	20	19%	GB/month
South East Asia and Oceania	2.3	3.6	17	29%	GB/month
India, Nepal and Bhutan	6.0	9.8	18	11%	GB/month
Middle East and Africa	1.9	3.0	16	32%	GB/month
Sub-Saharan Africa[2]	1.2	1.7	7.3	27%	GB/month
Total mobile data traffic					
North America	2.0	2.5	14	34%	EB/month
Latin America	0.88	1.4	8.9	37%	EB/month
Western Europe	1.8	2.8	14	31%	EB/month
Central and Eastern Europe	0.9	1.2	7.4	35%	EB/month
North East Asia	4.0	11	39	24%	EB/month
China[1]	2.4	8.6	30	23%	EB/month
South East Asia and Oceania	1.5	2.3	16	37%	EB/month
India, Nepal and Bhutan	2.1	4.6	16	23%	EB/month
Middle East and Africa	1.0	1.8	15	42%	EB/month
Sub-Saharan Africa[2]	0.32	0.53	4.2	41%	EB/month

[1] These figures are also included in the figures for North East Asia
[2] These figures are also included in the figures for Middle East and Africa

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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