CONTENT

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INTERFERENCE ANALYSIS OF UWB DEVICES TO THE SATELLITE SERVICES IN THE 7240-8240 MHZ FREQUENCY BAND

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ABSTRACT

Ultra-wideband radio technology (UWB), is a wireless access technology that allows exchanging of data over a radio channel between over short distances at very high speed and low power consumption. UWB signals are short pulses the entire energy of which is distributed over a given wide region of the spectrum. With a sufficiently high total power transmitted over the air and with low power consumption and a pulsed nature of data transmission, a high data transmission rate can be obtained. This work has done interference analysis of ultra-wide bandwidth technologies (UWB) operating in the frequency band 7240-8240 MHz to the Earth monitoring and meteorological satellite systems that operate in this band. Taking into account the rapid development of users' UWB devices in different frequency bands, the study tries to estimate the long-term impact of aggregate interference from UWB devices located around the satellite Earth stations. The study considers two satellite systems as an example of victim receivers. The UWB density assumptions made in the studies are based on the forecasts of CEPT and UWB Alliance.

KEYWORDS: *UWB, Earth exploration satellites, meteorological satellites, interfernce analysis, Monte-Carlo analysis, spectrum management.*

I. INTRODUCTION

Ultra-wideband radio technology (UWB), is a wireless access technology that allows exchanging of data over a radio channel between over short distances at very high speed and low power consumption. UWB signals are short pulses the entire energy of which is distributed over a given wide region of the spectrum. With a sufficiently high total power transmitted over the air and with low power consumption and a pulsed nature of data transmission, a high data transmission rate can be obtained. UWB technology uses radio signals with a spectrum width of at least 500 MHz allocated in the radio frequency band from 2.86 GHz to 10.6 GHz. UWB has been in use for more than 20 years and most of the devices are used for radar, positioning, and visualization systems. But today UWB technology has also been actively introduced into user devices such as laptops, smartphones, tablets, etc., and these days there is a trend towards a gradual increase of UWB device density. According to UWB Alliance by 2022 more than 500 million UWB devices will be in circulation and by 2025 the rates will exceed 1 billion devices. UWB smartphone accessories will drive a 1:1 chip ratio with smartphones by the end of 2025 [1]. Although UWB is categorized as a low-power device, a high density of devices has the potential to cause harmful interference to the operating radio services. At present, one of the main frequency bands for the development of UWB user devices can be the frequency band 7240-8240 MHz, in which UWB supports channels 8, 9, and 11. Table 1 shows the channels supported by UWB devices [2].

Table 1

Supported UWB channels

№ channel	Central frequency	Bandwidth
1	3494,4 MHz	499,2 MHz
2	3993,6 MHz	499,2 MHz
3	4492,8 MHz	499,2 MHz
4	3993,6 MHz	1331,2 MHz
5	6489,6 MHz	499,2 MHz
6	6988,8 MHz	499,2 MHz
7	6489,6 MHz	1081,6 MHz
8	7488,0 MHz	499,2 MHz
9	7987,2 MHz	499,2 MHz
10	8486,4 MHz	499,2 MHz
11	7987,2 MHz	1331,2 MHz
12	8985,6 MHz	499,2 MHz
13	9484,8 MHz	499,2 MHz
14	9484,0 MHz	499,2 MHz
15	9484,8 MHz	1354,97 MHz

The frequency band 7240-8240 MHz is allocated to various satellite services, including Earth-exploration satellite service, meteorological satellite service, fixed-satellite service, and mobile satellite service [3]. This study does simulations of interference analysis from UWB devices to the Earth stations of the satellite networks. As victim satellites systems, two example systems were considered.

II. SIMULATION PARAMETERS AND SCENARIOS

In UWB transmissions the data is carried in the polarity of the pulses in the BPSK modulation technique, symbol 1 has a phase value of zero degrees and symbol 0 has a phase value of 180 degrees. The transmitting and deployment characteristics of UWB used in the study devices are presented Table 2 [4].

Table 2

Parameters of UWB devices used in simulation

Parameter	Value
Channel bandwidth (MHz)	500
Modulation	BPSK
Antenna gain (dBi)	0
Antenna pattern	Omni
Spectral power density (dBm/MHz)	-41.3
Body loss	4 dB
Number of simultaneously active UWB per km^2	250
Number of UWB located indoors	70%

The first system that is considered a victim receiver is the Earth station of Kanopus. Kanopus is an Earth observation satellite that is designed to collect data for environmental monitoring and mapping, detection of fires, agricultural planning, and assessing land use. It can also be used to monitor man-made and natural disasters. In simulations, the victim receiving Earth station was tracking Kanopus satellite. Figure 1 shows the Earth station of Kanopus satellite while tracking it.

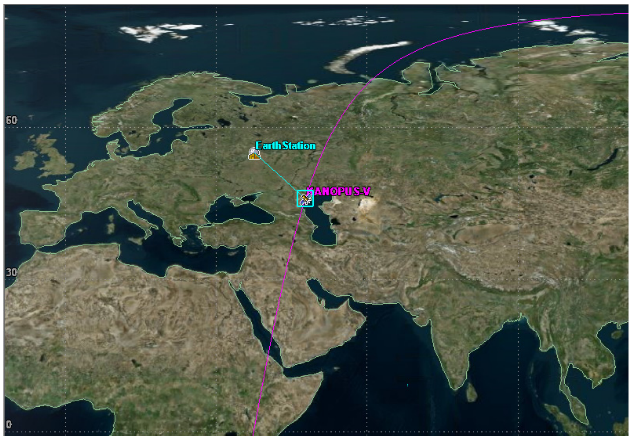

Fig. 1. Earth station tracking Kanopus satellite

Characteristics of the Kanopus satellite system used in simulations are presented in Table 3 [5], characteristics include the Earth station's receiving parameters, as well as orbital parameters of the satellite to implement the tracking mode of the Earth station.

Table 3

Parameters of Kanopus satellite system

Parameter	Value
Orbit type	Circular
Altitude of satellite (km)	510
Orbit inclination (degrees)	97
Receiving bandwidth (MHz)	123
Noise temperature of ES (K)	130
Antenna gain of ES (dBi)	53
Antenna pattern of ES	Rec. ITU-R S.465
Antenna height of ES (m)	10
Location of ES (degrees)	55 latitude 37.5 longitude

The second system that is considered in simulations as a victim receiver was the Earth station of Elektro-L. Elektro-L is a next-generation series of a meteorological satellites designed for producing images of the Earth's whole hemisphere in both visible and infrared frequencies, providing data for climate change and ocean monitoring in addition to their primary weather forecasting role. Figure 2 depicts the Elektro-L service footprint area as well as the Earth station that is pointed towards the satellite.

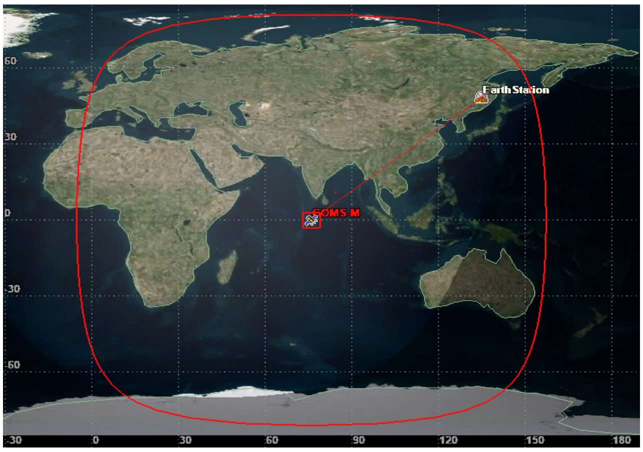

Fig. 2. Earth station pointing towards Elektro-L satellite

Characteristics of the Elektro-L satellite system used in simulations are presented in Table 4 [5], characteristics include the Earth station's receiving parameters, as well as the orbital position of the satellite to definite the antenna pointing of the Earth station.

Table 4

Parameters of Kanopus satellite system

Parameter	Value
Orbit type	Geostationary
Orbital position (degrees)	76
Receiving bandwidth (MHz)	30
Noise temperature of ES (K)	150
Antenna gain of ES (dBi)	50
Antenna pattern of ES	Rec. ITU-R S.580
Antenna height of ES (m)	10
Location of ES (degrees)	48.55 latitude 135.167 longitude

III. SIMULATIONS AND METHODOLOGY

The protection criterion of the satellite services was interference-to-noise ratio (I/N) which according the ITU recommendations is -12.2 dB. To calculate the I/N at each simulation step the following expression can be used [6]:

$$\frac{I}{N}[\text{dB}] = 10\,log_{10}\left(\sum_i 10^{\frac{I_{UWB}(i)}{10}}\right) - (D + NF + 10\,log(B))$$

where, I_{UWB} (i) are the interference from i^{th} active UWB device (dBm); D is receiver noise power density (dBm/Hz); NF is receiver noise figure (dB), B is receiver channel bandwidth (Hz).

The interference from each UWB transmitter can be derived from the below expression [6]:

$$I_{UWB} = P_{TX} + G_{IMT} + G_{ES} - L_p - L_{xpr}$$

where, P_{TX} the transmitted power of the i^{th} UWB device (dBm); G_{UWB} the transmit antenna gain of the i^{th} UWB device towards the victim receiver (dBi); G_{ES} the receive antenna gain of the Earth station towards the interfering station (dBi), L_p the propagation loss from the transmitting UWB and receiving ES (dB), L_{xpr} the polarization loss (dB).

Before the interference simulations were made, the movement of the satellite systems was simulated to define the distribution of elevation angles. The elevation angle is important because it determines the amount of interference the Earth station will receive from UWB generally the lower the elevation angle, the higher interference from UWB there will be. Azimuth in this scenario generally is not important since UWB are randomly distributed around the Earth station and the Earth station is located in the center of the simulated area, however, it was also taken into account. Kanopus satellite movement was simulated for 3 months with a 1-second step, at each step elevation angles and azimuths were defined. Figure 3 shows simulation of Kanopus satellite movement.

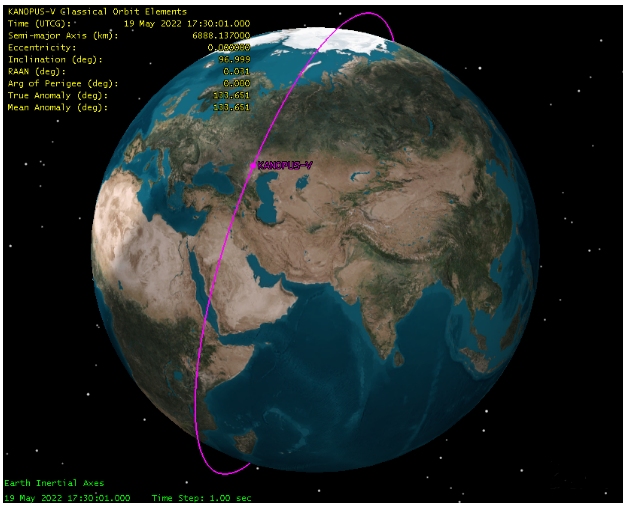

Fig. 3. Earth station pointing towards Elektro-L satellite

After the simulation of the satellite movement was finished, the obtained data array of elevation and azimuth angles was stored and uploaded to the ES during the interference simulations. Figure 4 shows the distribution of azimuths (green lines), elevations (red lines), and distances (blue lines) within the 3 months of simulation.

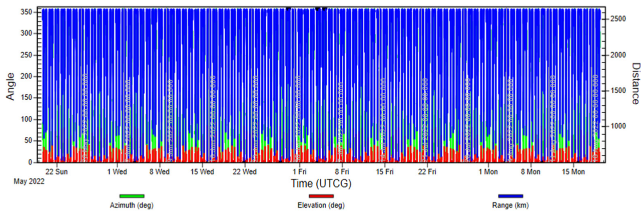

Fig. 4. Earth station pointing towards Elektro-L satellite

For the Elektro-L case, the elevation angle was calculated, however in this case the task was much easier since in the case of geostationary orbit the elevation angle and azimuth would be static. The elevation angle towards the geostationary satellite may be calculated using the following expression [7]:

$$\theta = \cos^{-1}\left(\frac{r_e + h_{GSO}}{d}\sqrt{1 - \cos^2(B)\ \cos^2(L_E)}\right)$$

where r_e is the equatorial radius = 6378.14 km; h_{GSO} is the geostationary altitude = 35 786 km; d is the range between the Earth station and the satellite (km); B is the differential longitude (degrees); L_E is the ES latitude (degrees).

Figure 5 shows the slant path from the Earth station towards the GSO satellite. It can be noticed that the elevation angle of the Earth station located in the simulated coordinates equals 11.322 degrees and azimuth equals 245.924 degrees.

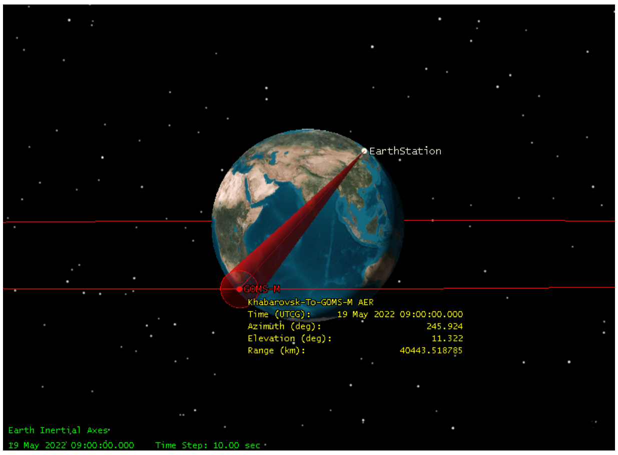

Fig. 5. Earth station pointing towards Elektro-L satellite

For interference simulation, Monte-Carlo analysis was used, and UWB devices were randomly distributed around the Earth station. The simulations considered the area of 4 m2 where UWB devices were randomly distributed around the Earth station. Since typically Earth stations have their territory where UWB devices won't be located, 150 meters protection zone around the Earth stations was configured. Figure 6 provides an example of interference simulation of aggregate interference from UWB devices to the satellite Earth station.

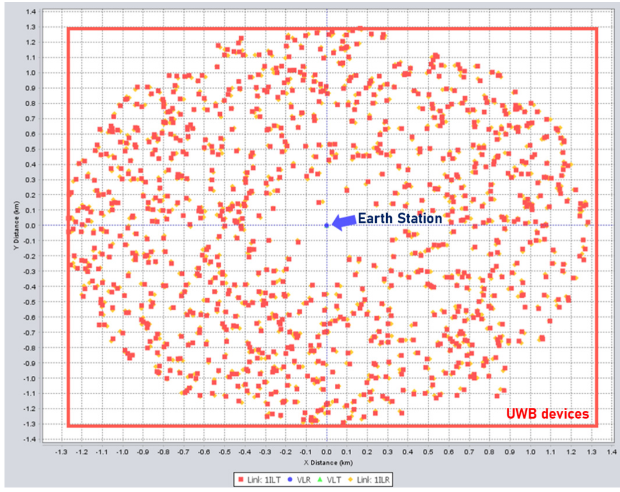

Fig. 6. Earth station pointing towards Elektro-L satellite

To calculate propagation losses in the study Recommendation ITU-R P.2001 [8] for p = 50% which gives median propagation losses between each UWB device and ES; To estimate additional clutter loss Recommendation ITU-R P.2108 [9] was used; To take into account building entry losses for those UWB that are located indoor Recommendation ITU-R P.2109 [10] with 50/50 ratio of building type between traditional and thermally efficient buildings.

IV. STUDY RESULTS

After the simulations, cumulative distribution functions of I/N were obtained and compared with the protection criterion to figure out whether I/N is exceeded at any step or not.

Figure 7 shows the cumulative distribution function of I/N for the Kanopus satellite, Figure 8 shows the vector representation of aggregate I/N for each simulation step. The blue line in both pictures show the threshold border which equals -12.2 dB.

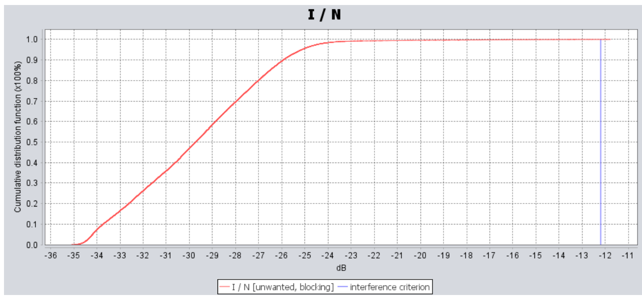

Fig. 7. Earth station pointing towards Elektro-L satellite

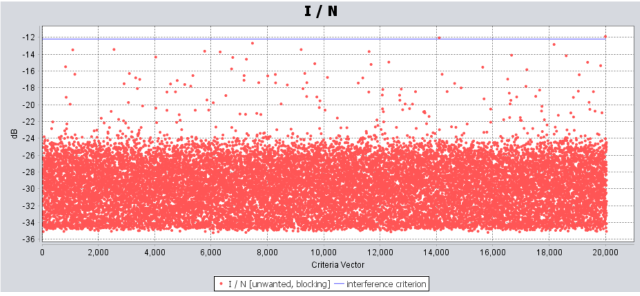

Fig. 8. Earth station pointing towards Elektro-L satellite

The figures above show that the criterion I/N = -12.2 dB is satisfied for each simulation step and that the levels of I/N are close to the I/N threshold only in a very small percentage of simulation steps.

Figure 9 shows the cumulative distribution function of I/N for the Elektro-L satellite, Figure 10 shows the vector representation of aggregate I/N for each simulation step.

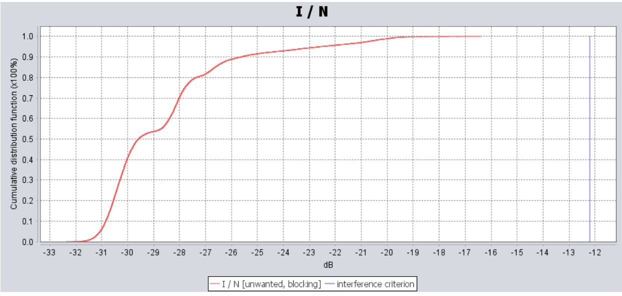

Fig. 9. Earth station pointing towards Elektro-L satellite

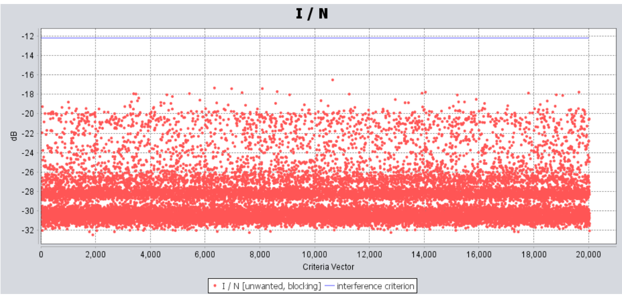

Fig. 10. Earth station pointing towards Elektro-L satellite

The figures above show that criterion I/N = -12.2 dB is satisfied for each simulation step and the levels of I/N are significantly lower than the threshold level.

V. CONCLUSIONS

Overall, the interference analysis results show that for both satellite systems the protection criterion interference-to-noise isn't exceeded. It should be noted that in the study Earth stations were assumed to be located in an urban area, but in practice, the Earth stations are usually located in suburban or rural areas where there is a low density of UWB. Additionally, in many cases, the minimum distance between the UWB devices and an Earth station would be higher than those that were considered in the study. Thus it may be concluded that no harmful interference to the satellite services is expected even when UWB density will reach significant levels.

ACKNOWLEDGMENT

The authors would like to express special thanks to the specialists of Radio Research and Development Institute for the extensive consultations and support.

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USING MPLS TECHNOLOGY TO SOLVE BGP "BLACKHOLE" PROBLEM

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ABSTRACT

Traditional IP networks use a hop-by-pop principle for transmitting traffic. This leads to aggregation of heterogeneous traffic on links in different parts of the network, which causes considerable possible growth of congestion and leaves the network with both unbalanced use of resources and link failure in congested parts. To support a growing number of users and multiple classes of applications with different performance requirements and characteristics, service providers have been forced to adapt to new technologies. Researchers have found that conventional IP packet forwarding is not suitable for applications such as VOIP and video conferencing, which are currently in huge demand. In addition to offer a general provision of MPLS technology, architecture, operation method and features, we will consider the Border Gateway Protocol (BGP) "Black hole" issue that results in the inability of the network to transfer traffic between some end points, and how MPLS help us avoid this problem and even optimize network operation and resources utilization.

KEYWORDS: _Label switching technology, MPLS, Multiprotocol label switching, MPLS TE, Routing problems, BGP "Blackhole"._

To improve traffic management and Internet service quality, the Internet Engineering Task Force (IETF) proposed MPLS technology to support several classes of latency-critical applications. MPLS is an extremely fast and efficient packet forwarding technology using labels look-up. MPLS components support the interconnection of many different multiple protocols on top of the current IP-based network to implement simple load balancing techniques as dynamic traffic management to maintain the required level of QoS and optimize network performance.

Traditional IP networks use a hop-by-pop principle for transmitting traffic. This leads to aggregation of heterogeneous traffic on links in different parts of the network, which causes considerable possible growth of congestion and leaves the network with both unbalanced use of resources and link failure in congested parts.

In conventional IP networks, routing is based on the destination address and one parameter, such as the number of hops or the value of the delay. The router looks for the next hop (the closest) to the destination without taking into account the results of congestion control, this results the route closest to the destination to become the most congested.

There is another problem related to the characteristics of different packets, for example, voice and video packets are different in length and size and should have a higher priority than regular data packets. In addition, searching the routing table takes time, so packets carrying voice and video may not be able to reach their destination in order and time, getting stuck behind regular data packets. For these reasons, researchers have found that conventional IP packet forwarding is not suitable for applications such as VOIP and video conferencing, which are currently in huge demand.

This raises the need for traffic engineering to ensure bandwidth guarantees and efficient use of network resources.

To overcome these problems, the IETF has proposed a new data transmission mechanism, which is MPLS (Multi protocol label switching), in accordance with the current requirements.

MPLS is an extremely fast and efficient packet forwarding technology using labels look-up.

An MPLS network consists of several routers called LSRs (Label Switching Routers). Other routers that connect to IP routers are called LERs (Label Edge Routers).

An ingress router is a router within an MPLS domain, connected to the outside world, through which a packet enters the MPLS domain. The Egress Router is the router through which packets leave the MPLS domain. Each incoming packet is assigned a label depending on the destination address, this label determines the most efficient and fastest label switching path (LSP) to direct traffic to the MPLS domain the entire way instead of finding the destination address at each point (see Figure 1).

The concept of label switching is not new; it was developed in the late 1990s from CISCO label switching. Multiprotocol label switching is called a 2.5-layer protocol because it sits somewhere between layer 2 (the data link layer) and layer 3 (the network layer).

MPLS was provided as a high-value WAN connection from the service provider and applied to all other types of WAN also has another application as MPLS VPN.

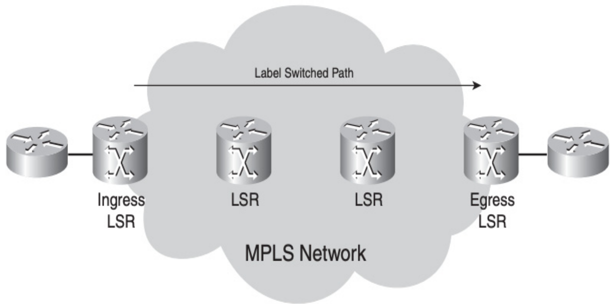

Figure 1. MPLS Architecture (MPLS domain consist of LSRs and LERs at the edges of the network field)

MPLS technology supports the interconnection of many different technologies including IP routers, ATM switches and Frame Relay, as LERs support the connection of multiple ports as edge carriers in an access network.

At the edge router (ingress) a label is assigned to each incoming packet. These labels are distributed by the signaling protocol to create an LSP and forward traffic into the MPLS network.

The label switched routers are the main routers in the MPLS domain and are commonly referred to as core network routers.

When a packet enters the MPLS network, a label or labels are attached to it, and when these packets leave the MPLS network, these labels are removed by the edge routers. The ingress router creates a small MPLS header 32 bits long to encapsulate each incoming packet. This small header is embedded between the Layer 2 and Layer 3 headers, so we call it shim (see Figure 2).

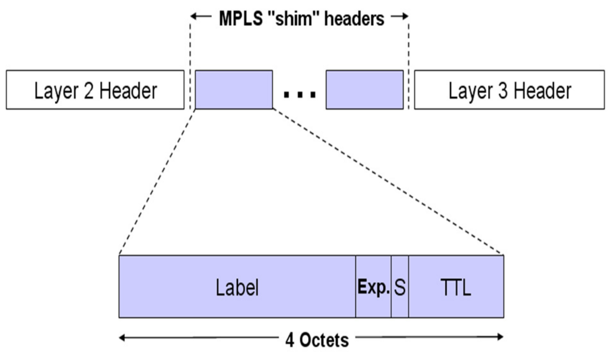

Figure 2. MPLS shim header

Label consists of 20 bits, which means it can have (2^20) values or labels.

However, the first 16 label values are from 0 to 15 are exempted from the normal use as they have a special meaning. Label value can be used by LSR to look up either next hop, operation to perform, or outgoing data-link encapsulation.

(EXP) or experimental consists of three bits and is used for QOS-related functions. It is now renamed TF traffic class. The next field is a single bit called bottom-of-stack. It is used as a flag when more than one label is assigned to a packet as in the case of the MPLS VPN or MPLS TE.

The next byte, the MPLS TTL (time to live) field, consisting of eight bits that can have a value from 0 to 255, serves the same purpose as the IP TTL byte in the IP header. Therefore, each time an LSR forwards a packet, it decrements the TTL field in the packet header, and if the value reaches zero the packet is discarded.

An edge router and a label-switched router create a short, fixed-length object to decide where and how to forward the frame, this object is called a label (see Figure 3). All label information is specified in the Label Forwarding Information Base (LFIB).

At each LSR the old label is removed and a new label is inserted into the packet, and then the packet is forwarded to the next hop.

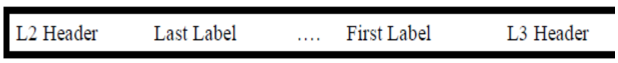

Figure 3. MPLS label structure between Layer 2 and Layer 3 headers

Forwarding Equivalence Class (FEC) is a group of packets that have the same characteristics and transport requirements. All packets that have the same FEC are forwarded along the same path with the same processing. The function of assigning FEC to a packet is a function of the edge router as it is part of the MPLS domain, then all information is embedded in the label and attached to the packet. This way there is no more header analysis within the MPLS domain in the forwarding process.

There are some applications that require a high level of QoS, such as audio/video conferencing and VPNs. These High revenue-generating applications have always been the main focus of service providers. The traditional conventional IP network cannot provide the necessary bandwidth for specific applications, and cannot provide an adequate level of QoS due to lack of support for traffic engineering, but is limited in scalability or flexibility, or sometimes both.

The Internet and service providers pose a new challenge due to some real-time or mission-critical applications because these applications have different latency, bandwidth, jitter and packet loss needs. On the Internet we have an unpredictable traffic flow, so there is a huge need for traffic engineering to run these applications efficiently.

IP (Internet Protocol) was not designed to support QoS, rather it was designed for education and research, but the network has to carry a large volume of traffic and still has limited resources, so it is important to allocate and optimize available resources. Allocating or scheduling network resources based on the required QoS to optimize the use of our network resources is known as traffic engineering. In traditional IP networks, some links are congested, but others remain underutilized because of the destination-based forwarding paradigm.

Making a forwarding decision without considering the available bandwidth and traffic flow between the destination and the source will create congestion on that link, while leaving other links in the network unused, resulting in reduced bandwidth, latency and packet loss.

MPLS provides a solution by providing a connection-oriented structure on top of the current IP-based network to maintain the required level of QoS for these applications. Traffic engineering in MPLS considers resource utilization, making it more efficient to design routes based on single flows or different flows between the same endpoints.

There are two main planes in the MPLS architecture, the control plane and the data plane.

Control Plane Performs information exchange between neighboring devices using various protocols such as OSPF (open Shortest Path First), IGRP (Interior Gateway Routing Protocol), EIGRP (Enhanced Interior Gateway Routing Protocol), IS-IS (Intermediate System-to-Intermediate System), RIP (Routing Information Protocol) and BGP (Border Gateway Protocol). Label exchange also takes place using TDP (Tag Distribution protocol), LDP (Label distribution Protocol), BGP, and RSVP (Resource Reservation Protocol).

Data plane based on labels and regardless of the routing protocol or label switching protocol, it simply forwards the packet. A label is assigned to each packet by searching the label forwarding information base (FIB) table, all information in the table is populated with TDP (label distribution protocol) or LDP (label distribution protocol).

From the name MPLS "Multi Protocol Label Switching" shows that MPLS has the wonderful feature of supporting multiple protocols. The main advantage of MPLS is that it can be used with other networking technologies, as well as in pure IP, ATM and Frame Relay networks or even all three technologies, because a router that supports MPLS can coexist with a pure IP network as well as with ATM and Frame Relay switches. Support for multiple protocols makes MPLS universal, which attracts other users with mixed or different network technologies.

LSP (label switched path) is a path through the intermediate LSRs from the entry and exit nodes in the MPLS domain (see Figure 4). All necessary information used to create the LSP is transmitted using two protocols between LSR.LSRs can transmit all packets depending on the label assigned to these packets.

One or more labels can be attached in the MPLS packet header, so here we do not have an IP table, but a label table, and packet switching uses label look-up instead of IP table look-up.

Adding a label to packets avoids route look-up to forward the packet over the LSP. To create an LSP, all labels must be distributed between MPLS nodes using the Label

Distribution Protocol (LDP) or RSVP (Resource Reservation Protocol).

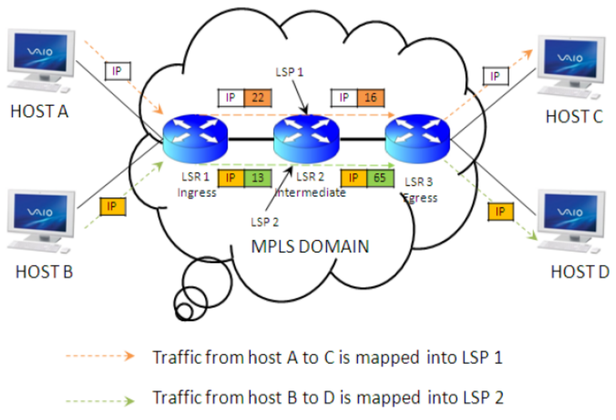

Figure 4. A label-switched path on an MPLS-enabled network

The flow of packets between the edge devices in the MPLS domain is defined by a label, which defines the forwarding equivalence class (FEC). Therefore, the packet forwarding process will take place along this label-switched route as virtual connections in a physical IP network without connection-oriented guaranteed processing.

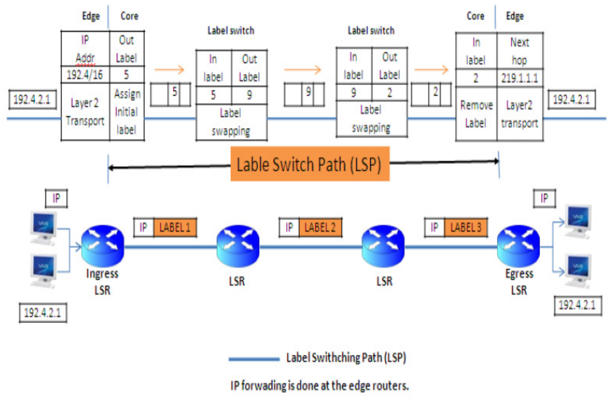

Figure 5. Label assignment in the MPLS domain and IP forwarding

MPLS edge routers only can determine whether a packet belongs to a label and forward it by examining its header and their special database to allocate the destination address.

Forward Equivalence Class (FEC) is a class for identifying a group of packets that have the same characteristics, transportation, processing and routing requirements for the destination. There are many parameters used to determine the FEC of a packet, such as source or destination IP address, source or destination port number, a DiffServ code point, and IP protocol identifier. Each LSR builds a table called the LIB label information base, which is based on the FEC, the FEC is determined for each packet, then the corresponding label from the LIB is attached to it.

And it is forwarded through the LSP, each LSR checks and replaces the packet label with another corresponding label before sending the packet to the next nearest LSR to the destination via the LSP.

In general, anything goes into the black hole never come back. In networking world, a Black hole is a routing mechanism in the ISP WAN used as a filter to drop unwanted traffic from different source IP's to unknown destination. Technique BGP Black hole can exclude and isolate some attacks by re-directing the unwanted traffic to a special interface (Null interface) so it never reaches to their intended destination.

BGP Black hole used to isolate DDoS attacks which aiming a certain IP addresses causing the congestion of physical link between services provide and a customer router. Installing a black hole on a provider router, can prevent unwanted traffic from entering customer's network or before that.

Sending traffic across an OSPF area with a lack of BGP routing information, will cause dropping packets (depending on Black hole mechanism) which have an unknown destination for these routers running OSPF.

So deploying MPLS technology within core network, BGP is still deployed at the network edges, provide transit traffic from any end point as MPLS routers carry just the information about the BGP's next step and don't scatter BGP across the network.

We will describe how MPLS can help us avoid the BGP black hole. In this topology we have: interface Loopback address is x.x.x.x/32, where x is the number of device.

X will be used as LDP transport address, LSR ID and OSPF router ID.

To advertise IP address of the interfaces (loop-back and directly connected), OSPF is running on all routers. IBGP neighbor's relationship based on loop-back 0, is established between R1 and R4, but BGP is not running on R3 and R2.

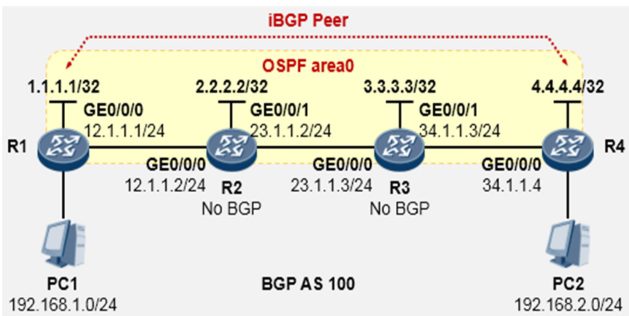

Figure 6. Network topology and configuration (Black hole is installed on routers with following IP addresses 1.1.1.1, 2.2.2.2, 3.3.3.3, 4.4.4.4)

R1 advertises the direct route 192.168.1.0/24 to BGP, and R4 advertises the direct route 192.168.2.0/24 to BGP, but on an OSPF network R1 cannot advertise the route to 192.168.1.0/24 and R4 cannot advertise the route to 192.168.2.0/24.

After completing the configuration this is what happens: R1 know form the BGP peer relationship the route to 192.168.2.0/24.

R1 start forwarding data packet (packets that are transmitted from PC1 to PC2) to R2, but R2 don't know about 192.168.2.0 because BGP is not running on it, so R2 will discard the packets and sending it to the black hole interface 2.2.2.2.

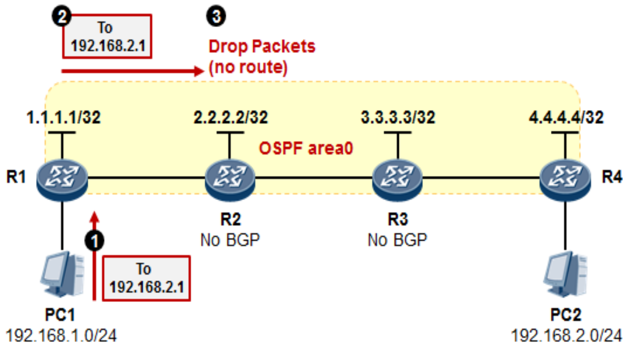

Figure 7. R2 discard the packets were sent it from R1 to his black hole interface 2.2.2.2

MPLS can be deployed on all routers to enable PC1 and PC2 to communicate with each other.

When PC1 wants to forward packets to PC2 it sent it to R1. From BGP, the next hop to 192.168.2.0/24 is 4.4.4.4. LFIB has an LSP destined for 4.4.4.4 so all packets to 4.4.4.4 be destined through this LSP, too.

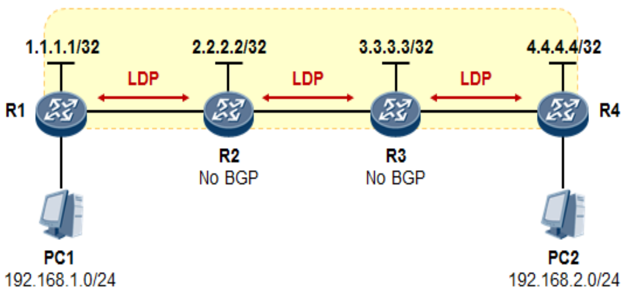

Figure 8. Deploying MPLS technology on all routers (Label Distribution Protocol or LDP distribute labels between MPLS nodes. All information in LFIB table is populated by LDP or TDP between MPLS nodes)

From PC1, the packets are first sent to R1.

Looking at the routing table, R1 finds that the destination can be reached depending on MPLS information. The next hop to the 192.168.2.0 is 4.4.4.4, R1 now adds a label in a push process (the 1026 label is corresponding to 4.4.4.4) into the packets and it sends them to R2.

R2 in its turn swaps label 1026 into label 1028 and sends the packets to R3. The next hop (4.4.4.4) R4 is directly connected so R3 pops out the label and sends the packet to R4. In this way, PC1 can successfully ping PC2 using MPLS.

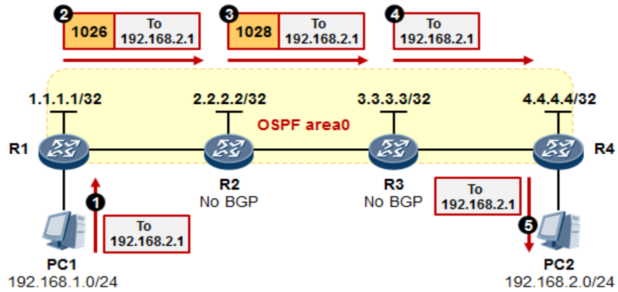

Figure 9. The packets successfully were sent from PC1 to PC2 depending on MPLS information, avoiding BGP "Black hole"

CONCLUSION

1. High revenue applications have always been the main focus of service providers. Internet and service providers have a new challenge because these applications have different latency, bandwidth, jitter and packet loss needs.

2. Internet Protocol was not designed to support QoS, rather it was designed for education and research. On the Internet, we have unpredictable traffic flow, so there is a huge need for traffic engineering to run these applications efficiently.

3. MPLS provides a solution by providing a connection-oriented structure on top of the current IP-based network to maintain the required level of QoS for these applications. The main advantage of MPLS is that it can be used with other networking technologies, as well as with pure IP.

4. Black hole is a routing mechanism, used as a filter to drop unwanted traffic from different source IP's to unknown destination. Sending traffic across OSPF area with a lack of BGP (Border Gateway Protocol) routing information, will cause dropping packets which have unknown destination for these routers running OSPF.

5. Deploying MPLS technology within core network, Border Gateway Protocol is still deployed at the network edges. Help avoiding Black hole and provide transit traffic from any end point as MPLS routers carry just the information about the BGP's next step and do not scatter BGP across the network.

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PRIVATE WIRELESS MARKET

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ABSTRACT

Industry 4.0 operations enable you to fuse physical and digital processes by connecting everything from vehicles to sensors and mobile workers in the most flexible, affordable, secure and reliable way. By digitalizing operations, enterprises can easily transform data into insights and become more agile and proactive. To meet the requirements of AI, machine learning and automation, industries need highly reliable, low latency and secure wireless connectivity with high bandwidth. 4.9G/LTE and 5G industrial-grade private wireless net-works are the only wireless solutions available that have proven records to meet the demands of Industry 4.0 mission- and business-critical applications. They provide robust, secure and reliable connectivity for everything that is critical to your operations, from people and machines to sensors and analytics. Radio access points provide coverage of your outdoor and indoor spaces, similar to Wi-Fi, but you will need far fewer. Unlike Wi-Fi, there is a core network, which is the key to enabling mobility, ensuring security and maintaining quality-of-service parameters. The backhaul network is no different than what you would use to connect Wi-Fi access points, whether cabled Ethernet, passive optical LAN and/or microwave depending on the application and the distances served.

KEYWORDS: *Internet of things, Bluetooth Low Energy, Home Automation System, Android, Lightning System, Arduino.*

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Stephane Daeuble *is responsible for Enterprise Solutions Marketing in Nokia enterprise. IT geek and machine connectivity advocate, he knows the value of secure and reliable industrial-grade wireless connectivity, and is an active evangelist on the role private wireless will play in helping industrials leapfrog into the 4th industrial revolution.*

Carlijn Williams *– Head of Marketing for Nokia's Enterprise Solutions business. She talks about how (5G) private wireless networks and solutions like edge cloud, devices and applications continue to change vertical industries. She gives insight in how industries can succeed in their digital transformation by using low latency, high bandwidth mission-critical communication networks. She believes topics like Automation, Security and AI-driven applications are vital to accelerate Industry 4.0. Dutch born, Carlijn holds a degree in Economics and Communications and lives in the UK.*

INTRODUCTION

Industry 4.0 operations enable you to fuse physical and digital processes by connecting everything from vehicles to sensors and mobile workers in the most flexible, affordable, secure and reliable way. By digitalizing operations, enterprises can easily transform data into insights and become more agile and proactive.

These highly collaborative, hybrid work environments and real-time responses are enabled by remote and autonomous technologies and advanced intelligence:

- a mission-critical private 4.9G/LTE or 5G wireless network that can help you digitalize your operational technology (OT) systems to make them infinitely more agile and resilient;
- a complementary Wi-Fi layer that can provide reliable connectivity for IT systems and non-business-critical OT use cases;
- an industrial edge that can unify industrial OT use cases and enable you to securely process your data on your premises;
- industrial devices that can enhance connectivity at any site and help you improve worker communication, productivity and safety;
- industrial applications that can cut through complexity and help accelerate your digital transformation.

4.9G/LTE and 5G are providing the next generation of private wireless networks for our connected world, supporting automation, safety, security and new levels of quality, efficiency and productivity.

To meet the requirements of AI, machine learning and automation, industries need highly reliable, low latency and secure wireless connectivity with high bandwidth. 4.9G/LTE and 5G industrial-grade private wireless networks are the only wireless solutions available that have proven records to meet the demands of Industry 4.0 mission- and business-critical applications. They provide robust, secure and reliable connectivity for everything that is critical to your operations, from people and machines to sensors and analytics.

Deploying the Nokia private wireless solution isn't much different than a Wi-Fi network, but there are a few extras to consider.

Radio access points provide coverage of your outdoor and indoor spaces, similar to Wi-Fi, but you will need far fewer. Unlike Wi-Fi, there is a core network, which is the key to enabling mobility, ensuring security and maintaining quality-of-service parameters. Depending on the size of your site, it can even run on a small desktop-sized edge server deployed in a server room.

The backhaul network is no different than what you would use to connect Wi-Fi access points, whether cabled Ethernet, passive optical LAN and/or microwave depending on the application and the distances served.

For most mission- and business-critical industrial applications, the Nokia private wireless network solution is the most cost-efficient compared to other wireless solutions.

Private wireless requires far fewer access points than other wireless solutions to cover the same area, which means less supporting infrastructure as well (power, cabling, poles, etc.). Engineering and planning the radio coverage is also much less expensive because of the characteristics of the radio spectrum used. Finally, you can consolidate all your current networks on a single 4.9G/LTE or 5G network, for significant operational cost savings.

Nokia has recognized that enterprise needs vary, thus we have two private versions of our industrial-grade private wireless solution. The Nokia Digital Automation Cloud (DAC) provides an integrated plug-and-play private wireless service solution and a digital automation platform with ready-to-run applications. Modular Private Wireless (MPW) solution offers all the elements needed to create a bespoke private wireless solution that is either completely autonomous or in a variety of hybrid configurations with third-party providers such as mobile operators.

Private wireless spectrum for industrial use is now available in many countries, and this is expected to grow. Many governments around the world are releasing spectrum specially designated for private networks. In Britain, Germany and Japan, private spectrum is only available for 5G, elsewhere it is also available for 4.9G/LTE. In the US, the CBRS initiative by the FCC, is based on spectrum that is shared with other organizations. The unique sharing schema is likely to be copied by other countries [1-6].

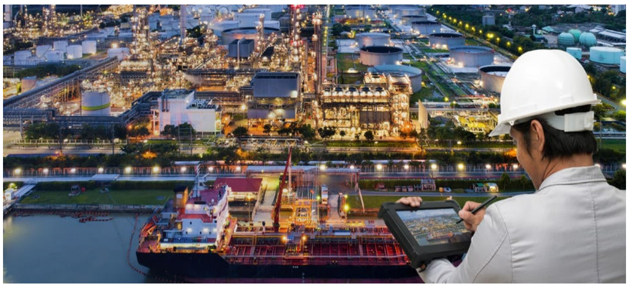
For those countries that don't have dedicated private spectrum for industry, there are many other solutions. Nokia has a range of CSP partners willing to lease spectrum (and you can ask your favorite CSP if they offer Nokia private wireless solutions). Finally, you can even deploy a private solution in the 5.x GHz unlicensed spectrum range with Multefire™, which provides a standardized LTE-based unlicensed technology and is available from Nokia. Private wireless based on trusted 4.9G/LTE can support almost all industrial use cases today and benefits from a large ecosystem of industrial devices, sensors and compatible systems.

For a few countries, licensed private spectrum is only available for 5G, otherwise 4.9G/LTE is the preferred choice at this time. It has a very developed industrial device ecosystem, with over 6,800 LTE-enabled non-phone-form-factor devices, and many industrial systems come with built-in 4.9G/LTE modems. Private wireless networks based on 4.9G/LTE will support 85% of industrial use cases. It gives you a competitive advantage, as you can start your Industry 4.0 transformation today. You will be able to easily add 5G when the 5G industrial ecosystem has matured.

NOT ALL PRIVATE WIRELESS SOLUTIONS ARE CREATED EQUAL

Given the very tight standards that 3GPP sets for 4.9G/LTE or 5G, it might be easy to assume that all solutions conforming to those standards are roughly equal when it comes to providing highly available and reliable wireless connectivity. But, as they say, the devil is in the details. Conforming to the standard is only the beginning. How the components and solution architecture are executed can make for very unequal results.

HIGH AVAILABILITY



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High availability in the range of, or above, 99.95% is typically expected for systems supporting mission- and business-critical use cases, and it is something that many of the leading private wireless solutions can support. If well designed for the site where they are deployed, private wireless that uses 3GPP standard technologies, can meet or even exceed such requirements. Typical features of these systems include multiple layers of redundancy in the core (hardware and geographic), overlapping coverage of cells, redundant backhaul and transport, hot-software updates, and graceful redundant server switch-over. For edge-based solutions, they also require the ability to support continuous operation, even if losing the WAN connectivity to the cloud or central office location.

When more stringent requirements are required, our private wireless solution capabilities and enterprise design practices at Nokia can beef up the solution by using multiple radio spectrum bands to create multi-layer radio connectivity, geo-spatial separation of redundant small cells, and a third level of redundancy from a public network core or a centralized core at HQ, for example. Today, our Nokia Digital Automation Cloud (DAC) solution, gives us real-time benchmarks on how the customers' networks we are managing are operating. On average we have achieved 99.999% uptime in the last 3 months (including planned but also unplanned downtime). For the most stringent deployments, using either DAC or our Modular Private Wireless solution (MPW) and looking at the hundreds of networks we are operating, we are exceeding 5x9s.

In other words, the missing ingredient in achieving very high availability is the experience of delivering end-to-end solutions for decades, whether private wireless or other critical enterprise networks such as GSM-R, IP-MPLS, microwave and optical. Experience and the right feature set for critical networks are the key ingredients to providing networks.

THE IMPACT OF CRITICAL NETWORK EXPERIENCE

At Nokia, we pride ourselves on being the vendor with the longest experience both in private wireless and running critical networks. We have been delivering mission-critical GSM-R for railway operators for 30 years. And in private wireless, we pioneered the technology and have been leading the industry for nearly 10 years.

This experience means that we understand the requirements of the industry. We know how different a network is in an underground mine versus a factory and how the requirements of various use cases can differ widely. Our many years running critical networks in our focus 12 industrial and government and cities segments have been essential to improving our software across all elements of the solution and ensuring the code is as sturdy as it can be.

In this regard, our deep experience in the telecom sector is also a huge benefit. Many of the components and software that we use in our private wireless solutions are also running on the nationwide public networks of our several hundred mobile operator customers operating around the world. Due to the sheer size of public networks, we must ensure reliability for networks with anywhere from 10 to 100 million subscribers in some of the harshest environments in the world, including deep jungle, sub-Saharan deserts and arctic zones in the north and the south – not to mention the most difficult environment of all, dense metropolitan urban centers. These networks provide mobile connectivity for ever-more-demanding subscribers, but as well, the critical services running on these networks such as public safety and logistics. We know intimately what telco-grade reliability means, and we are leveraging the techniques used there for our private wireless customers, including the continuous software improvements since the early days of 2G, which means our software-code is also well-hardened.

End-to-end is key to total system reliability. It starts with individual elements, how they are assembled and, very importantly, how they all work together. Enterprise customers understand this as they rarely buy operational technology (OT) elements piecemeal for their more complex systems. They historically have relied on trusted system integrators to provide them complete machines or production lines.

Even if some of our solutions are modular and can operate with other supplier's elements, most enterprise prefers to trust a single supplier for their private wireless networks, and for good reason. Nokia private wireless solutions are all pre-integrated and tested to function well together, end to end. This is more impressive when you understand that we have one of the widest portfolios of key elements for private wireless. We provide elements ranging from industrial devices to radios, the backhaul and fronthaul network, the core and edge cloud (including the server hardware), IP-MPLS routing, microwave and optical links, plus operations and maintenance and, finally, the applications running on the network.

These are all pre-tested to work like a swiss-clock. In comparison, many of our competitors would need four to five partners just to assemble such a solution or, in other words, more chances for glitches, requirements for regression testing at every new software release (= downtime) and, most importantly, the chance for multiple suppliers to pass the blame when things go wrong.

Still, even Nokia needs trusted partners to address every single use case in the market. But the point is that we need less than many others, and we take a systemic approach that we call "Segment Blueprints" to designing private wireless solutions that integrate, for example, specific industrial partners' elements, software, etc.

These blueprints go beyond our end-to-end solution and are created based on our learnings from deployments that we have had in each of the sub-segment we focus on. We create pre-integrated and tested solutions that can tackle the key use cases of each segment with a range of preferred partners assets. These systems go through our Enterprise services labs around the world to be tested and validated to reduce the need for customization and remove unwelcome surprises during deployment and operations. In conclusion, the availability of a private wireless solution is not something to take for granted when choosing a vendor. Experience in designing and running critical network is essential.

NOT ALL PRIVATE WIRELESS SOLUTIONS ARE EQUALLY RELIABLE

After discussing system availability in the last blog, I want to look at the reliability of private wireless connectivity. 3GPP standards are air-tight and deep by nature, but there are still many areas of differentiations when it comes to the implementation, which has a lot of impact on how a private wireless system performs.

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The further we go with the radio technology (5G and 6G), the more the implementation approaches will be critical to achieving the promise of new and even more complex capabilities such as MIMO (massive-input, massive-out radio), uRLLC (ultra-reliable low-latency communications), TSN (time-sensitive networks), and so on.

DIFFERENT TYPES OF CELLS/RADIOS MATTER FOR PRIVATE WIRELESS RELIABILITY

Public networks are reliable by nature but also benefit from additional "elements" of reliability by the fact that they are made of multiple layers of redundant services. In many countries today, you still have 2G and 3G running alongside 4G/LTE and 5G. Within each radio technology, there are also layers of connectivity using two or three separate spectrum bands (e.g., LTE can operate in 800MHz, 1800MHz and 2.6GHz).

Finally, in some urban areas and hot spots, you can even have physically separated layers of the same technology in the same spectrum bands, for instance, LTE/4G macro radios (BTS) running at height in 2600MHz and LTE/4G small cells on the street, also running in 2600MHz. Because today's smartphones can often support all of these standards and bands, if something goes wrong with one layer, you have multiple layers to use as an alternative – in fact, most phones nowadays can connect to multiple layers at the same time to boost performance. Most of today's private wireless networks, in contrast, operate a single technology with a single band of spectrum. Thus, the reliability of this single layer coverage is very critical.

THE IMPACT OF CHOOSING THE WRONG TYPE OF RADIO FOR PRIVATE WIRELESS

For CSPs to provide basic coverage in houses, small shops and in small- to medium-size businesses, a new type of small cell was invented in 2005 called the Femtocell. Compared to traditional small cells that are macro BTSs shrunk in size with a less powerful radio (lower coverage), but the same features and capacity, Femtocells are even smaller radio access points with a minimum set of features and capabilities designed to provide cellular connectivity to just a few people in small and not very challenging radio environments. They need to be very cost effective for the business model to work, which means a much more relaxed approach to reliability, availability, and performance. Because of the layering in the public mobile network, if a Femto goes down, you will probably still be able to connect to another layer of the public network. And even if you cannot, the failure of the Femto only affects a few people for a short amount of time and, most of the time, not for critical use cases.

Femtocells are great, but only when used for the use cases for which they were created. Outside their "comfort zone" – the multi-layered public mobile network— they lack the performance and reliability, for example, that would be required by a typical Industry 4.0 application. This is similar to Wi-Fi – a great technology designed for IT needs, but rarely fit for OT needs. Today, there are many of these Femtocell (or cheap small cells) all-in-one chipsets available from chipset vendors.

These vendors not only provide the reference design but also the baseline software stack. It means virtually any company, even not a radio expert, can work with a contract manufacturer to rapidly build a range of private wireless radios based on these chipsets and baseline software. This is what is fueling the explosion in the market of many smaller players, start-ups or established 3GPP core companies, suddenly coming up with their own radio portfolio.

The problem is that these companies (often coming from the core side or even Wi-Fi side) lack the experience of running telco-grade 3GPP networks; meaning, they underestimate the importance of good radios. They do not necessarily understand the difference between a Femtocell and a real macro-parity small cell. The impact on private wireless performance and reliability can be dramatic.

TELCO-GRADE SMALL CELLS AND RADIOS

Nokia has over 30 years' experience creating and running telco-grade radio cells that reliably support hundreds and even thousands of simultaneous connections in the field, despite the difficult radio environments they operate in. The Nokia Flexi Zone all-in-one small cell range, which is built using the same purpose-built chipsets as our macro cells, can support transmission with up to 840 simultaneous users.

Our other telco competitors' all-in-one small cells, using off-the-shelf small cell chipsets, are already more in the range of 64-128 simultaneous users. And the smaller vendors, using off-the-shelf Femtocell chipsets, are often closer to 16-32 simultaneous users, which often isn't enough considering all the systems, assets, sensors and people that need to be connected in a typical industrial site; the sensor set for a single digitalized legacy machine could eat up the capacity of a single Femto-based cell. In addition, since they lack the processing power to simultaneously serve more users, they are also unable to run the same feature set as real small cells.

THE SCHEDULER AND WHY YOU SHOULD CARE

One of the greatest areas of differentiation when it comes to radio performance is the software and in particular the software for the scheduler, which is the application that manages users or devices connecting to the radio cell. In a nutshell, the better the scheduler, the more simultaneous devices can be served with reliable performance and the better the performance will be when the radio environment gets tough.

Scheduler design and implementation are a key differentiator between the large telco vendors; hence, it is a big R&D investment area and really influences field performance. How many users you can reliably support simultaneously, how much performance you will get in different areas of the cells, how well it manages interference, and even how far and/or deep the coverage goes are heavily influenced by the strength and capabilities of the scheduler.

The scheduler is something that network vendors have spent years developing since the early days of 3GPP technologies, and the oldest telco vendors have over 30 years of experience in developing and perfecting powerful, intelligent and feature-rich schedulers to deliver reliable performance in real conditions.

This deep experience and software intelligence does not come as part of the included reference design and baseline software stack provided with the merchant Femto/small cell chipsets being used by many small cell vendors today. That is why, in challenging radio environments like industrial sites, there is a real-life performance difference, even beyond multi-user capacity, between a good radio and a bad one.

When it comes to Nokia, the scheduler performance has always been one of our strengths; we have plenty of independent public network testing showing the superiority of our scheduler. That is why, when we developed our range of small cells (largely used for private wireless), we decided to do what was needed to have the same scheduler and the same advanced features in our all-in-one Flexi Zone small cells as on our macro cells, so that the performance would not be sub-par. Nokia's small cell performance clearly puts us leagues ahead of other private wireless vendors, and provides a world of difference from the smaller private wireless vendors, whose improvised radio portfolio is based on off-the-shelf Femto/small cell chipsets with baseline software and scheduler.

In conclusion, just as with availability, which I covered in the first blog, the reliable connectivity expected from private wireless is not something to take for granted when choosing a vendor. Meeting the 3GPP standard is no guarantee of actual performance. Look for a vendor that has deep experience designing and running critical networks and, ideally, running public mobile networks. This ensures that their solution will be carrier grade and high performance.

Think about the end-to-end integration and testing they can provide. And don't dismiss the importance of reliable, optimized and feature-rich software that has evolved over decades. The choice of system architecture and the quality of the radio should not be underestimated if you want to meet the critical requirements needed for today and tomorrow's Industry 4.0 applications.

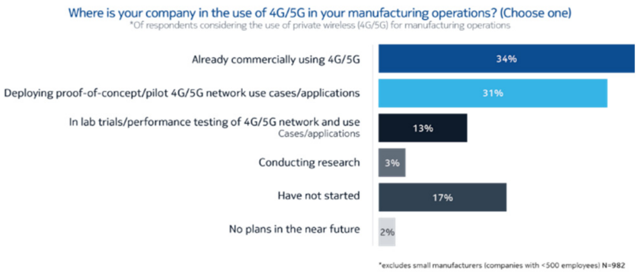
THE STATE OF THE PRIVATE WIRELESS MARKET 2022 FOR INDUSTRY 4.0

Over the last few years private wireless has proven to be the critical enabler to accelerate Industry 4.0. Its reliability, flexibility and mobility enable industries to adopt applications that have increased productivity, efficiency and sustainability. Nokia has led the private wireless revolution from the beginning, establishing the first private wireless network in 2012 with Rio Tinto, launching the world's first 5G SA capable private wireless solution in 2020, and working recently with NASA on their plans to put private wireless on the moon. As the pandemic winds down and we assess the private wireless market in 2022, what are the takeaways?

From the beginning, one of the challenges in developing the market has been to prove the relevance of the technology. Our efforts in the last decade have been about demonstrating capabilities and establishing trust. The good news in 2022 is that for most of the enterprise customers being surveyed, the importance of private wireless is now well established as the prime wireless connectivity solution for reliably connecting OT critical use cases assets.

PRIVATE WIRELESS IS HERE TO STAY

At this year's Mobile World Congress, private wireless was the main topic of the show. Based on research by Omdia – the Private LTE and 5G Network Tracker 1Q22, the top market for private wireless by number of announcements is manufacturing (28%) followed by transport and logistics (15%) and energy and mining (13%). According to Omdia Private LTE and 5G Network Enterprise Survey Insight – 2021 says that 78% of the surveyed enterprises are considering or already using private wireless technology, and 91% of those that are yet to deploy a private network view it as the desired technology for future deployments. When asked, 66% of enterprises expect a full return on their investment within two years.



4G/5G Adoption (Source: ABI Research)

Zooming in on the manufacturing market, 65% of executives say they are already using 4G/5G commercially or are piloting use cases (ABI). Only 2% of the manufacturing respondents said they have no plans to deploy private wireless.

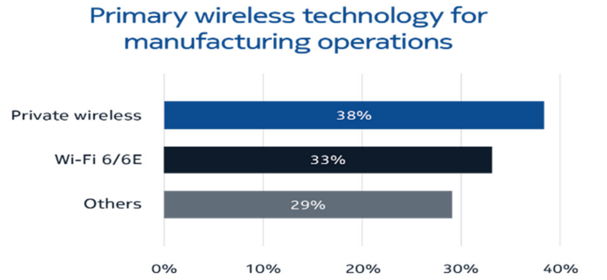
AN INDUSTRY 4.0 PLATFORM ENABLER

Our view of private wireless has always been that it would enable the digitization of physical industries. It is a necessary connectivity layer to support big data, industrial IoT, edge clouds, digital twins and analytics based on AI and machine learning (ML). These Industry 4.0 technologies will make widespread automation possible, allow for greater agility and resilience, and optimize processes within businesses and throughout their supply chains.

A GOOD RELATIONSHIP WITH WI-FI

A key shift we also see this year is the relationship between private networks and Wi-Fi. Private wireless 4.9G/LTE and 5G are enabling new OT applications that require high bandwidth, low latency like video inspection for example. However, Wi-Fi is not going away and there are a lot of industrial brownfield assets that connect via Wi-Fi. Having the right technology mix for the right applications is vital to transform businesses. Where basic connectivity for non-mission critical OT use cases is enough, Wi-Fi will continue to play a vital role.

While private wireless is gaining significant traction in all OT segments and will overtime dominate, currently Wi-Fi and especially the Wi-Fi 6/6E is also perceived as a viable wireless technology for certain non-business critical manufacturing operations. Wi-Fi doesn't require spectrum and can connect many assets that do not need mission critical connectivity. Daily IT applications for example that work in a static environment can be very well served by legacy Wi-FI 5 or Wi-FI 6.



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When it comes to OT use cases, such as important sensors inside machines, powering worker AR solution for critical repairs, remote control of a port cranes, or connection for autonomous mobile robot, private wireless is now seen as the prime solution providing the deep and wide reliable coverage and the predictable performance required to run such applications. Still, between IT and OT critical use cases, there are also less critical OT use cases – such as the plant manager MES access, static part storage solution, deskless worker information systems – that can tolerate variations in datarate and latency, and will not break the OT process if connectivity drops for a few seconds where Wi-Fi 6 and 6E can play a role.

CONCLUSION

2022 looks as if it is the start of the next phase of private wireless, with adoption beginning to climb the S-curve. We're seeing general enterprise acceptance of private wireless as a key technology in realizing Industry 4.0 ambitions [7, 8]. The ecosystem around 4.9G/LTE is there and 5G is developing with many new players becoming involved. End user devices are rapidly being developed and additional spectrum is coming available. It will be interesting to see how private wireless unfolds in 2022.

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ERICSSON MOBILITY REPORT (REVIEW. PART I)

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ABSTRACT

Resilient networks are the foundation for continued digitalization of societies and industries. Continuous network modernization and coverage build-out has led to several hundred million people becoming new mobile broadband subscribers every year. 5G is scaling faster than any previous mobile generation and we expect 5G subscriptions to reach 1 billion by the end of 2022. In several regions, deployment of 5G standalone networks is also picking up pace, as communications service providers prepare for innovation to address the business opportunities beyond enhanced mobile broadband. A solid digital network infrastructure underpins enterprises' digital transformation plans, and their new capabilities can be turned into new customer services. As exemplified in this edition, service providers are looking to expand out of pure connectivity into service enablement platforms. Global mobile network data traffic has doubled in the last two years, driven by continuing growth in smartphone usage, mobile broadband and now the digitalization of societies and industries. But traffic is not the only thing that grows. The ongoing war in Europe, as well as increased geopolitical tension in the world, leads to a range of global threats - economic as well as social - that must be navigated. And in our field of networking, the threat landscape calls for constant diligence in keeping ahead with security. You can read more about security in this edition. Managing the continued strong traffic growth while reducing energy consumption is also a top priority. Older technologies are being replaced by continuous build-out of 4G and 5G networks, substantially improving network performance and energy efficiency with each generation. 5G technologies play a key role in modernization, providing multiples of capacity while becoming more energy efficient. Innovative network technologies enable service providers to introduce new services that in turn support societies and enterprises to reduce their carbon emission footprint. In this edition, we share some examples of how 4G and 5G technologies make it possible to unleash the power of IoT connectivity to enhance both enterprises' business performance and sustainability.

KEYWORDS: *5G technologies, digitalization, mobile subscriptions.*

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INTRODUCTION

Taking a wide view, subscription and traffic trends are following the expected patterns in our forecasts – 5G and the associated new technologies are trending upwards, as older generations begin to slow or decline [1-3]. If we go down a layer, differences between the regions and countries become clear due to their unique circumstances. For example, while 5G dominates the stories in our forecasts, it's also notable that earlier-generation technologies still play an important role in closing the digital divide in many regions, by connecting the unconnected [4-7].

5G MOBILE SUBSCRIPTIONS TO SURPASS 1 BILLION IN 2022

By the end of 2027, 5G subscriptions are expected to reach 4.4 billion.

Service providers continue to switch on 5G and more than 210 have launched commercial 5G services globally. Deployment of 5G standalone (SA) networks is also increasing, with more than 20 commercial launches at the end of 2021. The most common 5G services that service providers have launched for con-sumers are enhanced mobile broadband (eMBB), fixed wireless access (FWA), gaming and AR/VR-based ser-vices. When it comes to 5G offerings for enterprises, the most common segments targeted are manufacturing (smart factories), transport, smart cities and ports.

A weaker global economy and the uncertainties caused by Russia's invasion of Ukraine have impacted our global estimate for 2022 by around 100 million, and the forecast has been adjusted accordingly.

Strong 5G subscription growth

5G subscriptions grew by 70 million during the first quarter to around 620 million, and that number is expected to surpass 1 billion by the end of this year. Currently, North America and North East Asia have the highest 5G subscription penetration, followed by the Gulf Cooperation Council countries and Western Europe. In 2027, it is projected that North America will have the highest 5G penetration at 90%.

By the end of 2027, we forecast 4.4 billion 5G subscriptions globally, accounting for 48% of all mobile subscriptions. 5G subscription uptake is faster than that of 4G following its launch in 2009, reaching 1 billion subscriptions 2 years sooner than 4G did. Key factors include the timely availability of devices from several vendors, with prices falling faster than for 4G, as well as China's large, early 5G deployments. 5G will become the dominant mobile access technology by subscriptions in 2027 (Fig. 1, 2).

Subscriptions for 4G continue to increase, growing by 70 million during the quarter to around to 4.9 billion. The technology is now projected to peak at 5 billion this year, then decline to around 3.5 billion by the end of 2027 as subscribers migrate to 5G.

3G subscriptions declined by 49 million, while GSM/EDGE-only subscriptions dropped by 59 million during the quarter and other technologies decreased by about 5 million.

During the quarter, China had the most net addi-tions (+16 million), followed by the US (+4 million) and Bangladesh (+3 million).

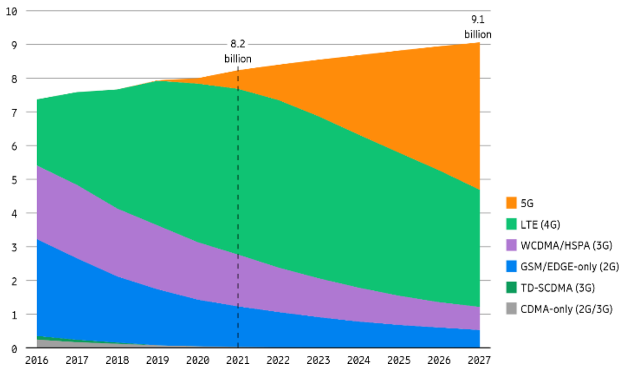


Figure 1. Mobile subscriptions by technology (billion)

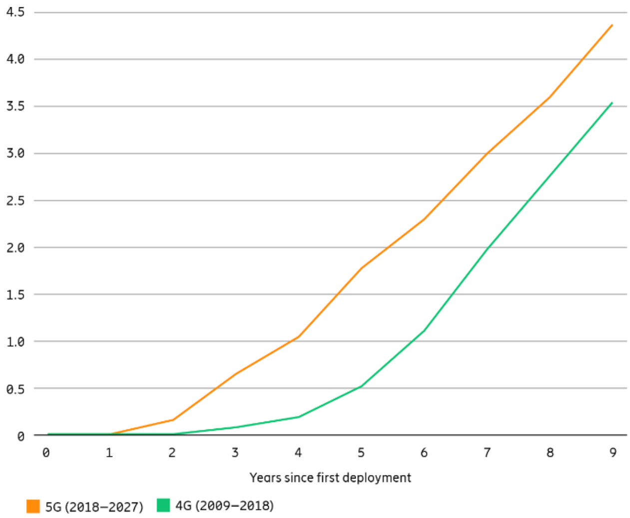


Figure 2. Comparison of 5G and 4G subscription uptake in the first years of deployment (billion)

Mobile broadband dominates mobile subscriptions

At the end of 2021, there were around 8.2 billion mobile subscriptions, and we project this figure will increase to around 9.1 billion by the end of 2027. During the same time, the share of mobile broadband subscriptions will increase from 84 to 93%. The number of unique mobile subscribers is projected to grow from 6.1 billion at the end of 2021 to 6.7 billion by the end of the forecast period.

Subscriptions associated with smartphones continue to rise. At the end of 2021 there were 6.3 billion, accounting for about 77% of all mobile phone subscriptions. This is forecast to reach 7.8 billion in 2027, accounting for around 87% of all mobile subscriptions at that time.

Subscriptions for fixed broadband are expected to grow around 4% annually through 2027.4 FWA connections are anticipated to show strong growth of 17% annually through 2027. Subscriptions for mobile PCs and tablets are expected to show moderate growth, reaching around 540 million in 2027 (Figure 3).

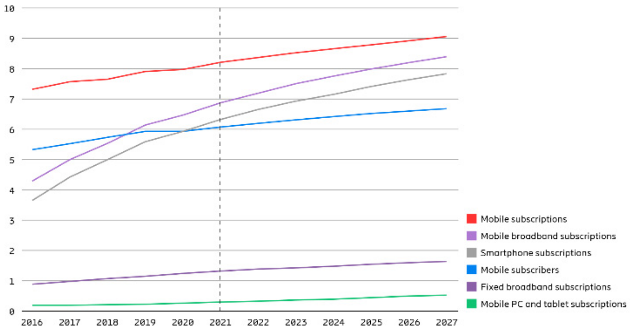


Figure 3. Subscriptions and subscribers (billion)

NORTH AMERICA AND NORTH EAST ASIA REGIONS REACHED SIMILAR 5G SUBSCRIPTION PENETRATION IN 2021

Sub-Saharan Africa

Demand for mobile voice and data services continues to grow in the region. Investment in telecom infrastructure accelerated during 2020-2021 in the wake of COVID-19, including mobile coverage and fixed wireless access (FWA) build-out, enabling service providers to address additional subscriber segments with mobile broadband. In 2021, the number of 4G subscriptions grew by 26%, and strong growth is expected to continue during 2022. Migration towards 4G devices continues to be an important driver for 4G subscription uptake, which in turn drives the growth of mobile data traffic. 3G mobile data traffic is still increasing, but the majority of traffic growth is expected to be in 4G. Over the forecast period, total mobile broadband subscriptions are predicted to increase, reaching 78% of mobile subscriptions.

Regulatory initiatives are being taken to make more spectrum available in key markets across Africa. This will enable access to mobile services for a larger part of the population, especially in rural areas that have traditionally been underserved.

Middle East and North Africa

Mobile subscription growth in the region is predominantly driven by the uptake of 4G services in less mature markets. In 2021, 4G subscriptions increased by about 54 million, while 2G and 3G declined.

Digitalization is a high priority in some countries as a means for transforming economies and societies. Service providers are motivated to undertake extensive network modernization and expansion to improve network performance, which stimulates further subscription growth. 5G subscriptions grew to around 10 million in 2021, and the region is forecast to reach nearly 200 million 5G subscriptions in 2027.

Gulf Cooperation Council (GCC)

In the GCC countries that are major travel destinations, tourism has begun to return to pre-pandemic levels, giving rise to seasonal, mostly pre-paid mobile subscriptions. 5G saw strong growth in 2021, adding 5 million subscriptions, while 4G grew by less than 1 million subscriptions. From 2022 onwards, 5G will be the only growing subscription type. It is expected to reach over 65 million, representing 80% of total subscriptions in 2027. Monetization through growing both traditional and IoT mobile connections remains a key short-term priority for service providers (Figure 4).

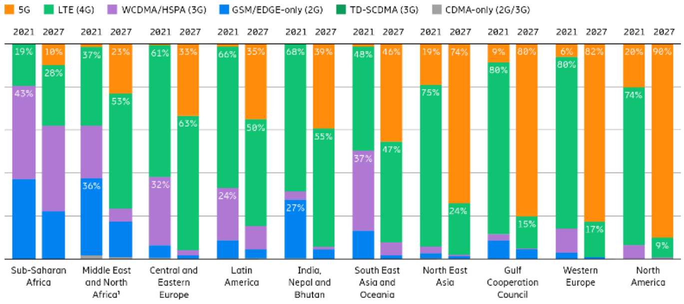


Figure 4. Mobile subscriptions by region and technology (percent)

Another focus is extracting value from network investments through partnerships with regulators, solution providers, and vendors. Service providers are also exploring new types of service offerings, for example at mega-events such as the 2022 international football tournament in Qatar.

GCC service providers are targeting a range of services beyond mobile broadband to monetize 5G, including IoT, financial services, video services and cloud gaming. All these have the potential to increase mobile subscriptions, data consumption and service revenues. As demand for high-speed connectivity increases, FWA will also drive growth in broadband subscriptions. Demand for dedicated networks is also expected to grow as 5G use cases emerge.

Central and Eastern Europe Technology adoption and subscription uptake are typically slower in this region than in Western Europe. This is due in part to slower spectrum allocation processes, as well as consumers being reluctant to upgrade to more expensive subscriptions. 4G is the dominant technology, accounting for 61% of all subscriptions at the end of 2021. Mobile subscription growth has flattened, and is expected to be virtually zero in the coming years. However, migration from 2G/3G to 4G continues to look strong up to 2024, from which time 5G is expected to add the most subscriptions. During the forecast period, there will continue to be a significant decline in 3G subscriptions, from 32% of mobile subscriptions to 3%.

Latin America

4G is currently the dominant radio access technology in the region, accounting for two-thirds of all subscriptions at the end of 2021. 4G subscription growth is strong, with more than 70 million added in 2021, and growth is expected to continue during 2022. However, 3G subscriptions are steeply declining as users migrate to 4G and 5G. Many service providers will sunset 3G networks in the next two years to enable the reuse of valuable radio spectrum for 4G deployments.

Commercial 5G has been launched in seven countries, and trials are ongoing in six other countries. Service providers are accelerating 5G deployments in mid-band (3.5GHz) and low-band to stimulate 5G subscription uptake. There were around 5 million 5G subscriptions at the end of 2021, and more substantial uptake is expected from 2023 onwards. By the end of 2027, 5G will account for 35% of mobile subscriptions.

India, Nepal and Bhutan

In India, mobile broadband is the foundation on which the government's "Digital India" initiative will be realized. Currently, 4G is the dominant subscription type driving connectivity growth.

Commercial launches of 5G networks are planned for the second half of 2022 in India, with enhanced mobile broadband expected to be the initial main use case.

With increasing availability and affordability of 5G smartphones, along with rapid adoption of smartphones in urban and rural areas, 5G subscriptions are expected to rapidly increase to reach around 50 million in the region by the end of 2023. 5G will represent around 39% of mobile subscriptions in the region at the end of 2027, with about 500 million subscriptions. As subscribers migrate to 5G, 4G subscriptions are forecast to decline annually to an estimated 700 million subscriptions in 2027.

South East Asia and Oceania

4G is currently the dominant radio access technology in the region, making up 48% of all subscriptions at the end of 2021. In 2021, almost 100 million 4G subscriptions were added, and this strong growth is projected to continue in 2022. 5G subscriptions were around 15 million at the end of 2021 and are expected to more than double during 2022. As more network deployments take place over the next few years, 5G mobile subscriptions are expected to grow at an CAGR of 83% over the forecast period, reaching 570 million in 2027.

There are about 15 commercial 5G mobile networks in the region, including in Australia, Singapore, New Zealand, Thailand, Indonesia, Malaysia and the Philippines. Trials have also commenced in several countries including Cambodia, Sri Lanka and Vietnam, highlighting the strong 5G momentum in the region.

In addition to mobile services, service providers in Australia, Indonesia and the Philippines have also launched 5G FWA services. In Australia, all service providers have deployed 5G in a combination of low-, mid- and high-bands.

North East Asia

Service providers continue to invest strongly in 5G deployments to further fuel 5G subscription growth. The current focus for service providers is to improve nationwide coverage by adding more sites or introducing services on low-band.

In 2021, 5G grew strongly, adding around 275 million subscriptions, as migration from 4G to 5G subscriptions picked up pace. 5G is the only growing subscription type and is expected to reach 1 billion at the end of 2023. The rapid growth of 5G subscriptions, supported by the availability of more 5G device models, has positively impacted service providers' financial performance. Major service providers in leading 5G markets, such as China, Taiwan and South Korea, have reported a positive impact of 5G subscribers on service revenues and ARPU in 2021.

Western Europe

4G is widely deployed and has the highest penetration of all regions.3 Due to continued migration from 2G and 3G, 4G subscriptions grew by 7%to account for 80% of all mobile subscriptions at the end of 2021. 5G subscription growth was also strong, rising from 5 million in 2020 to 31 million in 2021.

4G is expected to decline in favor of substantially increased 5G subscription uptake from 2023 onwards. 5G subscriptions are expected to reach almost 150 million at the end of 2023, and penetration will reach 82% by the end of 2027. Many service providers will be sunsetting 3G networks in the next few years to enable the reuse of radio spectrum for 4G and 5G.

North America

5G has entered the second wave of build-outs and user adoption. New mid-band spectrums (C-band and 3.45-3.55GHz) in multi-band 5G networks enhance the mobile user experience, stimulating subscription growth. In 2021, 5G grew strongly, adding around 64 million subscriptions, as migration from 4G to 5G subscriptions picked up pace significantly. 5G is the only growing subscription type and is expected to reach 250 million at the end of 2023. An increasing variety of broadband bundles offered by service providers across North America makes it easy for customers to find suitable 5G service offerings. FWA has gained traction as a fixed broadband option for consumers, as well as small and medium enterprises. By 2027, 400 million 5G subscriptions are anticipated, accounting for 90% of mobile subscriptions.

INDIA'S 5G FUTURE: A CLOSER LOOK

India is among the world's fastest growing economies. It has a developed software industry with e-commerce, digital payments and educational technology standing out. Industrial enterprises are making unprecedented investments in digital transformation to modernize their processes – increasing demand for reliable network connectivity.

India's strong growth supports a dynamic mobile services market. Over the past five years, it has seen rapid adoption of smartphones and migration up to 4G. In the region as a whole (including India, Nepal, and Bhutan), the share of 4G has grown from 9% of mobile subscriptions in 2016 to 68% in 2021.

This has had a significant positive impact on India's consumers, economy and society. With a low penetration of fixed broadband, consumers have mostly relied on mobile broadband for remote working, education, healthcare services, shopping and other services during the COVID-19 pandemic.

Challenges in the Indian market

While India presents significant opportunities for growth, it also holds challenges for service providers.

Indian service providers have recently been raising the price of data (the average price of 1GB of mobile data reached USD 0.68 in 2021) and mobile services revenue has continued to grow. Despite this, service provider ARPU remains low. Moreover, India has some of the highest prices for spectrum in the world, constraining service providers' ability to invest in infrastructure.

In the India region as a whole, mobile data traffic has grown by more than 15 times in the past 5 years (from 0.8EB per month to 13EB per month in 2021) and is expected to more than double in the next 3 years.

With the projected traffic increase, service providers would benefit significantly from the efficiency gains provided by 5G.

The state of 5G

The Indian Department of Telecommunications (DoT) plans to auction 5G spectrum in June–July 2022. Even as the government continues to work on the process of auctioning 5G spectrum, India's leading service providers are testing 5G at multiple locations, focusing on use cases for both urban and rural consumers. These include FWA for rural broadband, mobile cloud gaming, cloud-connected robotics, and remote healthcare.

5G outlook

5G is projected to account for almost 40% of mobile subscriptions – 500 million – by the end of 2027. By then, smartphone users in the region are forecast to consume 50GB of data per month on average. Even though 5G has not been launched commercially, there is already a good foundation for 5G uptake in India. There is significant consumer interest in adopting 5G – as an Ericsson ConsumerLab study indicated, 40 million smartphone users could take up 5G in its first year of availability.

Additionally, 21% of respondents that are smartphone users indicated that they already have a 5G-ready device.

Indian consumers also claim to be willing to pay 50% more for 5G bundled plans. This presents a unique opportunity to grow revenue within a market that has historically had very low ARPU.2

Looking into the future

According to an Ericsson-Arthur D Little study, 5G will enable Indian mobile service providers to generate USD 17 billion in incremental revenue from enterprises by 2030. Much of this is projected to be driven by the adoption of 5G in the manufacturing, energy and utilities, ICT and retail industries. Indian enterprises consider 5G to be the most important technology for their digital strategies.

5G will also enable service providers to launch new services for consumers, including home broadband (5G FWA), enhanced video, multiplayer mobile gaming, and AR/VR services. Consumers anticipate that service providers will offer pricing plans with service bundling and data sharing.

5G can play an important role in achieving India's digital inclusion goals, especially in bringing broadband to rural and remote homes. Trials have proven the potential offered by 5G to bridge the digital divide by enabling access to high-speed broadband through FWA.

OVER 100 MILLION FWA CONNECTIONS IN 2022

More than 75% of service providers surveyed in over 100 countries are offering fixed wireless access (FWA) services. Around 20% of these service providers apply differential pricing with speed-based tariff plans.

Service providers with FWA offerings doubled in three years

An updated Ericsson study1 of retail packages offered by service providers worldwide shows that, out of 311 service providers studied, 238 had an FWA offering, representing an average of 77% globally. Service providers' adoption of FWA offerings has more than doubled in the last three years.

More service providers now offering 5G FWA

During the last 6 months, the number of service providers offering 5G FWA services has increased from 57 to 75, representing growth of around 30%. There is growth across all regions, with the strongest increase in North America, where 60% of all service providers surveyed now offer 5G FWA. During the last 6 months, the number of service providers offering 5G FWA services has grown by about 30% (Fig. 5, 6).

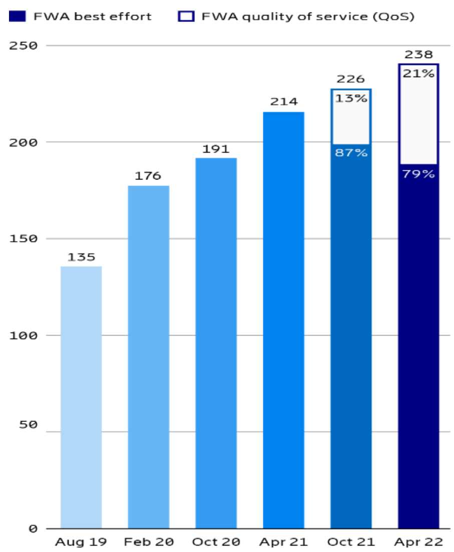


Figure 5. Global number of service providers offering FWA

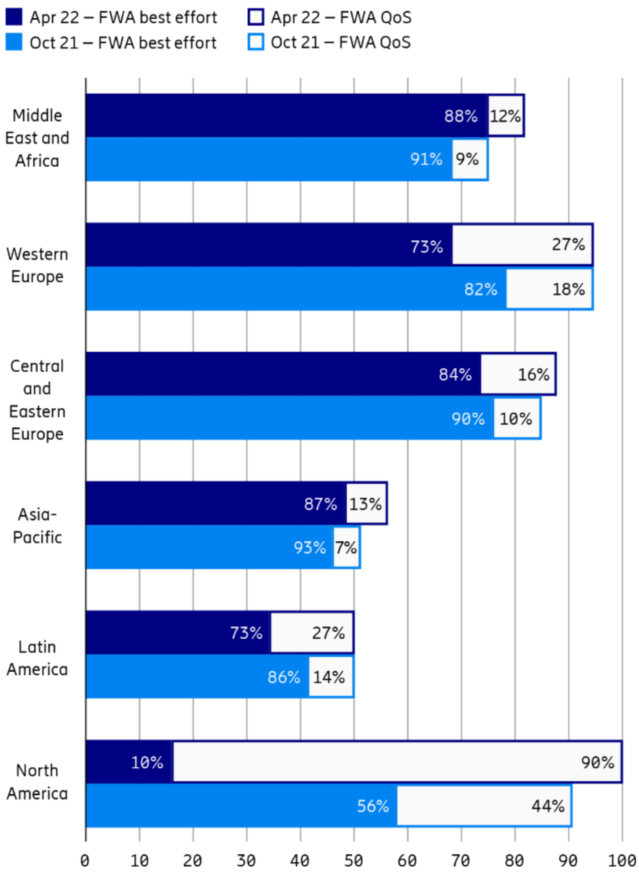


Figure 6. Regional% age of service providers offering FWA

Speed-based tariff plans on the rise

The majority (79%) of FWA offerings are still best effort, with volume-based tariff plans (that is, buckets of GB per month). About 20% of service providers offer speed-based tariff plans (also referred to as QoS), a significant increase from 13% in October 2021.

Speed-based tariff plans are commonly offered for fixed broadband services such as those delivered over fiber or cable. These types of plans are well understood by consumers, enabling the service providers to fully monetize FWA as a broadband alternative. Around 20% of these speed-based offerings are basic, with average/typical speeds being advertised. Almost 80% are more advanced offerings, involving speed tiers, such as 100Mbps, 300Mbps and 500Mbps. Service providers with 5G FWA are more likely to have QoS FWA with speed-based offerings, with 26 out of 75 utilizing this approach (35%). Speed-based offerings are growing across all regions, with the North America region showing the highest adoption, with 90% of all offerings being speed based.

High numbers of service providers in all regions offering FWA

More than 80% of service providers in North America, Europe and the Middle East and Africa regions are offering FWA. In Latin America and Asia-Pacific, more than 50% of service providers are offering FWA. All service providers in North America offer FWA services.

FWA connections set to more than double by 2027

Some service providers and regulatory bodies are starting to report FWA connections, but globally there is still limited reporting. Based on Ericsson's own research, we estimate that there were close to 90 million FWA connections by the end of 2021, and during 2022 that figure will exceed 100 million. This number is forecast to more than double by 2027, reaching almost 230 million. This figure represents 15% of fixed broadband connections. Of these 230 million, the number of 5G FWA connections are expected to grow to around 110 million by 2027, representing almost half of the total FWA connections.

FWA data traffic projected to grow by almost five times

FWA data traffic represented almost 20% of global mobile network data traffic by the end of 2021, and is projected to grow almost 5 times to reach 86EB in 2027.

MID-TIER SMARTPHONES TAKE 5G INTO THE MAINSTREAM

5G adoption continues

- Over 650 5G smartphone models have been launched, accounting for 50% of all 5G devices by form factor.
- 5G device shipments more than doubled in 2021 over 2020 and surpassed 615 million units shipped.
- There is a greater focus on standalone (SA) enablement for smartphones including 3CC New Radio (NR) carrier aggregation.
- Global smartphone shipments rose 6% in 2021 compared with 2020. However, additional limitations are evident in 2022 due to geopolitics, continued supply chain constraints and the COVID-19 situation in China.
- There is an optimistic outlook for extended reality (XR) use cases over the intermediate term based on XR glasses, headsets or heads-up displays as peripherals connected to smartphones or other 5G smart devices.

Devices in 2022

In line with expectations, devices introduced so far in 2022 show improved capabilities, including carrier aggregation extended from two to three NR carriers for SA, NR dual connectivity for SA and improved uplink capabilities. The trend is clear, with more focus on SA. Apart from improved device capabilities, a wider range of 5G smartphone models are now available in the mid-tier price segment. This means that 5G smartphones are becoming increasingly affordable for more market segments.

This comes at a time when we see a price trend break at the lowest end of 5G devices. Impacted by supply, inflation and globalization challenges, there have been indications for some time of an emerging price floor of USD 120.

5G use cases for the future

The latest Mobile World Congress was awash with XR demos. Bounded – or committed maximum – latency, combined with network slicing, enables new device-powered use cases and will result in new innovations. As XR glasses will be connected through companion devices for the next few years, the smartphone will likely be part of that innovation for a longer time than generally anticipated. The first devices have started to enter the market, and more are expected throughout this year.

In 2024, the first reduced capability (RedCap) devices should be available, introducing relaxed requirements on the receiver in the device, allowing lower costs compared to standard NR. RedCap devices can facilitate the expansion of the NR device ecosystem to cater to the use cases that are not currently best served by NR specifications. This includes wearables, industrial wireless sensors and video surveillance (Figure 7).

5G SA networks increasingly deployed More than 20 service providers had launched public 5G SA networks on mid- and low-band by the end of 2021.

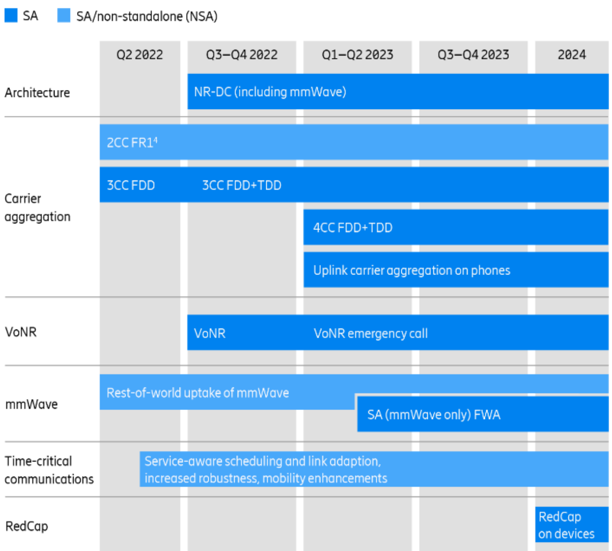


Figure 7. 5G technology market readiness

MASSIVE IOT SHOWS STRONG GROWTH IN 2021

The Massive IoT technologies NB-IoT and Cat-M – primarily consisting of wide-area use cases involving large numbers of low-complexity, low-cost devices with long battery life and low throughput – continue to be rolled out around the world. The number of IoT devices connected via 2G and 3G has been in slow decline since 2019, and NB-IoT and Cat-M technologies are the natural successors. The number of devices connected by these Massive IoT technologies increased by almost 80% and reached close to 330 million in 2021.

The number of IoT devices connected by NB-IoT and Cat-M technologies is expected to overtake 2G/3G connected IoT devices in 2023, and to overtake broadband IoT in 2027, making up 51% of all cellular IoT connections at that time. The growth of Massive IoT technologies is enhanced by a recently added network capability that enables Massive IoT co-existence with 4G and 5G in FDD bands, via spectrum sharing.

About 124 service providers have commercially launched NB-IoT networks and 55 have launched Cat-M. These technologies complement each other, and around 40 service providers have launched both technologies.

In 2021, broadband IoT (4G/5G) overtook 2G and 3G as the technology that connects the largest share of all cellular IoT connected devices, accounting for 44% of all connections. Broadband IoT mainly includes wide-area use cases that require high throughput, low latency and large data volumes.

By the end of 2027, 40% of cellular IoT connections will be broadband IoT, with 4G connecting the majority. As 5G New Radio (NR) is being introduced in old and new spectrum, throughput data rates will increase substantially for this segment.

North East Asia is the leading region in terms of the number of cellular IoT connections, and is forecast to reach 1.5 billion in 2022. The region is set to account for 60% of all cellular IoT connections in 2027 (Figure 8).

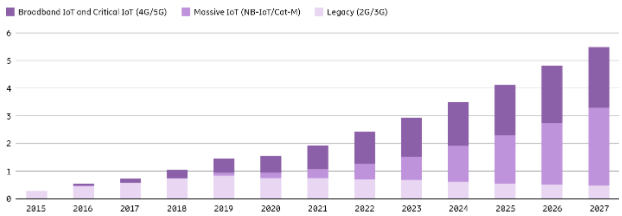


Figure 8. Cellular IoT connections by segment and technology (billion)

ENHANCED COMMUNICATION SERVICES FROM VOLTE TO VONR

VoLTE continues to grow

Service providers continue to use the IP Multimedia Subsystem (IMS) to support mobile voice services for 4G and 5G smartphones and other smart devices.

Voice over LTE (VoLTE) has been activated in over 280 networks to date. Now, launches of Voice over New Radio (VoNR) – the voice application for 5G standalone (SA) networks – have commenced.

It is estimated that the number of subscriptions with voice service built on IMS will exceed 4.6 billion by the end of 2022 and is projected to reach nearly 7 billion by the end of 2027. This will account for around 90% of all combined 4G and 5G subscriptions at that time. This is partly driven by the growing obsolescence of Circuit-Switched Fallback (CSFB) which requires 2G or 3G.

First commercial VoNR services to be introduced

IMS is the standardized voice platform for 5G SA networks, which do not support CSFB. 5G voice services can be deployed using a variety of applications in 5G networks: LTE New Radio (NR) dual connectivity, Evolved Packet System (EPS) fallback and VoNR. These are used in different phases of the 5G coverage build-out. Once nationwide 5G SA is in place, only VoNR will be used. The first EPS fallback voice-enabled networks have gone live in North America, Asia-Pacific and Europe. VoNR and 5G video calling has completed interoperability testing with network infrastructure and devices, and the first VoNR services are ready to be rolled out.

Device availability and use case uptake There are more than 650 voice-enabled 5G smartphone models available.

The majority of these smartphones support 5G non-standalone (NSA) networks and the remaining, and quickly growing, part supports 5G SA. Note that all 5G SA smartphones support IMS for voice. Other devices include indoor and outdoor customer premises equipment with fixed wireless access (FWA) capabilities.

New voice use cases leveraging IMS include multi-device network capabilities which tie several devices – such as phones, smartwatches, smart speakers and cars – to the same phone number. More than 100 networks support cellular smartwatches with a VoLTE one-number service.

Europe following North America's trends An application built on IMS enables mission-critical push-to-talk services for public safety organizations, utilities and local private 4G networks. This has started to be deployed widely in North America, and now the European market is following suit. Once mission-critical communications for 5G have been finalized in the 3GPP standards, additional use cases with low latency and high-capacity broadband can be enabled.

VoLTE subscriptions are predicted to exceed 4.6 billion by the end of 2022 (Figure 9).

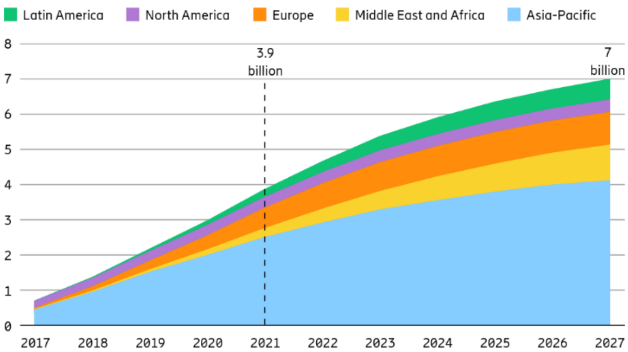


Figure 9. VoLTE subscriptions by region (billion)

Continued strong smartphone adoption and video consumption are driving up mobile data traffic, with 5G accounting for around 10% of the total in 2021.

Total global mobile data traffic – excluding traffic generated by fixed wireless access (FWA) – reached around 67EB per month by the end of 2021 and is projected to grow by a factor of around 4.2 to reach 282EB per month in 2027. Including FWA, this takes the total mobile network traffic to around 84EB per month by the end of 2021, and to 368EB per month by the end of 2027. The traffic growth up to 2027 includes an assumption that an initial uptake of XR-type services, including AR, VR and mixed reality (MR), will happen in the latter part of the forecast period. If adoption is stronger than expected, data traffic could increase even more than currently anticipated towards the end of the forecast period (particularly in the uplink). Currently, video traffic is estimated to account for 69% of all mobile data traffic, a share that is forecast to increase to 79% in 2027.

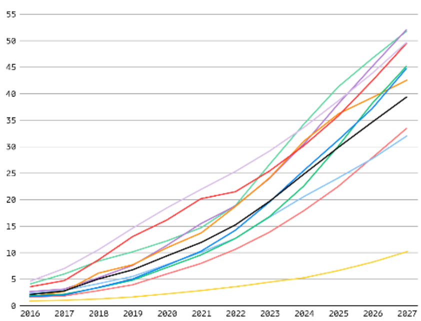
Populous markets that launch 5G early are likely to lead traffic growth over the forecast period. 5G's share of mobile data traffic was around 10% in 2021, and this share is forecast to grow to 60% in 2027.

Traffic growth varying across regions Traffic growth can be highly volatile between years and can vary significantly between countries, depending on local market dynamics. Globally, the growth in mobile data traffic per smartphone can be attributed to three main drivers: improved device capabilities, an increase in data-intensive content and growth in data consumption due to continued improvements in the performance of deployed networks.

Globally, the average monthly usage per smartphone is expected to surpass 15GB in 2022. These differences are reflected, for example, in the difference between the Sub-Saharan Africa region, where the average monthly mobile data usage per smartphone was 3GB, and the Gulf Cooperation Council countries where it was 22GB per smartphone in 2021. The global monthly average usage per smartphone was 12GB by the end of 2021 and is forecast to reach 40GB by the end of 2027.

New services expected to drive data growth in North America

In North America, the average monthly mobile data usage per smartphone is expected to reach 52GB in 2027. Unlimited data plans and improved 5G network coverage and capacity are increasingly attracting new 5G subscribers. The data traffic generated per minute of use will increase significantly in line with the expected uptake of new XR and video-based apps. This is due to higher video resolutions, increased uplink traffic, and more data from devices off-loaded to cloud compute resources. In 2027, 5G subscription penetration in North America is predicted to be the highest of all regions at 90% (Figure 10).



Regions	2021	2027	CAGR 2021–2027
North America	15	52	24%
Western Europe	15	52	23%
GCC	22	50	15%
India, Nepal, Bhutan	20	50	16%
South East Asia and Oceania	9.4	45	30%
Middle East and North Africa[1]	10	45	28%
North East Asia	14	43	21%
Global average	12	40	22%
Latin America	7.9	34	28%
Central and Eastern Europe	10	32	22%
Sub-Saharan Africa	2.9	11	25%

Figure 10. Mobile data traffic per smartphone (GB per month)

In **Western Europe**, service usage and traffic growth is expected to follow a similar pattern to that anticipated for North America. The more fragmented market situation has led to later mass-market adoption of 5G. But, by 2027, traffic usage per smartphone is projected to reach 52GB per month – similar to the usage in North America at that time.

The **North East Asia** share of total global mobile data traffic is expected to be around 30% in 2027. In the region, 5G subscribers currently use, on average, 2–3 times the amount of data than 4G subscribers. As more 4G subscribers migrate to 5G, average mobile data traffic per smartphone will increase. Video is the dominant traffic type. For example, in South Korea, video traffic share has increased 6% age points since the introduction of 5G services in 2019. Service providers expect additional traffic growth with the introduction of new video services, for example high-definition video and XR services.

In the **Middle East and North Africa region**, data traffic is expected to continue rising as the transition to 4G networks continues, coupled with the availability of more affordable 4G devices and data packages. The average data traffic per smartphone is expected to be around 45GB per month in 2027.

In the **Gulf Cooperation Council (GCC)** countries, smartphone data traffic will increasingly be lifted by 5G traffic due to the availability and relative affordability of 5G devices, especially in the higher ARPU markets. Operator monetization plans for 5G will also bring to bear a myriad of services relying on eMBB (enhanced Mobile Broadband), further stimulating data traffic growth. By the end of the forecast period, it is expected to reach an average of around 50GB per month.

Data traffic in **Sub-Saharan Africa** will maintain an upward trajectory, as mobile broadband-capable devices become more accessible. This is due to increasingly affordable price plans and service provider subsidies in some parts of the region. In markets such as South Africa and Kenya, recent spectrum allocations will enable service providers to extend their coverage and capacity of 3G/4G networks, leading to rising data traffic. 3G mobile data traffic is still increasing, but most of the traffic growth is expected to be in the 4G networks. The average data traffic per smartphone is expected to reach 11GB per month over the forecast period.

In **India, Nepal and Bhutan**, people have been dependent on mobile networks to stay connected during the successive lockdown waves, in both their personal and work lives. Mobile networks continue to play a pivotal role in driving social and economic inclusion, as service providers in India prepare to launch 5G this year.

Total mobile data traffic in the India region is estimated to grow by a factor of 4 between 2021 and 2027. This is driven by high growth in the number of smartphone users and an increase in average usage per smartphone. The average data traffic per smartphone in the India region is the second highest globally. It is projected to grow from 20GB per month in 2021 to around 50GB per month in 2027 – a CAGR of 16%.

In **South East Asia and Oceania**, mobile data traffic per smartphone continues to grow strongly and is expected to reach around 45GB per month in 2027 – a CAGR of 30% . Total mobile data traffic is expected to grow by a factor of around 6 between 2021 and 2027, driven by continued strong growth in 4G subscriptions and increasing 5G subscription uptake in several markets. Wider 5G adoption and new XR services are expected to drive traffic growth in the latter part of the forecast period up to 2027.

Latin America is expected to follow a similar trend as South East Asia and Oceania over the forecast period, while individual countries show very different growth rates for data traffic per smartphone. Traffic growth is driven by coverage build-out and continued strong adoption of 4G (and eventually 5G), linked to a rise in smartphone subscriptions and an increase in average data usage per smartphone. The average data traffic per smartphone is expected to reach 34GB per month in 2027.

In **Central and Eastern Europe**, growth is fueled by the migration of 2G and 3G subscribers to 4G, up to 2024, which is when 5G is expected to overtake previous generations as the technology contributing the most subscriptions. Over the forecast period, the monthly average data traffic per smartphone is expected to increase from 10GB to around 32GB per month.

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

5G OFFERINGS PICKING UP SPEED

An updated Ericsson study1 of retail packages offered by 311 mobile service providers worldwide shows that, although the type of service packaging remains similar to previous studies, an increasing number of service providers are expanding the list of options available to consumers. However, the most common variants are the same and the innovation is mostly found in variations of existing themes.

Data buckets remain the default offerings for nearly all service providers (99%). A common approach is to complement with "service-based connectivity packs" or an unlimited option at the premium end. Nearly 40% of all service providers surveyed offer unlimited data under their premium packages. However, boundary conditions, such as not allowing tethering or limiting the use of IoT devices, are becoming more common with these offerings.

More than 90% of service providers applying these conditions have launched 5G. It may sound counterintuitive to put limitations on packages that are being sold as "unlimited". However, it highlights some of the challenges that these types of packages bring, especially with 5G offering throughput which could mean that certain usage may equal hundreds, if not thousands, of GB per month.

The service-based connectivity model seems to be going through a change. The total number of service providers offering any type of service-based connectivity continues to increase. At the same time, the number of those targeting data-intensive services, such as gaming or video and music streaming, have decreased somewhat. However, many of these seem to have been refining their packaging.

Previously, add-on packs were often found under a separate website "tab" and were at risk of going unnoticed by many consumers. Now, numerous service providers have made them an integral part of the subscription selection process. After choosing the bucket size, and perhaps a speed tier, it is a matter of choosing click-to-add extras such as a "video pack" or an "education pack" (Figure 11).

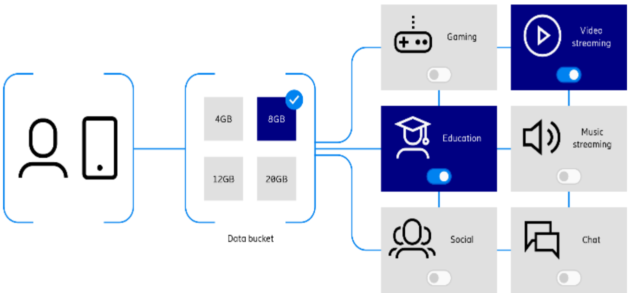


Figure 11. Example of how consumers can build custom service packages

This selection then provides additional GB to use for that particular service class, or even unlimited use without depleting the basic bucket. Service-based connectivity packs offer GB or hours (unlimited also available) to be used only for a specific service, without consuming data from the base subscription. Commonly, these offerings target data-intensive services like video streaming/conferencing or cloud gaming. The offering only provides the connectivity; service subscriptions must be purchased separately.

During the early days of the pandemic, specific service-based connectivity packages, often labeled "work and education packs" were offered in some markets. These packages typically offered discounted GB to use for a combination of video conferencing services, streaming, office software suites and web browsing.

These types of packages have now become quite common, especially in markets with lower income levels, mostly in South East Asia and Eastern Europe (Figure 12).

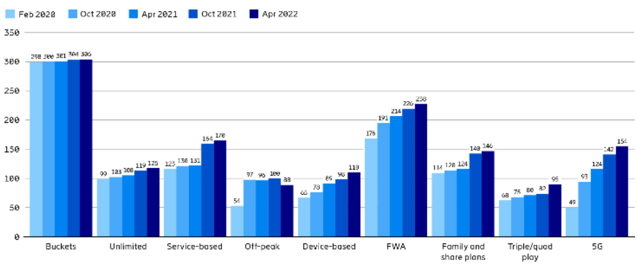


Figure 12. Number of service providers per type of offering

Extracting a premium for 5G

The number of networks that offer 5G continues to increase and nearly 50% of the service providers surveyed have now launched 5G for smartphones. Of these, 35% charge a premium for 5G services. The average price premium over 4G is around 11%.

Using speed tiers to incentivize consumers

A significant% age of service providers offering fixed wireless access (FWA) have been using speed tiers (also known as quality of service, or QoS) to segment the market and motivate consumers to move up to higher-priced tiers. Similarly, 5G service providers are now starting to use speed tiers for smartphones to extract additional value. Some of them also offer speed tiers for 4G services, but it is the wider range of speed enabled by 5G that makes such offerings attractive. Nearly 18% of 5G service providers are utilizing speed as a segmentation tool.

In Western Europe, however, this proportion is nearly 30%. A majority (60%) of the service providers using speed tiers are doing so in combination with both bucket and unlimited packages. In many cases, speed is used in combinations where the consumer can choose between similarly priced packages with a high speed but limited data allowance, or a lower speed coupled with unlimited traffic.

Others simply provide the highest speeds with the most expensive plans. One interesting, and somewhat unique, example is a service provider which offers consumers a choice between two premium packages (a 15GB bucket or unlimited data) followed by a choice between three speed tiers: 15Mbps, 150Mbps or 1Gbps – at different price points.

Gaming draws consumers to 5G

So far, cloud gaming services have exclusively been launched alongside 5G packages, with 35 service providers offering this at the time of the study. Generally, these services are developed by a partner company that provides the cloud gaming hardware acceleration platform, which is then packaged and offered by the service provider. This is often done with a revenue share model and the service provider implementing some form of "carrier billing".

About one in five service providers have taken this approach a step further, and have created specific connectivity packages targeting gaming users.

These are designed as service-based connectivity packs which offer unlimited or time-based gaming sold as add-on packages. This allows consumers to play cloud-based games without consuming data from their regular buckets.

So far, only one service provider surveyed has created a package targeting the frustration at the heart of all gamers – lag. They use marketing terms like "priority" and "more network resources to beat lag when gaming" as a way to attract gamers and make 5G stand out in terms of the low-latency capability it offers.

Beside the use of speed tiers and adding new advanced services, like gaming, it is common to bundle with popular streaming services. Around 45% of 5G service providers are doing this in various forms with their more expensive offers. To summarize, there is an increased effort to differentiate 5G subscription offerings to provide additional value compared to 4G.

5G SA DEPLOYMENT: MOVING BEYOND EMBB

An increasing number of progressive service providers in several markets are deploying 5G SA networks. More than 20 had launched public 5G SA networks on mid- and low-band by the end of 2021. This figure is expected to double during 2022 as more service providers deploy 5G New Radio (NR) SA and 5G Core networks. China and North America were the first markets in which 5G SA was launched, followed by commercial launches in several other markets, including Australia, Japan, South Korea, Singapore, Thailand, Germany and Finland. 5G SA networks provide a substantial competitive advantage for service providers that leverage its full benefits and potential.

5G SA mid-band (TDD) deployments with continuous coverage are important to deliver a consistent user experience for the new differentiated service offerings enabled by SA architecture.

Realizing 5G's full potential

The overwhelming majority of commercially launched 5G networks are based on NR non-standalone (NSA) technology, using existing 4G radio access for signaling, and an Evolved Packet Core (EPC) network. However, many use cases for Critical IoT, enterprises and industrial automation will only be feasible with the 5G NR SA and 5G Core architecture. In 5G SA architecture, automated end-to-end network slicing is simplified, with assured quality of service (QoS), security and flexibility, to multiple customer segments. The 5G SA core is a flexible and programmable platform, allowing services to be flexibly designed based on customers' specific requirements.

5G Core is built using cloud-native technologies which allow upgrades and new functionalities to be more cost-efficiently deployed, without impacting live services. The possibility to add new network functionalities, quickly scale capacity and run in-service software upgrades will make it possible for service providers to create and deploy new services for automated and customized connectivity in hours, rather than days or weeks. With 5G Core, service providers will be able to provide better network slicing and offer end-to-end service-level agreements (SLAs) to customers. Service exposure and traffic steering functionalities introduced in 5G Core will provide additional tools for service differentiation. Edge computing support enables distribution of user plane functionality to break out traffic dynamically at the edge. The reduction in latency and increased service reliability leads to enhanced end-user service experience.

5G SA DEVICE AVAILABILITY INCREASING

5G SA-compatible devices are increasingly becoming available, accounting for over half of all announced 5G devices. China is moving fast towards 5G SA-only networks.

In China, it has been mandatory for 5G devices to be SA-capable since early 2020, and since February 2021, both new and existing 5G devices are on "SA by default". 5G network traffic has increased due to continued 5G subscriber uptake, plus part of the traffic previously generated on the 4G network moving to 5G NR.

The device ecosystem is also developing support for multiple network slices on commercial smartphones. End users can be provided with differentiated services, for example, setting separate personal and work profiles, with one slice for generic mobile broadband traffic, another for services like gaming, and one or several slices for enterprise applications like video conferencing and collaboration. This functionality will only be supported in 5G SA architecture.

The need for network and business transformation Consolidated feedback from service providers who have already commercially launched 5G SA networks highlights a set of business, network technology and operational drivers for their deployments.

A common driver is the sense of urgency to transform the network into a new service delivery machine as the foundation for creating new business opportunities for top-line revenue growth. Another driver mentioned is the importance of overcoming learning-curve barriers related to new operating models, business strategies and service innovation.

Early deployment of 5G SA architecture provides a first-mover advantage for service providers with market-leading ambitions (frontrunners). Service providers that do not evolve as fast as their competitors risk falling behind during this significant transformation.

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GLOBAL CONNECTIVTY REPORT 2022

CHAPTER 2. THE JOURNEY TO UNIVERSAL AND MEANINGFUL CONNECTIVITY

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ABSTRACT

The Global Connectivity Report 2022 takes stock of the progress in digital connectivity over the past three decades. It provides a detailed assessment of the current state of connectivity and how close the world is to achieving universal and meaningful connectivity, using a unique analytical framework. It goes on to showcase solutions and good practices to accelerate progress. The second part of the report consists of seven thematic deep dives on infrastructure, affordability, financing, the pandemic, regulation, youth, and data. Chapter 2 relies on the framework for universal and meaningful connectivity and the associated targets for 2030, developed by ITU and the Office of the Secretary-General's Envoy on Technology, to analyse the current state of digital connectivity globally and progress towards reaching the targets by 2030. The framework considers usage by various stakeholders (universal dimension of connectivity) and the five enablers of connectivity (meaningful dimension of connectivity): infrastructure, device, affordability, skills, and safety and security. The assessment reveals that the world is still far from universal and meaningful connectivity. Infrastructure needs to be rolled out or improved to bridge the coverage gap. There are still significant differences between and within countries in network availability and quality. Fixed broadband is a costly investment and is not available or is unaffordable for many. Mobile broadband offers greater flexibility and is less expensive, and most rely on this technology to go online. But in many rural areas of developing countries, only 3G is available, when meaningful connectivity requires 4G. The coverage gap, currently at 5%, is dwarfed by the usage gap: 32% of people who are within range of a mobile broadband network and could therefore connect, remain offline. Data compiled by ITU make it possible to classify the offline population based on who they are and where they live. The main reasons cited by people for not using the Internet are the lack of affordability, of awareness about the Internet, of need, as well as the inability to use the Internet. Globally, connectivity became more expensive in 2021 due to the global economic downturn triggered by the COVID-19 pandemic. After years of steady decline, the share of income spent on telecommunication and Internet services increased in 2021. The global median price of an entry-level broadband plan in the majority of countries amounts to more than 2% of the gross national income per capita, which is the affordability threshold set by the Broadband Commission for Sustainable Development. People should not be forced to use the Internet. However, evidence suggests that introducing people to the Internet usually entices them to stay online. Based on activities people reported, use of the Internet leads to an improved social life, with the use of social networks, making Internet calls and streaming video the most common activities.

KEYWORDS: *ITU, Digital onnectivity, Internet of Things (IoT).*

CHAPTER 2.
THE JOURNEY TO UNIVERSAL AND MEANINGFUL CONNECTIVITY

2.1. Measuring digital connectivity

Universal connectivity means connectivity for all, measured across four categories: people, households, communities, and businesses. Meaningful connectivity is a level of connectivity that allows users to have a safe, satisfying, enriching, and productive online experience at an affordable cost and with a sufficiently large data allowance. Meaningful connectivity is reliant on the "connectivity enablers" of infrastructure, affordability, device, skills, and safety and security (Figure 2.1). Much of what is set out in this chapter builds from this framework.

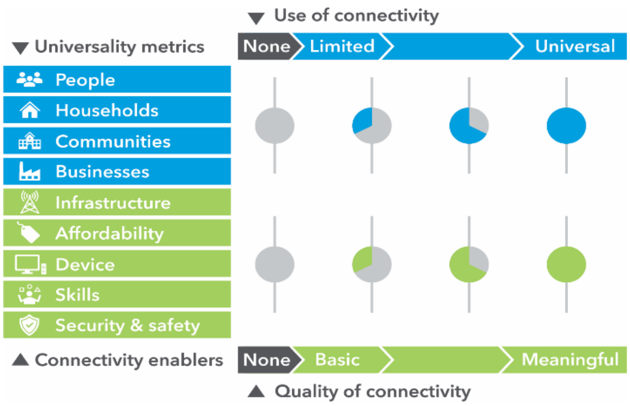

Figure 2.1. Framework for universal and meaningful connectivity

This chapter uses this framework and its targets to assess the state of digital connectivity around the world and how close the world is to achieving universal and meaningful connectivity. Table 2.1 shows the targets and where the world currently stands on these targets.

2.2. The state of digital connectivity

This section provides an overview of Internet use, broken down into three categories: individuals, households, and schools.

Individuals' use of Internet

The headline indicator to assess universal connectivity is the percentage of individuals using the Internet. Some individuals however choose not to use the Internet – so while the universality target in this context is a penetration rate of 100% for the population aged 15 and above, this is considered "met or nearly met" when the share is 95% or higher.

The World Wide Web was invented in 1989 and the Internet is a relatively young technology. In 1994, an estimated 20 million people browsed the Internet, less than half a % of the world population. Penetration grew at double-digit rates until 2010, when it reached a 29% penetration rate.

Table 2.1

Aspirational targets for 2030 and current situation

Indicator	Target	Current situation globally[a]	Number of countries meeting the target[b]
Internet users (% of population)			
Aged 15 and above	100%	63%[c]	13/151[c]
Gender parity ratio (1 = parity)	1	0.92	40/112
Households with Internet access (%)	100%	66%	13/126
Schools connected to the Internet (%)	100%	40% (primary)	42/93
		51% (lower sec.)	50/94
		66% (upper sec.)	50/97
Businesses using the Internet (%)			
0 employees or more	100%	n.a.	6/24
> 10 employees	100%	n.a.	23/47
Mobile network coverage (% of population)			
3G	100% for the most advanced technology already in use in the country with minimum coverage of 40%	95%	2/29[d]
4G		88%	66/157
5G		n.a.	n.a.
Fixed-broadband speed (% of subscriptions)			
>10 Mbit/s	100%	91%	25/150
School connectivity			
Min. download speed (Mbit/s per school)	20	n.a.	8/24
Min. download speed (kbit/s per student)	50	n.a.	n.a.
Minimum data allowance (GB)	200	n.a.	n.a.
Entry-level broadband subscription price			
% of gross national income per capita	2%	1.9% (mobile)	96/185
		3.5% (fixed)	64/174
% of average income of bottom 40 percent of earners	2%	2.5% (mobile)	50/110
		6.0% (fixed)	21/106
Individuals using a mobile phone			
Gender parity ratio (1 = parity)	1	n.a.	29/56
Individuals owning a mobile phone (% of population)			
Aged 15 and above	100%	n.a.	22/78
Gender parity ratio (1 = parity)	1	n.a.	30/72
Population aged 15+ with basic digital skills (%)	70%	n.a.	8/77
Gender parity ratio (1 = parity)	1	n.a.	5/70
Population aged 15+ with intermediate digital skills (%)	50%	n.a.	11/76
Gender parity ratio (1 = parity)	1	n.a.	5/70

Notes: n.a. = not available (global situation cannot be assessed due to limited data coverage).
a: Data are either for 2021, 2020, or the latest year available in the last four years; more details are provided in this chapter.
b: Among countries for which data is available. *x/y* means that in *x* out of *y* countries for which data are available the target has been achieved or almost achieved (see text for details).
c: Percentage of total population instead of population aged 15 and above.
d: Number of countries where coverage of 4G has not reached 40 per cent of the population.
See ITU and OSET (2022) for details.
Sources: ITU; UNCTAD (retrieved May 2022); UNESCO-UIS database (retrieved February 2022).

Figure 2.2 shows growth in the number of people using the Internet from 1994, the year when the first ITU World Telecommunication Development Conference (WTDC) was held.

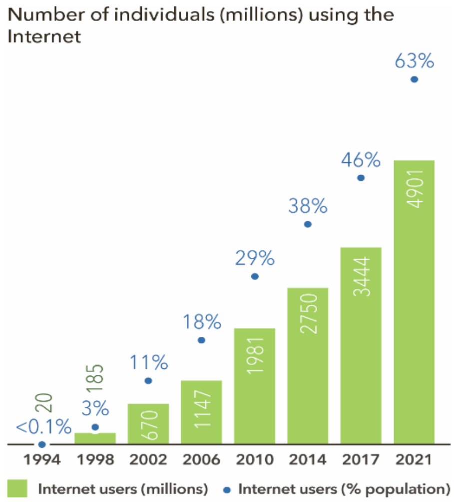

Figure 2.2. Growth of Internet use between 1994 and 2021 (Source: ITU)

Growth continued gradually until the effects of the COVID-19 pandemic sparked a surge in Internet use and in 2020 an estimated 466 million people began using the Internet for the first time, an increase of 10.3% in penetration. By the end of 2021, 4.9 billion people were online, some 63% of the world population.

Figure 2.3 shows Percentage of the population using the Internet, 2021.

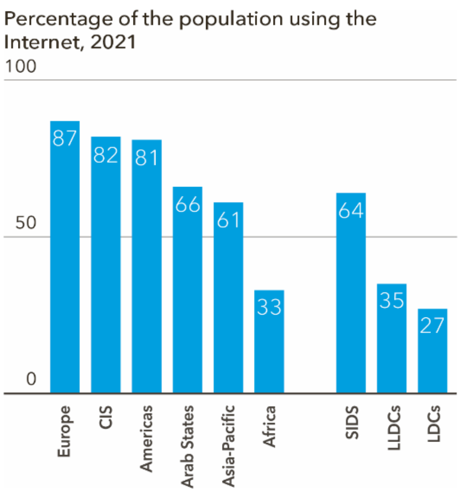

Figure 2.3. Internet penetration around the world
(Note: CIS = Commonwealth of Independent States Source: ITU)

Analysis shows that countries that were first to reach 10% Internet use in the 1990s grew at a faster rate on average than in subsequent decades.

Household access to the Internet

The growth of the percentage of households with Internet access evolves in parallel with the percentage of individuals using the Internet. However, having Internet access at home does not mean that all household members are able to use the Internet with a quality connection, if at all. For example, when schools were closed in many countries, around two-thirds of children and young people aged 25 years or less (about 2.2 billion) did not have fast and reliable, fixed Internet access at home (UNICEF and ITU 2020).

Many households with broadband Internet access rely on a mobile-broadband connection at home, often inadequate for data-intensive activities such as remote schooling. For instance, in Morocco, Thailand, and Uzbekistan, over 70% of households accessed Internet via mobile broadband only. Interestingly, in the 27 countries that provide data on Internet access by service, there is no link between income levels or the rate of Internet access and the choice of subscribing to a mobile-broadband connection only. This implies that there are other factors influencing the choice of service used to access the Internet. In some areas, for example, a mobile-broadband connection may be faster than a fixed-broadband connection, and therefore the preferred option.

Access to the Internet in schools

It is essential that schools have access to the Internet. Young people need digital skills to enter the labour market as many jobs involve working with ICTs and schools play a crucial role in teaching students these skills. Teaching can also be enhanced by the multitude of resources available on the Internet, including open educational resources – of critical importance for children who do not have adequate Internet access at home. Moreover, schools without Internet access were unable to move their teaching online when forced to close during the pandemic. With these benefits in mind, the target for connected schools is set to 100%. Data collected by UNESCO for 2020 show that around the world, 40% of primary schools and 66% of secondary schools had access to the Internet in 2020. In LDCs, these numbers were 28% and 35%, respectively. In 42 of 93 countries for which data were available, the target has been met for primary schools. For secondary schools, the target has been met in 50 countries (available data from 94 countries for lower secondary and 97 countries for upper secondary).

Giga is a joint ITU-UNICEF initiative that seeks to connect every school to the Internet and every young person to information, opportunity and choice.9 Giga maintains a real-time map of school connectivity to identify demand for infrastructure and funds, measure progress towards increasing Internet access, and continuously monitor global connectivity. So far, 1 million schools in 42 mostly lower-income countries have been mapped by Giga from an estimated 6 million schools worldwide. Data from UNESCO show that 43% of those schools do not have any connectivity. For 24 countries, the average download speed per school is available as well. In eight of those countries, seven small island developing States (SIDS) in the Caribbean plus Brazil, the average download speed was above 20 Mbit/s.

2.3. Divides in connectivity

Since 1994, the Internet has developed from a collaboration network for academics to an indispensable tool for work, communication, education, entertainment and more.

For most people, it is hard to imagine life without the Internet. The COVID-19 pandemic has highlighted how important it is to have access to fast and affordable Internet. Indeed, in the first year of the pandemic, growth in the percentage of Internet users was the highest in a decade.

In 2021, an estimated 2.9 billion people were still offline. The bulk of the global offline population, 1.7 billion people, lives in Asia-Pacific and was concentrated in China and India, followed by Africa with 738 million people offline. The combined offline population in the other four regions was 470 million people [1-5].

As the map in Figure 2.5 shows, in percentage terms, Africa was the least connected region in 2020, with 67% of the population offline, followed by Asia-Pacific (39%) and the Arab States (34%).

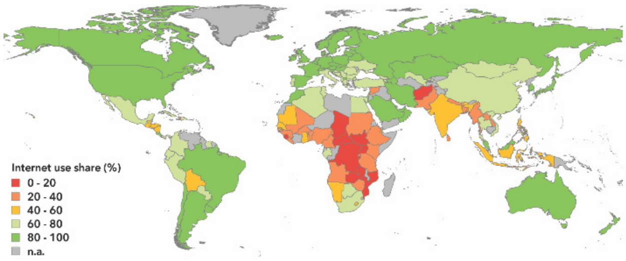

Figure 2.5. The global digital divide
Note: The designations employed and the presentation of material on the map do not imply the expression of any opinion whatsoever on the part of ITU and of the secretariat of ITU concerning the legal status of the country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries. The base map is the UNmap database of the United Nations Cartographic Section (Source: ITU)

The income divide

Several gaps emerge when looking at the socio-economics of the offline population. A country's level of development, proxied by its gross national income per capita, strongly correlates with Internet penetration. As further illustration of the digital divide across countries, Figure 2.6 shows the breakdown of the 2.9 billion people still offline by income group and by country. High-income countries (blue tiles) account for 16% of the world's population, but they account for only 4% of the total offline population. Low-income countries (orange tiles) account for just 7% of the world's population, yet they account for 14% of the offline population.

Despite an estimated sevenfold increase in Internet use in low-income countries since 2005, Internet use in these countries remains far below that of higher-income countries, reaching only 22% in 2021. In contrast, high-income countries, at 91% penetration, are close to universal usage12 and the gap between upper-middle-income countries and high-income countries is closing rapidly. While the difference was 41 percentage points in 2005, by 2021 this gap had shrunk to 15 percentage points. Internet use in lower-middle-income countries nearly doubled from 2017 to 2021, reaching 50%.

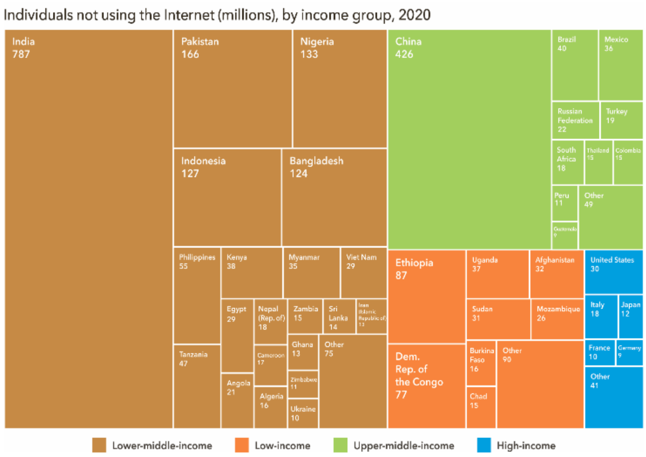

Figure 2.6. Development level and the offline population
Note: Size of the tiles represent the country's share in the world's offline population (Source: ITU)

The urban-rural divide

Globally, the share of Internet users is estimated to be twice as high in urban areas as in rural areas in 2020. An urban-rural divide exists in all regions but the higher the overall Internet use, the smaller the urban-rural gap. In Europe, for example, which is close to universal usage, urban use was less than 10% higher than rural use. This contrasts sharply with Africa where Internet use in urban areas was almost 3.5 times as high as use in rural areas. Lower rural usage is partly a result of a lack of infrastructure, but there are additional factors at play. Rural areas usually have lower income levels, and the population often has lower levels of education and lower levels of ICT skills, all of which are negatively correlated with Internet use.

The gender divide

Globally, more men (62%) were using the Internet in 2020 than women (57%). Men were more likely to use the Internet than women in all regions, except the Americas.

The gender gap is significantly smaller in countries where a higher proportion of the population uses the Internet, and a higher gender gap exists in countries with low Internet use. In countries where everyone is using the Internet, by definition there must be gender parity.

The gender parity ratio (GPR) is calculated as the proportion of women using the Internet divided by the proportion of men using the Internet. A value smaller than 1 indicates a larger proportion among men than among women. A value greater than 1 indicates the opposite. Values between 0.98 and 1.02 reflect gender parity as established in the 2030 targets.

Lower GPR values are most pronounced in LDCs and LLDCs, illustrating that low levels of Internet use are strongly correlated with low income levels. However, in line with increasing Internet use rates, the number of low GPR values has been shrinking in recent years.

The education divide

Education is another important determinant of Internet use. For those countries for which data were available, 94% of people with a completed tertiary education were using the Internet, about 9 percentage points higher than those with completed upper secondary or post-secondary non-tertiary education. In contrast, those with a primary or lower secondary education are much less likely to use the Internet than those who have reached a higher level of education [6-10].

2.4. Barriers to connectivity

Understanding why people and households do not use the Internet is critical for designing effective, targeted interventions. In this context, household ICT surveys provide invaluable insight. Since the pertinence of some of the reasons depends on the level of Internet access in countries, the results are plotted against the share of households without Internet access.

The most cited barriers in the 49 countries providing data included: Do not need the Internet; Cost of the equipment is too high; or Cost of the service is too high. Thirty-three countries cited Do not need the Internet as the main reason as did more than 50% of respondents in 27 countries. More than 80% cited this reason in the Czech Republic, Egypt, Republic of Korea, and Ukraine. Fifty% of respondents in seven countries cited both the high cost of equipment and the high cost of service.

Not exempt from such concerns, 55% of high-income countries also cited the high cost of equipment and services as well as 82% of households without Internet access in those countries. Several countries such as Brazil and the United Arab Emirates featured a large share of respondents who cited having access elsewhere as a reason for not having access at home. Privacy and security concerns as well as cultural reasons also play a part in countries such as Brazil and Switzerland.

2.5. Enablers of connectivity

To achieve universal usage, all barriers to connectivity need to be overcome. Figure 2.1 shows that barriers can be transformed into connectivity enablers. For example, replacing a slow and expensive connection with a fast and affordable one will enable people to go online as often and for as long as they wish, and teaching the necessary ICT skills will enable meaningful use of the Internet as a satisfying, enriching, and productive experience.

Infrastructure

The network is a precondition for Internet use. For decades, Internet access has been available over the fixed line telephone network. Originally using a modem to access the Internet, which incidentally would block the telephone line from making or receiving calls, people today use technology and network infrastructure that have improved the experience immeasurably, enabling high-speed fixed and mobile broadband networks that deliver always-on Internet access in most countries.

Although more people use mobile networks than fixed networks to connect to the Internet, the latter remains important. For example, fixed-broadband networks generally have a higher data capacity than mobile networks, and download limits are higher than similarly priced mobile-broadband plans. They are faster and are more reliable than 3G or 4G networks, making them more suited for high-bandwidth activities such as games and video calls. However, fixed-broadband networks are very expensive to roll out, maintain and upgrade, depending on the geography and extension of the territory to be covered.

The topology of many fixed-broadband networks consists of fibre-optic rings with access points from which homes and businesses are connected.

In this case, for network deployment to be efficient and profitable, there needs to be a high geographic concentration of households and businesses. Figure 2.7 shows that the vast majority of people do not have access to fibre-optic networks because of their location, in fact only 2.3 billion people (29%) lived within 10 kilometres of a fibre-optic network in 2021. It is worth noting too that living within 10 kilometres of a fibre-optic network is no guarantee of a connection for many reasons, not least being the absence of a point of presence (PoP), optical-line terminal or fibre-optic drop to connect the network to the home or office (ITU 2020b).

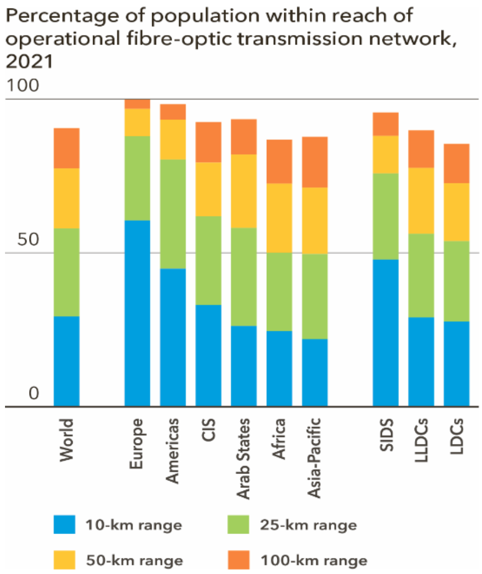

Figure 2.7. Fixed-network coverage
Note: CIS = Commonwealth of Independent States (Source: ITU)

In Europe, more than 60% of the population lives within 10 kilometres of a fibre-optic network, while the reach of fibre-optic networks in the Asia-Pacific region is only 22%, Africa is 25%, and the Arab States is 26%.

For a household to access a fixed network, a "last mile" connection is needed to bring that network to the home. For the past few years, ITU has collected data on the number of households covered by a fixed network. Figure 2.8 (left-side panel) shows that in Africa only 7% of households can potentially subscribe to a fixed network (for LDCs this figure is just over 1%), whereas in other parts of the world almost all households have access to a fixed network.

No access to a fixed network obviously impacts the number of fixed-broadband subscriptions (Figure 2.8, right-side panel). In Africa and in LDCs and LLDCs, few subscribe to fixed broadband services. In the Arab States, where only 40% of homes are served by fixed-network services, only 9 out of every 100 inhabitants subscribe to fixed broadband. The highest proportion of fixed-broadband subscriptions is found in Europe, where 35 out of every 100 inhabitants subscribe to fixed broadband, and since fixed broadband is usually shared with all family members, this means that most households have a fixed-broadband connection.

The breakdown by speed provides an indication about the quality of the subscription, although it might also reflect cost.

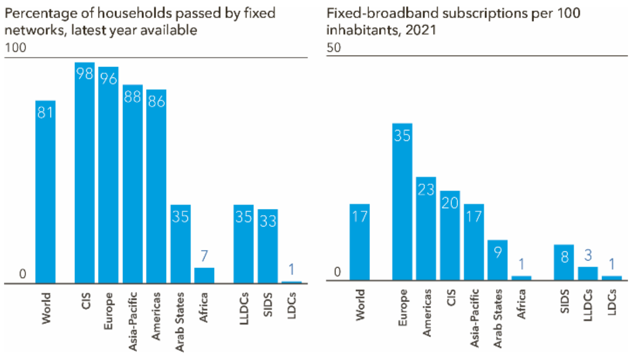

Figure 2.8. Fixed-broadband coverage
Note: CIS = Commonwealth of Independent States (Source: ITU)

The framework for universal and meaningful connectivity sets a target of at least 10 Mbit/s for all fixed-broadband subscriptions by 2030. In Asia-Pacific and Europe, this target has almost been met, with respectively 95 and 94% of fixed-broadband subscriptions reaching 10 Mbit/s or faster. In LLDCs, only 39% of subscriptions were high speed, and although in LDCs the situation was better, this was mainly because 70% of fixed-broadband subscriptions were high speed connections in Bangladesh, which has a very high weight in the group aggregate (Figure 2.9).

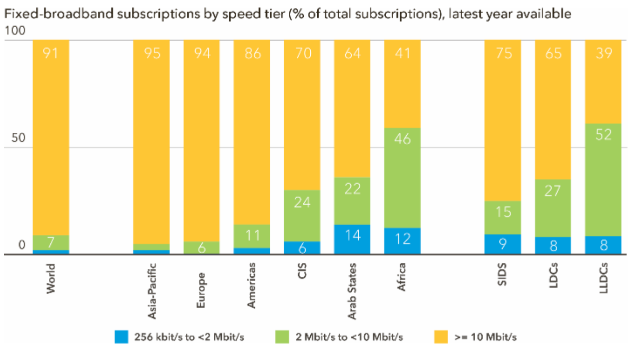

Figure 2.9. Fixed broadband speed
Notes: Values equal to or less than 3 are not labelled due to space considerations. CIS = Commonwealth of Independent States (Source: ITU)

Mobile broadband networks are not just a supplement to fixed networks but are the main gateway to the Internet for many users, given the availability and cost issues associated with fixed-broadband networks. Except for optical fibre, 4G can offer average download and upload speeds equivalent to fixed-broadband connections.

Another framework target for universal and meaningful connectivity aims to extend coverage of the mobile-broadband network to the world's population.16 Globally, 95% of the population is within reach of a mobile broadband network (at least 3G) and 88% has access to a 4G network. The flattening curve in the evolution of 3G coverage underlines the challenge of connecting the rest of the population: 3G coverage doubled from 40 to 80% between 2010 and 2015 but has increased only by 15 percentage points since, and has barely changed in the past three years. Even coverage by 2G technology, which is being phased out, never exceeded 97% of the world's population.

Similar to SDG Target 9.c, which aimed to significantly increase access to ICTs and provide universal and affordable access to the Internet in least developed countries by 2020, the target set out in the framework for universal and meaningful connectivity intends to extend coverage to the entire world population by a mobile network of the latest technology (currently 4G) by 2030.

Although the SDG indicator does not specify a technology, Asia-Pacific and Europe have already met the target of universal 4G coverage, and the Americas and CIS regions are close to meeting it. However, Africa (49%) and the Arab States region (70%) are struggling to reach universal coverage for 4G.

Combining data on coverage and Internet usage makes it possible to distinguish between those who are not using the Internet because of a lack of infrastructure, and those not using the Internet for other reasons. The coverage gap refers to the lack of access to a mobile or fixed network, and the usage gap refers to the number of people not using the Internet minus those without access to a network (coverage gap). For example, in Asia and the Pacific, the coverage gap affects only 2% of the population, whereas the usage gap concerns 37%. This is consistent with the findings that affordability and skills are bigger barriers to connectivity than the lack of Internet availability.

While most urban areas in the world are covered by a mobile-broadband network, gaps persist in rural areas. In Africa, almost 30% of the rural population cannot access the Internet, 18% of the rural population has no mobile-network coverage, and another 11% has only access to a 2G network. The coverage gap is almost as significant in the Americas, where 22% of the rural population is not covered at all and another 4% is covered only by a 2G network.

This disaggregation underlines how much usage and coverage gaps vary depending on location. This has important implications for policy prioritization. For example, in rural areas of the CIS region, the usage gap is negligible, almost everyone uses the Internet. In rural Africa, only 15% of the population uses the Internet and the coverage and usage gaps are almost the same size, whereas in Africa's urban areas, mobile-broadband coverage is almost universal and only a usage gap exists.

Despite the lack of access to a mobile-cellular network in some parts, the world has witnessed tremendous growth in the use of the mobile phone. In 1994, there were 56 million mobile-cellular subscriptions worldwide, less than one for every 100 inhabitants. Mobile-broadband subscriptions have grown from 4 per 100 inhabitants in 2007 to 83 per 100 inhabitants in only 14 years.

The rise in Internet use has been accompanied by an explosion in data usage, but this has been unevenly distributed. For example, international bandwidth usage saw a 30% increase from 719 Tbit/s in 2020 to 932 Tbit/s in 2021. The highest regional total for international bandwidth use was in the Asia-Pacific region at over 400 Tbit/s, twice as high as in Europe (204 Tbit/s) and in the Americas (180 Tbit/s).

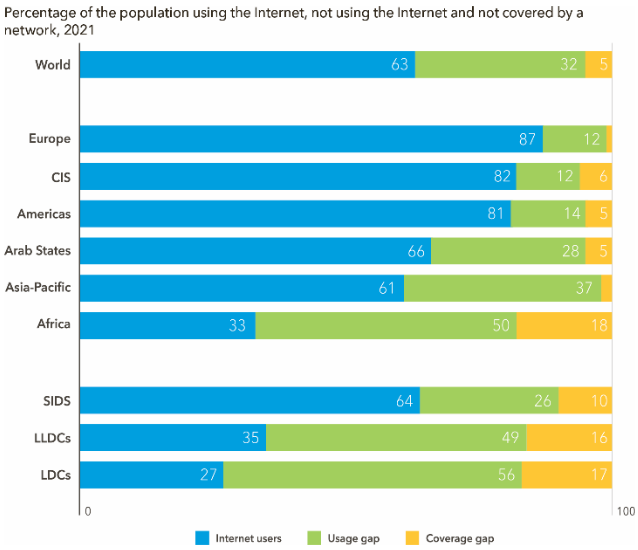

Figure 2.10. Coverage gap and usage gap
Notes: The coverage gap is the percentage of the population that does not have access to a mobile or fixed network. The usage gap is the percentage of the population not using the Internet minus the coverage gap. Values equal to or less than 3 are not labelled due to space considerations. CIS = Commonwealth of Independent States (Source: ITU)

However, it is on a per-user basis that the digital divide becomes apparent (Figure 2.11, right-side panel). In Europe, bandwidth usage stood at 340 kbit/s per Internet user, followed by the Americas at 214 kbit/s and the Arab States region at 174 kbit/s. In Africa, on the other hand, international bandwidth usage was 60 kbit/s. In the LDCs, it was just 34 kbit/s per Internet user.

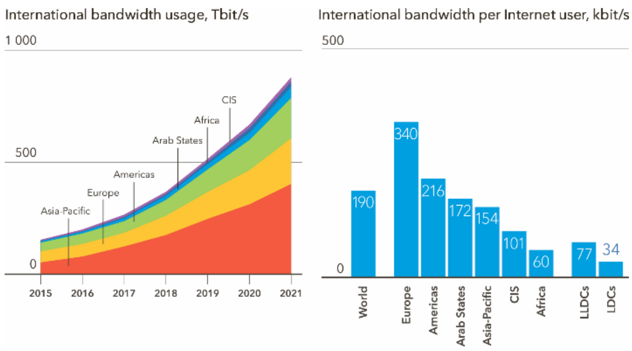

Figure 2.11. Growth in international bandwidth
Note: CIS = Commonwealth of Independent States (Source: ITU)

The global speed divide

Users generally judge their broadband quality on their experience of connection speeds. The three time points (2020, 2021, and 2022) in the chart refer to the emergency, recovery, and 'new normal' phases of the Covid-19 pandemic and reflect, through the median upload and download speeds, differences in connection quality experienced by consumers as well as revealing how the gaps have evolved across regions over that time. The widest connection quality gap is between Europe (and high-income economies in general) and the rest of the world in both fixed and mobile networks. Interestingly, there is a divide between countries depending on which network provides faster speeds. In low- and lower-middle-income economies, mobile broadband offers the faster alternative (this is the case across African countries), while in high-income economies, fixed-broadband speeds are 30-50% faster. Two years after the start of the pandemic, as networks adapted capacity, speeds measured on fixed networks overtook those on mobile – this global trend has been driven by the Americas, the CIS, and the Asia-Pacific regions.

While mobile networks provide a comparable alternative to fixed networks in most parts of the world concerning download speeds, there is a clear gap between the upload speeds provided by the two technologies. Mobile upload speeds measured in the different regions are surprisingly similar, remaining around the global median of 10-12 Mbit/s (highest in Europe at 15 Mbit/s in 2022, lowest in Africa at 8 Mbit/s in 2020). Users on fixed networks, on the other hand, could benefit from 2-3 times faster upload speeds than those in the same region using mobile networks. This difference is particularly important when it comes to using cloud computing or video conferencing services.

Affordability

After years of steady decline, the share of income spent on telecommunication and Internet services increased across the world in 2021, mainly as a result of the global economic downturn triggered by the COVID-19 pandemic (ITU and A4AI 2022). In many economies, the long-standing trend of gradually declining prices for such services was outweighed by a steep drop in average GNI levels in 2020.

In 2021, only 96 economies met the 2% target with regard to the data-only mobile broadband basket in 2021 (seven fewer than in the previous year), and only 64 economies met the target with respect to the fixed broadband basket (two fewer than in the previous year).

Furthermore, only 50 out of 110 countries for which these data are available met the 2% target for the bottom 40% in 2021. Due to its high costs, fixed broadband is out of reach for the bottom 40% in most regions, except Europe. Mobile broadband is more affordable, but there are many countries where even if the basket is affordable for the average earner, the bottom 40% would need to pay more than 2% of GNI per capita, and in 22 out of the 110 countries with data available, they would face costs over 10% of GNI per capita.

Chapter 5 on affordability of ICT services offers an in-depth assessment of the price of ICT services and devices, and sets out policy options for improving affordability.

Devices

Until the early 2010s, computers were the Internet device of choice. Now however, mobile devices (smartphones and tablets) are a viable alternative, although not a perfect substitute. Indeed, while the share of households with Internet access has been exhibiting a steady growth over the past 15 years, the growth of households with a computer has slowed since the early 2010s as mobile devices became more popular.

The framework for universal and meaningful connectivity recognizes how inexpensive most basic mobile phones are while also taking into account that computers allow for a richer experience. The framework examines the use and ownership of mobile phones, while recognizing that mere access to a device (as opposed to ownership) imposes constraints – including when and for how long the user can be online. The framework sets a target only for mobile phone ownership, which allows someone to go online at any time, rather than first having to ensure a mobile phone is available.

The high cost of mobile telephones in low-income countries is reflected in the low share of individuals owning a mobile telephone. Despite the fact that in many countries mobile phone ownership is very high, there remains a significant number of countries where only some can afford a mobile phone. In eight of 78 countries for which there are data, less than 50% of the population owned a mobile phone, far short of the target of universal ownership. A mobile phone is often the only means of Internet access – so there is a strong correlation between Internet use and mobile phone ownership.

According to A4AI data, the average cost of a smartphone in these countries was 41% of monthly GNI per capita. In 22 countries, universal ownership (i.e. over 95%) was achieved, while in an additional 11 countries this percentage stood between 90 and 95%. The average cost of a smartphone in these countries were 8.8 resp. 14.5% of GNI per capita.

Reaching gender parity is also a target for all individual-based indicators. When universal ownership is reached, gender parity is reached. But for many countries, universality remains a distant prospect and the gender divide for ownership persists. In 30 countries out of 72 for which data is available, gender parity has been reached. In 13 countries, more women than men own a mobile phone, while in 29 countries the opposite is the case [11-12].

Digital skills

Section 2.4 revealed the barriers to using the Internet for individuals such as the high costs of equipment and services, lack of need of the Internet, and not knowing how to use it. These results confirm the importance of ICT skills as an enabler of meaningful connectivity. In the framework for universal and meaningful connectivity, there are two skills-related targets: by 2030, at least 70% of individuals should have basic ICT skills, and at least 50% should have intermediate ICT skills.

It is difficult to measure the general level of ICT skills in a country. The best way is through assessment tests, such as the International Computer and Information Literacy Study (ICILS). These assessments are expensive to run however and are therefore administered in few countries and only periodically.

Surveys offer an alternative. One approach is to ask people to assess their proficiency for certain skills, although studies show that self-assessment is a poor measure. A study by the ECDL Foundation (2019) for example, "revealed that people tend to overestimate their abilities and that significant digital skills gaps exist in all of the analysed countries. Moreover, young people have digital skills gaps that are just as wide as in the rest of society".

The approach adopted by Eurostat and ITU is to ask survey respondents whether they have undertaken certain tasks or activities using digital devices. The activities are categorized as basic ICT skills, as intermediate ICT skills and as advanced ICT skills.22 This approach assumes that people who have performed certain tasks have the corresponding skills – and avoids bias.

The data show there is a long way to go to reach the skills-related targets. In only eight of 77 countries for which data is available, 70% or more of the population have basic ICT skills. And in just 11 out of 76 countries, 50% or more of the population have intermediate skills.

For basic skills, in only five out of 70 countries, gender parity has been reached. In 12 countries, a greater share of women have basic skills than men. Similarly, for intermediate skills, gender parity has been reached in five countries and has been exceeded in ten countries (gender parity score above 1.02). For advanced skills (although not a target) two countries could boast gender parity, in one country there was a female majority, but in 59 countries there was a male majority.

Another driver of differences in ICT skills is age. For the 51 countries reporting data, children less than 15 years of age tend to have fewer ICT skills, although this is to be expected since skills are more in demand for tasks undertaken more regularly by adults. Similarly, fewer of those in the 75+ age group have ICT skills than in the general population. This is due in part to the large number of retired individuals in this age group, but also mirrors the gap seen in rates of Internet use.

Individuals in the 15-24 and 25-74 age groups show higher rates of using ICT skills, with those aged between 15 and 24 showing the highest rates for basic, intermediate and advanced skills for all countries providing data. This is consistent with Internet usage rate statistics.

Content

Content does not feature in the framework for universal and meaningful connectivity as it does not directly influence the quality of connectivity.

In recent years, 68 countries have provided some data on how Internet users are spending time on the Internet. Comparing this data to GNI per capita shows a very steep uptake in activities such as Internet banking, acquiring health and government information, reading, and purchasing goods or services as countries' incomes increase. This may reflect the increased availability of online services in richer countries. For most activities, there is a flattening off where countries are considered 'high income' by the World Bank, indicating that countries do not need to be wealthy for their residents to have a rich online experience.

A different pattern emerges when looking at the share of those using social networks and making calls. Here similar levels of participation are seen across income levels, illustrating the primacy of communication for Internet users. The analysis suggests that such activities are less dependent on the government and level of development of a country [13-14].

Analysis of data from 52 countries suggests that Internet activity connected to information and e-commerce is strongly related to education. This trend stands out for Internet banking, purchasing/ordering goods and services, and researching government information. However, there is a divide in Internet users accessing health information by education level, a factor that may have some bearing on disparities in health outcomes. In contrast, activities related to communication and entertainment are less tied to education level.

2.6. Conclusions

Achieving universal and meaningful digital connectivity requires a rethinking of what being connected means. The analytical framework introduced in this chapter aims to prompt a major mindset shift, by identifying the key determinants of universal and meaningful connectivity, the relevant indicators to track, and the main targets to chase.

Connectivity is much more than the possibility of connecting. ITU data show that having access does not necessarily translate into usage. While 95% of the world's population is within the footprint of a broadband network, only two-thirds are online. Out of the 151 countries for which data are available, only 13 have met the universality target (at least 95% of the population online). The usage gap is much wider than the coverage gap. This not only means priorities are shifting but that the challenge has grown. It is not only about building up infrastructure for universal access but also about addressing the many barriers that deter or prevent one third of humanity from going online: lack of money, of skills, of knowledge, of devices.

Lowering these barriers enough so that everyone gets online is an enormous challenge. Moving from basic connectivity to meaningful connectivity requires clearing all the barriers, making the challenge more daunting. For instance, having access to a device may be enough to go online, but owning a device is a necessary condition (but not sufficient) for enjoying meaningful connectivity. Similarly, an Internet subscription may be barely affordable but not offering enough data or bandwidth to allow for a meaningful experience.

The assessments based on disaggregated data reveal that the world's offline population is unevenly distributed across regions, countries, and population groups, creating multiple digital divides such as generation, gender, location, income, education. Measuring and understanding these divides will focus efforts and help to design more effective interventions targeting specific connectivity areas and population groups.

Similarly, one must go beyond global or regional figures, which may be misleading. The global coverage gap and the digital gender gap have almost been bridged, thus wrongly suggesting that these issues have become less pressing. But there are countries where 3G coverage does not exceed 40% of the population (mostly living in urban areas) and 4G has yet to be rolled out. Similarly, while in high- income countries a digital gender gap hardly exists anymore, in countries with low Internet use, men are significantly more likely to use the Internet than women.

Finally, measuring connectivity and how close countries and regions are to achieving universal and meaningful connectivity requires good data, which unfortunately are not universally available, affecting the quality of assessment. This data divide mirrors the income digital divide: the less developed a country, the less data available. Low-income countries that stand to benefit the most from digital development are those that know the least about their state of digital development. Improving data coverage and quality must be part of any digital development strategy for an extended discussion about data poverty and options to address it).

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MWC 2022: ALL THE TOP B2B NEWS FROM THIS YEAR'S MOBILE WORLD CONGRESS

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ABSTRACT

Mobile World Congress (MWC) 2022 is now at an end, but what a week it's been. After a virtual show in 2021 due to the coronavirus pandemic, many of the top mobile companies returned in Barcelona to show off their latest products and services. MWC Barcelona (formerly, but still commonly referred to as Mobile World Congress) is an annual exhibition organized by the GSMA and dedicated primarily to the mobile communications industry. The event is held in Barcelona, Catalonia, Spain at the Fira de Barcelona Gran Via, usually in February or early March. It is attended mainly by device manufacturers, network equipment vendors, representatives of wireless operators and the press, among others. The name of the event has changed over the years. The origins of the event date back to the business conference "Pan-European Digital Cellular Radio" (the original working name of the GSM mobile system) held in Brussels in 1987. The name "GSM World Congress" was first used in 1990 when the event was held in Rome. Over the next few years, the event moved to a new city each time, passing through Nice, Berlin, Lisbon, Athens and Madrid, before taking place in Cannes in 1996. The event was held in Cannes for ten consecutive years, and since 2003 it has been called the 3GSM World Congress. In 2006, the event moved to Barcelona and was held at the Fira de Barcelona Montjuc. In 2008, the GSM Association, which had been established in 1996 and had shown increasing interest in the event, completed the purchase of the exhibition, changing its name to Mobile World Congress for the first time. The GSMA endorsed the 2008 International Mobile Gaming Awards, which ran at the event from then until 2012. In 2011, the GSMA announced a long-term deal to continue hosting the event in Barcelona until 2023.

KEYWORDS: *Mobile World Congress, GSMA, Mobile industry*.

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It's the place to find out where the industry, your business and your career are headed. Miss out on MWC Barcelona, miss out on the next 12 months.

"It's hard to believe that the chatter around 5G started to become louder at MWC 2014, eight years ago when the Samsung Galaxy S5(opens in new tab) was launched. Since then the pandemic and the following lockdowns have changed how business is done. The conversation is now clearly focused on the transformative impact 5G can have on everything around us. It now feels right to bring MWC back to its B2B industrial roots after a decade when the headlines were dominated by new smartphones that didn't really bring much to the table after the first iterations. So, like the previous years, expect to hear a lot about IoT, AI, Edge computing, Blockchain, analytics, robotics and automation. Oh and the Metaverse of course". ***Desire Athow, Managing Editor, TechRadar Pro***

"After a year away as a virtual event, it's good to see the appetite for Mobile World Congress is still there. Although not all the big vendors will be present, it should still be an exciting show for tech fans across many industries. This could be the first time we get a proper look at 6G networks, even if just as a proof of concept, as well as maybe finding out what blockchain actually does and how it can help the mobile industry. And with 5G networks now firmly set in place across the world, I'm hoping to see and hear more about some amazing use cases that make the most of superfast connections". ***Mike Moore, Deputy Editor, Tech Radar Pro***

INTEL UNLEASHES NEW XEON PROCESSORS FOR THE NETWORK AND EDGE

Not every company is waiting until MWC kicks off to announce new products and services. Take Intel, which just unveiled new Xeon processors designed specifically for network and edge deployments.

The Intel Xeon D-2700 and D-1700 are built on the company's Ice Lake platform and feature integrated AI and crypto acceleration, built-in Ethernet and various other features that cater to common network and edge workloads.

Intel told that the chips deliver "breakthrough performance" across use cases such as security appliances, enterprise routers and switches, cloud storage, wireless networks, AI inference and edge servers.

GSMA CONFIRMS THERE WILL BE NO RUSSIAN PAVILION AT MWC 2022

The organisers of Mobile World Congress (MWC) in Barcelona have confirmed there will be no Russian Pavilion at this year's event and that certain companies and executives from the country will be barred from attending due to international sanctions. The Russian Pavilion is one of several country-specific stands that usually populate the halls of MWC and are usually organised by investment bodies or government departments to showcase companies and startups from their nation. Industry body the GSMA said it would adhere to sanctions imposed by the US, UK, EU and others on Russia for its invasion of Ukraine but said it did not expect any major impact on the show, which is due to be staged in its traditional spring timeslot for the first time since the start of the pandemic.

DELL WANTS TO HELP ACCELERATE A MAJOR MOBILE INDUSTRY SHIFT

Dell has taken the wraps off a new range of hardware, software, and services that will make it easier for operators to build networks that take advantage of open and cloud architec-tures(opens in new tab) in the 5G era.

The Dell Telecom Multi-Cloud Foundation com-prises hardware, orchestrator management software and support for integrated telecom platforms from the likes of Red Hat, VMware and Wind River. Dell is also adding bare metal orchestrator modules to its software, meaning operators can deploy and lifecycle manage the entire cloud foundation stack.

The shift to a cloud-native model will make net-works more scalable and cost-effective, allowing mo-bile operators to rapidly roll out new services and re-duce costs. Meanwhile technologies such as Open RAN will enable a shift away from highly integrated, proprietary equipment and allow operators to mix and match innovations from multiple vendors and use commoditized hardware.

Image credit: Shutterstock

HPE LAUNCHES NEW PRIVATE 5G OFFERING

HPE has announced a new private 5G offering designed to bring the benefits of high-speed, high-bandwidth private networking to industry and enterprise.

The new service is said to enable "seamless inter-working" across private 5G and Wi-Fi, thereby helping business capitalize on the wide area coverage offered by 5G and the cost benefits of Wi-Fi in indoor envi-ronments. HPE says its private 5G solution is pre-integrated with radio access capabilities from a number of ven-dors, which means it can be rolled out rapidly and in a flexible manner. Data growth is creating countless new opportuni-ties across many industries, but superfast, stable and secure connectivity is essential to enable these digital experiences. Together, HPE's private 5G solution and Aruba Wi-Fi technology promises a complete private networking solution that helps to optimize the working environment, as well as giving telcos new opportunities to grow their enterprise busi-ness.

NOKIA TO DEPLOY MACHINE LEARNING TO TACKLE 5G COMPLEXITY

Nokia has lifted the lid on plans to deploy machine learning (ML) techniques to address 5G network complexity. The company's new Intelligent RAN Operations solution is said to enable operators to improve network quality and efficiency, while also cutting costs and emissions. To make this possible, the service uses ML to automate a selection of common network management tasks, which improves the ability to identify and rectify network issues promptly. Nokia says human error is also eliminated from the equation, thereby eliminating another source of risk. Nokia's Intelligent RAN Operations helps opera-tors deliver 5G services in the most efficient and effective way possible. Through intelligent machine learning, it boosts network performance, quality, and the subscriber experience whilst reducing power consumption and operational costs.

HUAWEI: 5G IS RAPIDLY GATHERING STEAM, BUT WE NEED TO FOCUS ON SUSTAINABILITY

Solid state drives (SSDs) could drive traditional hard disk drives (HDDs) to the brink of extinction in the data center as early as 2025, Huawei predicts. The company's VP of Data Storage, Fupeng Zhang, explained that the falling price and superior performance of flash storage are squeezing HDDs from the market. Zhang says the process will be a gradual one, but anticipates that SSDs will account for as much as 80% of non-archival data center storage by 2025, up from roughly 30% today.

The global 5G rollout is quickly gathering pace, paving the way for new consumer experiences and improved productivity across various industries, says Huawei.

According to Ding, the 5G ecosystem has devel-oped rapidly since rollout first began, driving "re-markable commercial success" for early adopters.

Speaking at an event hosted by Huawei ahead of MWC 2022, Upwards of 200 mobile operators have now deployed commercial 5G net-works, serving more than 700 million end users.

Image credit: Future

Huawei at MWC 2022 veiling a whole host of new mobile and computing de-vices at it looks to rebound from a difficult few years.

Among the new launches is the Huawei MateSta-tion X, the company's first all-in-one PC. Built around a 28.2in 4K touchscreen, the PC is powered by an AMD Ryzen 5000H Series processor, 16GB RAM and 512GB storage, along with Wi-Fi 6 as standard.

Huawei says the MateStation X offers utlimate customization when it comes to posing and tuning, making it ideal for home workers. Thanks to the company's multi-screen collaboration service, it can also link seamlessly with other Huawei smartphones and tablets, meaning you can click and drag files or other items across devices, giving easy access to the data you need.

There's no news on availability, release dates or price just yet, but Huawei says it'll provide updates soon.

Credit to Bobby Hellard from our sister publica-tion, IT Pro (opens in new tab), for this picture that cap-tures our imagination.

The PixLab X1 is Huawei's first printer and it turns out to be a bit of a surprise. Running on Huawei's own HarmonyOS operating system, the PixLab X1 is an all in one printer, offering scanning and copying functions alongside just printing.

As a laser rather than inkjet unit, this could be a great SMB printer, although we don't know whether it offers color printing or just monochrome. Huawei says that it will be the industry's first printer to feature a toner cartridge designed for easy pigment replacement, so a nudge towards the growing environmental-friendly market.

GSMA REVEALS OPTIMISTIC PREDICTIONS FOR A 5G FUTURE

To mark the opening of the show, MWC organisers the GSMA has revealed its latest Global Mobile Economy Report, examining the current state of the worldwide market.

Unsurprisingly, it's good news when it comes to 5G, with the report claiming that the total number of 5G connections is now expected to reach one billion in 2022 as usage grows rapidly around the world.

This is largely thanks to widespread investment in 5G technology across the world, with the global coverage gap shrinking from a third of the population to just 6%.

The report predicts that by the end of 2025, 5G will account for around a quarter of all mobile connections, and more than two in five people worldwide will live within reach of a 5G network. Last year, mobile technologies and services generated $4.5 trillion of economic value, equating to 5% of global GDP - which is set to grow to $5 trillion in 2025.

However, the GSMA adds that there is still work to be done, as it estimates 3.2 billion people, or 41% of the global population, are still not using mobile internet.

BULLITT GROUP UNVEILS ITS FIRST RUGGED 5G HOTSPOT AND UK MVNO

Ruggedised devices are growing increasingly popu-lar as more industries embrace handheld and mobile products, but wireless hotspots have so far failed to get the tough upgrade. Now, Cat Phones maker Bullitt Group has revealed the Cat Q10, its first rug-ged 5G hotspot designed for use in some of the tough-est conditions around. Able to survive extremes of hot and cold temperatures, the Cat Q10 features an IP68 dust and water-proof rating, and can survive a drop onto steel from six feet/1.8 metres.

The company says the Cat Q10 will offer ultra-fast 5G connectivity far ahead of 4G or LTE wherever there is good cellular network coverage, with up to 32 devices able to connect to a single hotspot. It also sports a swappable 5300mAh battery that offers up to 10 hours of usage from a single charge, and also offers fast recharging.

There's no concrete details on pricing just yet, but the Cat Q10 will go on sale in Q2 2022, the company says.

In a slightly puzzling move, the company also announced it has partnered with Transatel and EE to launch an MVNO for use in the UK market. Bullitt Connect will offer voice, text and data services to both consumer and industrial customers, including the likes of the gigi economy or logistics market.

2022 is shaping up to be the year when manufacturers battle out to find out who can charge a smartphone the fastest. Realme announced that its GT NEO3 can reach a staggering 150W with a cable with future models reaching 200W. Just a few hours later, archrival Oppo released its very own 150W charging technology with plans to pus it to 240W, one capable of charging a 4500mAh battery in nine minutes, that's 540 seconds.

Honor on the other hand unveiled its HONOR Magic4 handset that can be charged wirelessly at 100W. In comparison, Tesla's Level 1 charging or "trickle charging" delivers 1400W to an electric vehicle.

QUALCOMM IS BRINGING FASTER 5G TO MORE DEVICES

Qualcomm took the opportunity to launch a host of new products and partnerships at MWC this year - too many to summarize effectively here.

The thread that connects all the announcements together, however, is an ambition to bring 5G support to more devices (and device types) and optimize performance to the greatest possible extent.

Image credit: Future

HUAWEI AND AWS TAKE TO THE STAGE

Kicking of day at MWC is a keynote ses-sion featuring AWS CEO Adam Selipsky and Huawei's Rotating Chairman Guo Ping.

Selipsky dedicated his speech to the opportunities arising from the interplay between cloud, AI and 5G technologies. Specifically, he highlighted the ability to deliver a new generation of apps that demand rapid speeds and low latency, in sectors ranging from autonomous vehi-cles to entertainment, robotics and industry.

Adam Selipsky, AWS CEO, spoke about the opportunities relating to the interplay between 5G and cloud. Image credit: Future

Ping, meanwhile, used the session as a platform to reiterate his company's refusal to back down from the international stage, despite sanctions affecting its ability to operate in US and European markets.

"To see the future, we need to look up, above the politics, partisanship and rhetoric," said Ping.

"Many people ask whether Huawei will retreat from the international market. But the answer continues to be, no. We are committed to helping customers who choose us to achieve the greatest business success."

Guo Ping, appearing virtually during a keynote session at MWC 2022. Image credit: Future

MEET THE THINKPAD X13S

Lenovo has launched a new always-connected laptop for business users, the ThinkPad X13s.

The X13s will be the first laptop to feature Qualcomm's Snapdragon 8cx Gen 3 compute platform, which delivers mmWave 5G connectivity and a whopping 28-hour battery life for workers on on move.

“ThinkPad X13s promises to end power anxiety and delight users with AI accelerated collaboration experiences and hyper-speed connectivity wherever they happen to be,” said Jerry Paradise, VP Global Commercial Product Portfolio, Lenovo PC and Smart Devices.

The laptop will hit the market in May, starting at €1399.

ORANGE TO SWITCH OFF 2G AND 3G ACROSS EUROPE BY 2030

Orange will switch off its 2G and 3G networks in Europe by the end of 2030, paving the way for network modernization and spectrum refarming that will boost more advanced and efficient 4G and 5G services.

The Paris-based telecoms group is Europe’s fourth largest mobile operator, with divisions in Belgium, France, Luxembourg, Poland, Romania, Slovakia, and Spain. It will adopt a two-stage approach, with the timeline for the shutdowns depending on each country’s circumstances.

In France, 3G coverage is greater than 2G, meaning the latter will be decommissioned first in 2025, before 3G is turned off in 2028. In other territories, 3G will be switched off by 2025 and then 2G no later than 2030.

META SAYS MODERN NETWORKS ARE INCAPABLE OF SUPPORTING THE METAVERSE

Meta has revealed it is working closely with mobile operators in an effort to prepare networks for the so-called metaverse.

The company says the metaverse will demand "vast enhancements" in network capacity and a significant shift in the way networks are architected, due to the scale and complexity of the experiences it will enable, connecting virtual and physical worlds.

"Today, we’re at the start of the next transition as we build for the metaverse. But creating a true sense of presence in virtual worlds delivered to smart glasses and VR headsets will require massive advances in connectivity. Bigger than any of the step changes we’ve seen before. Things like remote rendering over edge compute cloud and wide-scale immersive video streaming will take entirely new types of networks," said Mark Zuckerberg, Meta CEO.

"We need to create connectivity infrastructure that can evolve as fast as technology does. So we’ll continue to work with partners that share this vision for the next computing platform – supporting breakthroughs in this ecosystem over the next decade to make sure people around the world can participate in the metaverse we’re all building."

MEDIATEK IS COMING FOR QUALCOMM'S SMARTPHONE CROWN

MediaTek has announced two new premium chipsets designed for flagship 5G mobile devices: the Dimensity 8000 and Dimensity 8100.

Launched at MWC 2022, the new SoCs add an additional tier to the company’s existing portfolio, filling a performance gap between the recently launched Dimensity 9000 and the less performant Dimensity 1300.

The Dimensity 8000 series chips bundle four Arm Cortex-A78 cores, an Arm Mali-G610 MC6 GPU and MediaTek’s latest AI processing unit, a combination the company says delivers “the most power-efficient performance in its class”.

AN ANDROID SMARTPHONE, BUT MORE SECURE

Sikur One, a new security-focused business smartphone. The phone is manufactured by Brazilian company Multilaser, and Sikur provides a modified and slimmed-down version of Android, which utilizes Zero Trust principles to offer an additional layer of protection.

The Sikur One can also be locked or wiped remotely, in the event it's lost or stolen, minimizing the chances that sensitive corporate data ends up in the wrong hands. You can't buy the phone from Sikur direct, only via resellers, but the company says it expects to device to sell for roughly $500.

According to the analyst house, smartphone sales rose by 6% in 2021, rebounding from the 12% drop off in 2020 caused by pandemic lockdowns.

Gartner says the arrival of 5G support in mid-tier smartphones was a significant driver of upgrade purchases, with Chinese brand Xaomi enjoying the greatest level of growth (29%).

However, the outlook isn't entirely positive; the global chip shortage and ongoing supply chain disruptions are expected to limit market growth.

FUJITSU 5G VRAN INNOVATION COULD CUT EMISSIONS IN HALF

Fujitsu has announced it will launch new vRAN technology that the company claims could slash base station emissions by 50%, in addition to offering end users a higher quality of service.

The innovation makes use of artificial intelligence to optimize the allocation of compute resources, thereby enabling a high level of performance with low power consumption.

This month, the new vRAN technology will be made available to network operators for testing, before rolling out globally at a later date.

Image credit: Shutterstock / Suwin

Image credit: TechRadar

GSMA CELEBRATES A "VIBRANT" MWC

With MWC 2022 now drawing to a close, organizers the GSMA have released a celebratory alert hailing a positive show.

Around 60,000 people from almost 200 countries are thought to have attended the show (with Around 500,000 unique virtual and daily viewers on MWC22 and partner platforms), with more than 1,900 companies showing off their latest products and updates.

"Nothing beats MWC in person, and it was exciting to bring our community – which is so passionate about connectivity – back together to discuss the opportunities that lie ahead," said GSMA CEO John Hoffman.

"On behalf of the GSMA, I would like to thank all of our attendees, exhibitors, sponsors, and partners who came together to make MWC22 so productive, safe, and successful. I also want to thank Barcelona City Council, Generalitat de Catalunya, the Ministry of Economy and Digital Transformation, Fira de Barcelona, Tourism de Barcelona, the L'Hospitalet de Llobregat, Mobile World Capital, and the people of Catalonia and Spain. Your support is unwavering, and your creativity, hospitality, and perseverance continually inspire us."

MWC BARCELONA 2023 & 4YFN 2023

We unlock the full power of connectivity so that people, industry and society thrive. Mobile has been at the forefront of innovation for over three decades. From the Nokia 3210, to the Tesla Model S, we continue to build upon our revolutionary successes – evolving technology and looking forward to a future that early tech pioneers could never have dreamed of.

As well as innovation in technology, the connectivity industry offers the world new opportunities, new revenue streams, new landscapes and even new vocabulary. Welcome to the hyperconnected and hyperreality world!

Every generation has a mission. Ours is digital everything. And it is going to take all of us, every industry –and every community to get there.

Be a part of the technological shift at MWC Barcelona 2023.

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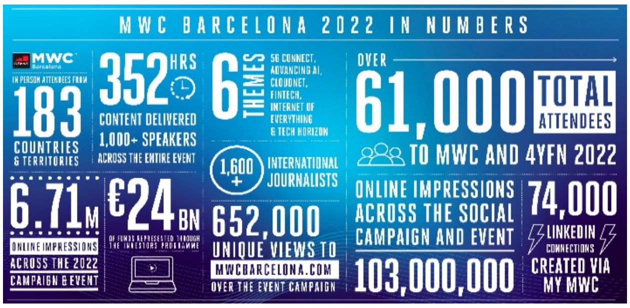

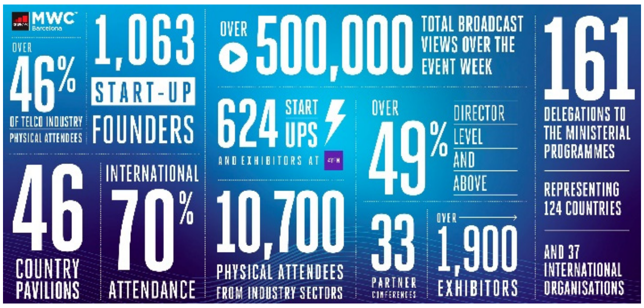

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ADVISORY BOARD ANNOUNCED FOR GEO WEEK 2023

Geo Week Advisory Board set to help craft programming, recommend speakers, and deliver critical insights to geospatial and built world professionals

Organizers of Geo Week, the premier event that champions the coming together of geospatial technologies and the built world, have announced an impressive list of influential leaders within the geospatial and built world industries who will be participating on the 2023 event's Advisory Board.

The 2023 event will take place February 13-15, 2023 in Denver, Colorado.

The Advisory Board will assist in developing conference programming comprised of both general sessions and breakout sessions that delve into the full spectrum of data needs, work processes, software integration and standards in both the geospatial and BIM worlds. Specific vertical industries include architecture, engineering, & construction; asset & facility management; disaster & emergency response; earth observation & satellite applications; energy & utilities; infrastructure & transportation; land & natural resource management; mining & aggregates; surveying & mapping; and urban planning / smart cities.

www.geo-week.com