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# ICT Trends

Digital Healthcare | Mobile Payment | Assistive Technologies | Internet of Things (IoT)

5th Generation Mobile Networks (5G) | Artificial Intelligence and Machine Learning

Blockchain and Shared Ledgers | 3D Printing

# ICT Trends 5G Mobile Networks

APCICT ASIAN AND PACIFIC TRAINING CENTRE FOR INFORMATION AND COMMUNICATION TECHNOLOGY FOR DEVELOPMENT

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# ABOUT

The 2030 Agenda for Sustainable Development provides a plan of action for achieving an economically, socially and environmentally sustainable future. Information and communication technologies (ICTs) are recognized as enablers of the 2030 Agenda for Sustainable Development. Their diffusion and application in all sectors of society provide new solutions to persistent development challenges.

As new technologies, along with increased connectivity, spread rapidly and transform the ICT landscape around the world, it is important for policymakers and government officials to understand the current trends in order to fully leverage the potential benefits of ICT.

This publication aims to provide timely and relevant information on the major ICT trends and the implications of these trends. It serves as a knowledge resource for policymakers and government officials in Asia and the Pacific to increase their awareness and appreciation for the continuously evolving ICT landscape. It intends to present a broad understanding of how new and emerging ICT trends could be utilized to support sustainable and inclusive development.

This publication is a collection of brief write-ups on the following eight ICT trends:

1. Digital Healthcare
2. Mobile Payments
3. Assistive Technologies
4. Internet of Things
5. 5th Generation Mobile Networks
6. Artificial Intelligence and Machine Learning
7. Blockchain and Shared Ledgers
8. 3D Printing

This set of topics was selected based on their relevance to achieving the Sustainable Development Goals (SDGs). The topics selected also aim to provide a broadly representative sample covering a wide range of technology areas spanning hardware, networking, software and data, as well as application domains (i.e., healthcare, finance and disability).

Each write-up introduces the topic by first describing the technology features and components, and then proceeds to highlight potential application areas and use cases, with examples from the Asia-Pacific region and beyond. This is followed by a discussion on the policy implications involving regulatory aspects, standards and linkages to the SDGs. Each write-up may vary slightly to highlight relevant aspects.

The write-ups can be read independent of the other. Although the topics have been presented in a certain sequence, readers may start with any topic of interest and move on to any other topic that they find of relevance or interest. While going through the write-ups, readers may find multiple connections across application domains and technology areas. This has been intentional to foster

a better appreciation of the potential use of the new and emerging technologies for sustainable development. As these are brief descriptions, interested readers are advised to go through the references provided at the end of the write-ups for a more comprehensive understanding of the topics.

# ACKNOWLEDGEMENTS

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# 1. Introduction

The fifth generation (5G) of mobile communications technology refers to the next mobile wireless standard that is currently under development and will hit the market in 2020. Compared with the current fourth generation (4G) Long Term Evolution (LTE) technology, 5G is targeting to reach higher speed, lower power[1] and lower latency (1ms or less).[2] The minimum requirements for peak data rate are 20 Gbps on the downlink and 10Gbit/s on the uplink.

The following are some of the expected features of the 5G network:

- 10-100 times greater bandwidth than 4G;
- 90 per cent reduction in the ratio of power consumption to service provided, particularly in mobile devices;
- A reliable network to connect over 7 trillion devices in the Internet of Things (IoT) that are controlled by over 7.5 billion people;
- A faster, secure and robust network with near-zero downtime; and
- Enable advanced user controlled privacy.

Previous generations of mobile networks, like the third generation (3G) mobile networks, were considered a breakthrough in communications. 3G receives a signal from the nearest cell tower and is used for phone calls, messaging and data. 4G works the same way as 3G but with a faster Internet connection and lower latency. 4G claims to be around five times faster than existing 3G services and theoretically, it can provide download speeds of up to 100Mbps.

Two significant trends[3] are driving the wireless industry to develop 5G—the explosive increase in demand for wireless broadband services needing faster, higher-capacity networks that can deliver video and other content-rich services; and IoT that is fuelling a need for massive connectivity of devices, and a need for ultra-reliable, ultra-low-latency connectivity over Internet protocol.

1 A low-power wide-area network (LPWAN) interconnects low-bandwidth, battery-powered devices with low bit rates over long ranges. Created for machine-to-machine and IoT communications, LPWANs operate at a lower cost with greater power efficiency than traditional mobile networks. They are also able to support a greater number of connected devices over a larger area.

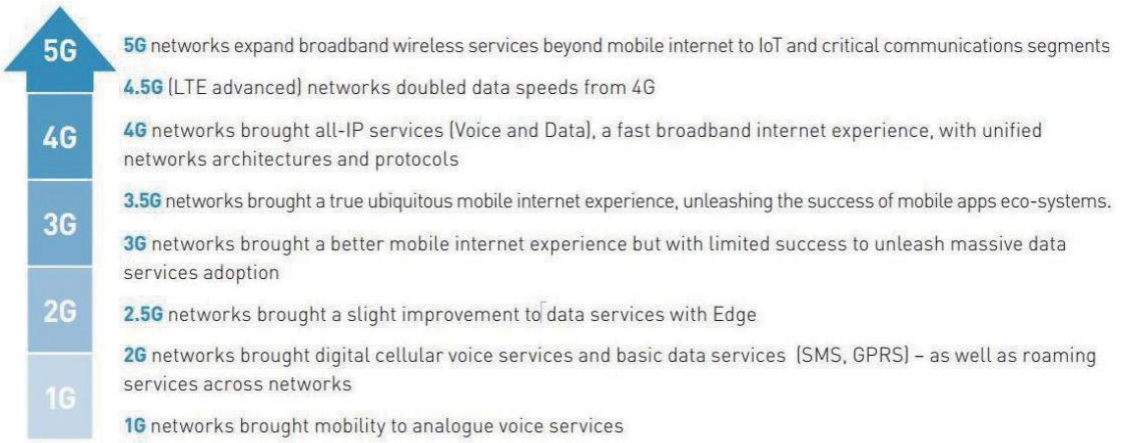
2 Latency is the amount of time a message takes to traverse a system. In a computer network, it is an expression of how much time it takes for a packet of data to get from one designated point to another. It is sometimes measured as the time required for a packet to be returned to its sender. A low latency network is a network in which the design of the hardware, systems and protocols are geared towards minimizing the time taken to move units of data between any two points on that network.

3 Global Mobile Suppliers Association, "The Road to 5G: Drivers, Applications, Requirements and Technical Development", November 2015. Available from http://www.huawei.com/minisite/5g/img/GSA_the_Road_to_5G.pdf.

The next (5th) generation of mobile communications technology is looking beyond mobile Internet to powering IoT.[4] For example, low latency will provide real-time interactivity for services using the cloud, which is key for the success of self-driving cars. In addition, low-power consumption will allow connected objects to operate for months or years without the need for human assistance.

Unlike current IoT services that make performance trade-offs to get the best from existing wireless technologies, 5G networks are expected to be designed to bring the level of performance needed for massive IoT. It will enable a perceived ubiquitous connected world.

**Figure 1: Evolution of Mobile Wireless Networks**




Source: Gemalto, "Introducing 5G networks – Characteristics and usages", 2016. Available from http://www.gemalto.com/brochures-site/download-site/Documents/tel-5G-networks-QandA.pdf.

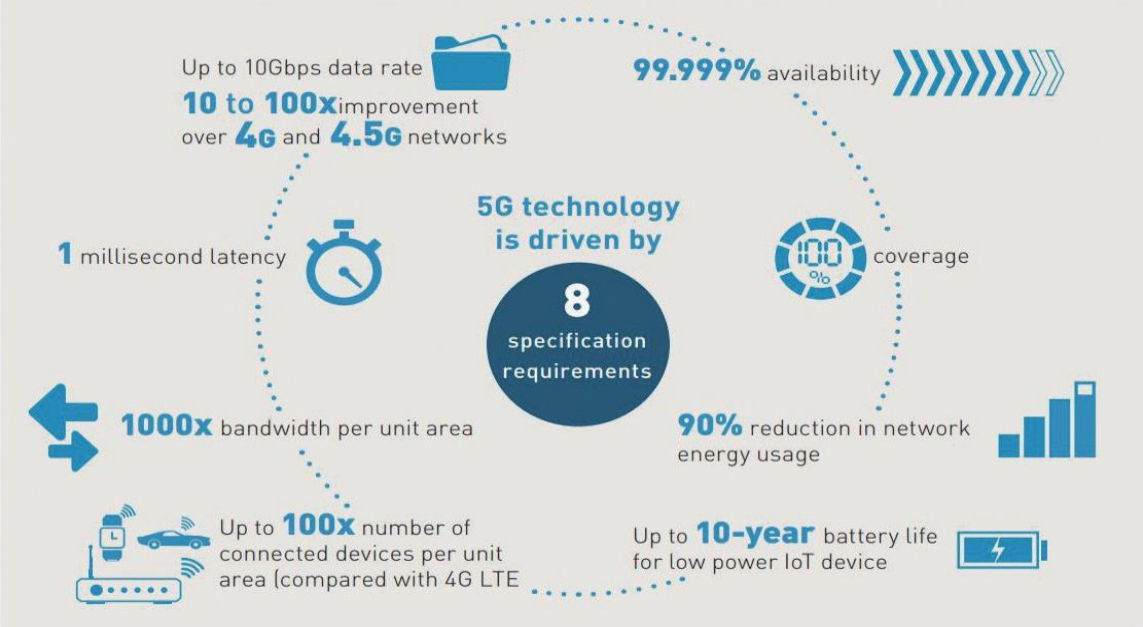
4 IoT is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems and the Internet.

# 2. Technology and Ecosystem

The ecosystem of 5G consists of network and radio equipment manufacturers, hardware platform providers, software providers, handset providers, app providers, digital service providers and consumers (individuals and industries).

For a connection to qualify for 5G, it should meet eight criteria,[5] which relate to connectivity speeds, round trip delay, minimum bandwidth per unit, scalability of the connected devices, coverage, availability, green initiatives like reduction of the network energy usage and battery life of devices. Figure 2 provides the criteria details.

**Figure 2: Criteria to Qualify for 5G**




Source: Gemalto, "Introducing 5G networks – Characteristics and usages", 2016. Available from http://www.gemalto.com/brochures-site/download-site/Documents/tel-5G-networks-QandA.pdf.

5 GSMA, *The Mobile Economy* 2017 (London, 2017). Available from https://www.gsmaintelligence.com/research/?file=9e927fd6896724e7b26f33f61db5b9d5&download.

The development of 5G is introducing a re-architecture of the core, incorporating new technologies and approaches that have emerged in the networking industry such as software-defined networking,[6] network functions virtualization,[7] and mobile edge computing,[8] to name a few. In addition, the architecture is required to support sharing infrastructure, providing various levels of "as-a-service" offerings leading to complex architectures. As 5G will be driven by software and network, functions will run over a unified operating system. In fact, 5G can be considered a completely different system rather than an evolution of 4G.

5G will support a heterogeneous set of integrated interfaces from evolutions of previous generations to brand new technologies. Seamless handover between heterogeneous wireless access technologies like Wi-Fi to mobile and vice versa will be a native feature of 5G. It will use simultaneous radio access technologies[9] to increase reliability and availability. The deployment of ultra-dense networks[10] with numerous small cells[11] will require new interference mitigation,[12] backhauling[13] and installation techniques. 5G will ease and optimize network management operations.[14] The exploitation of data analytics and big data techniques will pave the way to monitor users' quality of experience.

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6 Software-defined networking is an architecture purporting to be dynamic, manageable, cost-effective and adaptable, seeking to be suitable for the high-bandwidth, dynamic nature of present day applications. Software-defined networking architectures decouple network control and forwarding functions, enabling network control to become directly programmable and the underlying infrastructure to be abstracted from applications and network services.

7 Network functions virtualization is a network architecture concept that uses the technologies of information technology virtualization to virtualize entire classes of network node functions into building blocks that may connect, or chain together, to create communication services. Network functions virtualization relies upon, but differs from, traditional server-virtualization techniques, such as those used in enterprise information technology. A virtualized network function may consist of one or more virtual machines running different software and processes, on top of standard high-volume servers, switches and storage devices, or even cloud computing infrastructure, instead of having custom hardware appliances for each network function.

8 Mobile edge computing is a network architecture concept that enables cloud computing capabilities and an information technology service environment at the edge of the cellular network. The basic idea behind mobile edge computing is that by running applications and performing related processing tasks closer to the cellular customer, network congestion is reduced, and applications perform better. This technology is designed to be implemented at the cellular base stations, and enables flexible and rapid deployment of new applications and services for customers. Combining elements of information technology and telecommunications networking, mobile edge computing also allows cellular operators to open their radio access network to authorized third parties, such as application developers and content providers.

9 5G radio access will be built upon both new radio access technologies and evolved existing wireless technologies (LTE, HSPA, GSM and Wi-Fi).

10 Ultra-dense network is a technique to meet the requirements of explosive data traffic in 5G mobile communications.

11 Small cells (also known as femtocell and picocell) can improve the coverage and capacity of cellular networks by exploiting spatial reuse of limited spectrum. Dense small cells can also offload the wireless data traffic of user equipment from traditional macrocells, especially for an indoor environment where more than 80 per cent of data traffic takes place.

12 Interference is the chief limiting factor in high-capacity mobile communications. Interference is responsible in many cases for dropped calls, slow download speeds and shortened battery life. Using high speed parallel processing digital signal processors and computer processing units (DSP/CPU@50 billion operations per second) for signal processing in combination with multiple-input and multiple-output antenna systems, the interference can be mitigated from multiple sources.

13 Backhaul is a challenge in 5G due to the use of small cells supporting high bandwidth. Densification of small cells produces massive backhaul traffic in the core network, which inevitably becomes a bottleneck in the system. Employing fibre or cable in dense small cell backhaul would result in prohibitively high cost and practical difficulty in implementation. Wireless backhaul in millimetre wave is considered a possible cost-effective solution.

14 Network management is the process of administering and managing the 5G network covering fault analysis, performance management, provisioning of network and network devices, and maintaining the quality of service.

The service provider has many new challenges to address in 5G as the type of usage, network design and architecture of the system go through complete changes. 5G will trigger mobile edge computing as it enables massive amounts of data to pour in from the edge. This will require shared edge computing resources at switching centres and base stations using network functions virtualization. All this computing, coupled with the associated management and orchestration required to operate it, will result in a distributed and dynamically configurable service provider infrastructure. Hence, a service provider has to shift from being a telecom operator to a digital service provider covering the mobile infrastructure and computing to support the new applications and surge of data that will come because of the newapplications.

5G is expected to be a convergence of network built on virtualized computing platforms, using ultra-dense network architectures, radio technologies with small cells and millimetre wave backhauls. The convergence encompasses usage of big data and analytics for enhancement of the service experience. Hence, many institutions, including technological companies and research organizations are collaborating to develop these technologies. Some of the key areas of research are described below.

### Centimetre and Millimetre Wave

There is a significant amount of spectrum available at higher frequencies. 5G technology is looking beyond the congested centimetre waves that are occupied by the current 3G and 4G networks. The advantage of using millimetre waves for mobile communication is their wide channel bandwidth of 1-2 gigahertz in contrast to the current bandwidths of 10-20 megahertz.

### Massive Dense Networks

Massive dense networks provide higher data rates to more users. It is being used in existing technologies like LTE (4G) and Wi-Fi, but the number of antennas is restricted. With the use of millimetre waves in 5G communication, massive dense networks can theoretically use an infinite number of antennas.

### Battery Life

Batteries that can last for years are very important in IoT networks as the machine connected to the network may not be near a power source. 5G technology will be characterized with more efficient use of power for extended battery life. This will cover terminal devices, network elements and the network as a whole, including data centres. For example, recommendations are to enable a 10-year battery life for a battery-powered sensor. However, it is not very clear how this efficiency will be achieved in the practical roll out of 5G.

### Cognitive or Smart Radio Technology

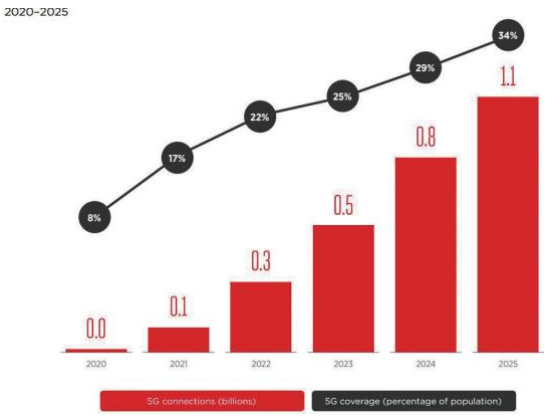
Cognitive or smart radio technology is a dynamically programmable radio system where the transmission and reception of signals is designed to use the best available channel in the proximity.

### Pervasive or Ubiquitous Network

Ubiquitous network allows the user to be connected to different wireless technologies like 2G, 3G, 4G and Wi-Fi simultaneously, and can switch between them without any issues.

# 3. 5G Opportunity

**Figure 3: 5G Adoption**




Source: GSMA, *The Mobile Economy* 2017 (London, 2017). Available from https://www.gsmaintelligence.com/research/?file=9e927fd6896724e7b26f33f61db5b9d5&download.

Early 5G networks[15] will be deployed in dense urban areas as operators look to supplement existing mobile broadband capacity, and at the same time provide a test-bed for 5G use cases to emerge. Operators are expected to roll out 5G at a similar rate to the deployment of 4G, attaining coverage of 34 per cent of the global population (2.6 billion people) by 2025. Adoption will scale rapidly, as device vendors see the technology as a means to differentiate devices, while the fact that average selling prices for smartphones have declined since the launch of 4G means affordability will prove less of a barrier to ownership. 5G connections (excluding cellular machine-to-machine connections) are anticipated to reach 1.1 billion by 2025. Industry reports claim that by 2035, "5G's full economic benefit should be realized across the globe", and could produce up to USD 12.3 trillion worth of goods and services.[16] Qualcomm's study indicates that the 5G value chain itself is seen as generating up to USD 3.5 trillion in revenue by 2035. The study further claims that, over time, 5G will boost real global GDP growth by USD 3 trillion cumulatively from 2020 to 2035, roughly the equivalent of adding an economy the size of India.

Ovum[17] estimates that 5G services will be available in over 30 countries worldwide by the end of 2021, with services in all four major world regions. However, the report indicates that the vast majority of 5G subscriptions will be concentrated in China, Japan, Republic of Korea and United States of America where major operators have revealed aggressive timelines for launching 5G

15 GSMA, *The Mobile Economy* 2017 (London, 2017). Available from https://www.gsmaintelligence.com/research/?file=9e927fd6896724e7b26f33f61db5b9d5&download.

16 Qualcomm, "Landmark Study on Impact of 5G Mobile Technology Released", 17 January 2017.Available from https://www.qualcomm.com/news/releases/2017/01/17/landmark-study-impact-5g-mobile-technology-released.

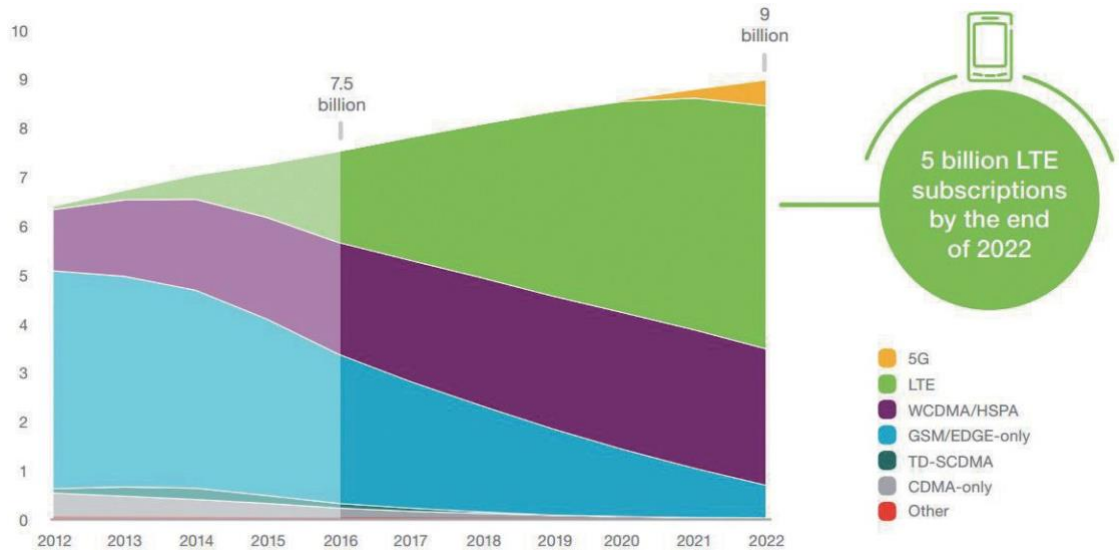
17 Mike Roberts, "Ovum: 5G will be available in nearly 30 countries by 2021", *Telecom Asia*, 7 February 2017. Available from https://www.telecomasia.net/content/ovum-5g-will-be-available-nearly-30-countries-2021.

services. Industry reports state that by 2023, the number of 5G subscriptions[18] will reach more than 500 million.[19]

In April 2017, United States telecoms giant AT&T[20] announced a list of 20 cities where it will initiate its first 5G roll out campaigns. The company has dubbed the high-speed network plans the "5G Evolution" and has indicated that it will we be able to provide top speeds of up to 400Mbps.

AT&T is racing against its top rival, Verizon, to deploy the first commercial 5G in the USA. Verizon is in the midst of launching ten 5G market trials across the country in both dense urban and suburban areas beyond its local exchange carrier footprint. Verizon[21] released its 5G specifications to vendors in 2016, which it said was intended to assist vendors in developing interoperable 5G equipment for pre-standard testing and fabrication. The company has been trialling, what it calls "wireless fibre", since February 2017.

**Figure 4: Mobile Subscriptions by Technology**




Source: Ericsson, *Ericsson Mobility Report* (Stockholm, 2017). Available from https://www.ericsson.com/assets/local/mobility-report/documents/2017/ericsson-mobility-report-june-2017.pdf.

18 A 5G subscription will require a device capable of supporting 5G services and use cases, which is connected to a 5G-enabled network.

19 Ericsson, *Ericsson Mobility Report* (Stockholm, 2017). Available from https://www.ericsson.com/assets/local/mobility-report/documents/2017/ericsson-mobility-report-june-2017.pdf.

20 AT&T, "AT&T Plans to Bring 5G Evolution to Over 20 Metros by End of Year", 25 April 2017 Available from http://about.att.com/story/5g_evolution_to_over_20_metros_in_2017.html.

21 Diana Goovaerts, "Verizon Announces 5G Customer Trials in 11 Cities with 5G Forum Partners", *Wireless Week*, 22 February 2017. Available from https://www.wirelessweek.com/news/2017/02/verizon-announces-5g-customer-trials-11-cities-5g-forum-partners.

### *Case: 5G-Related Efforts being Adopted by Different Countries*

The Government of the Republic of Korea has recently announced plans to expand the bandwidth allocated to 5G mobile services by 2018, when the country will host the Pyeongchang Winter Olympic Games. The Ministry of Science and ICT will share bandwidth in the 1.3GHz range between the country's three mobile carriers, Korea Telecom, SK Telecom and LG Uplus.[22]

In China, the leading telecom operator China Mobile said that it would begin major trials for 5G in 2018, kicking off a new round of billions of dollars in investment to usher in the high-speed communications era of the IoT. The company said it would test the technology for about two years and launch 5G commercial services in 2020.[23]

Press statement from Nokia announced partnerships with Airtel and BSNL for preparing 5G networks in India to support IoT and future smart cities. The partnerships will explore operations, cost-effectiveness, quality and reliability, and develop a strategy for rolling out 5G.[24]

22 The Korea Herald, "South Korea mobile carrier KT begins installing 5G network in PyeongChang", 18 September 2017. Available from http://www.nationmultimedia.com/detail/Startup_and_IT/30326959.

23 Qin Min and Yang Ge, "China Mobile Plans to Launch 5G Trials in 2018", *Caixin Global*, 21 December 2016. Available from https://www.caixinglobal.com/2016-12-21/101029326.html.

24 Money Control, "Nokia inks MoUs with Airtel and BSNL to bring 5G network in India", 10 April 2017. Available from http://www.moneycontrol.com/news/business/companies/nokia-signs-mous-with-airtel-and-bsnl-to-bring-5g-network-in-india-2255549.html.

# 4. 5G Standards

As 5G develops globally, it is the adoption of standards that will define its ubiquitous use and widespread deployment. The International Telecommunication Union launched "International Mobile Telecommunications for 2020 and Beyond" in 2012, setting the stage for 5G standards development and roll out. A number of standards bodies are actively working towards the goal of setting standards for 5G by 2020. They include, but are not limited to the Institute of Electrical and Electronics Engineers, Internet Engineering Task Force, International Telecommunication Union and the 3rd Generation Partnership Project (3GPP).[25] The first set of 5G standards is scheduled to be released by 3GPP in 2018.

In addition, Audi, BMW, Daimler, Ericsson, Huawei, Intel, Nokia and Qualcomm announced in September 2016 the formation of the "5G Automotive Association"[26] with the goal of addressing issues around connected mobility and road safety in the IoT era. Vodafone has joined the association and has begun testing LTE-V2X, a new technology for vehicle-to-vehicle communications.

The main activities of the association include: defining and harmonizing use cases, technical requirements and implementation strategies; supporting standardization and regulatory bodies, certification and approval processes; addressing vehicle-to-everything technology requirements, such as wireless connectivity, security, privacy, authentication and distributed cloud architectures; and running joint innovation and development projects.

Meanwhile, a large number of joint research and trials are going on to ensure a strong presence and play in the 5G arena by equipment manufacturers, service providers and governments of many countries. Some of the trials and announcements of trials include the following:[27]

- Japan and the Republic of Korea started to work on 5G requirements in 2013.
- Samsung, Huawei and Ericsson started 5G prototype development in 2013.
- NTT DoCoMo, Japan conducted the first set of 5G experimental trials in 2014.
- AT&T tested 5G wireless service in Austin, Texas in 2017.
- Fujitsu demonstrated speed rates at 56 Gbps in 2017.
- The Republic of Korea's SK Telecom plans to demo 5G in 2018 at the Pyeongchang Winter Olympics.

25 3GPP unites seven telecommunications standards development organizations—ARIB, ATIS, CCSA, ETSI, TSDSI, TTA and TTC—known as "Organizational Partners" and provides their members with a stable environment to produce the reports and specifications that define 3GPP technologies. The project covers cellular telecommunications network technologies, including radio access, the core transport network and service capabilities, including work on codecs, security and quality of service, and thus provides complete system specifications. The specifications also provide hooks for non-radio access to the core network, and for interworking with Wi-Fi networks. 3GPP specifications and studies are contribution-driven, by member companies, in working groups and at the technical specification group level. See 3GPP, "About 3GPP". Available from http://www.3gpp.org/about-3gpp.

26 Sacha Kavanagh, "What is the 5G Automotive Association?" *5G.co.uk*, no date. Available from https://5g.co.uk/guides/what-is-the-5g-automotive-association/.

27 Gemalto, "Introducing 5G networks – Characteristics and usages", 2016. Available from http://www.gemalto.com/brochures-site/download-site/Documents/tel-5G-networks-QandA.pdf.

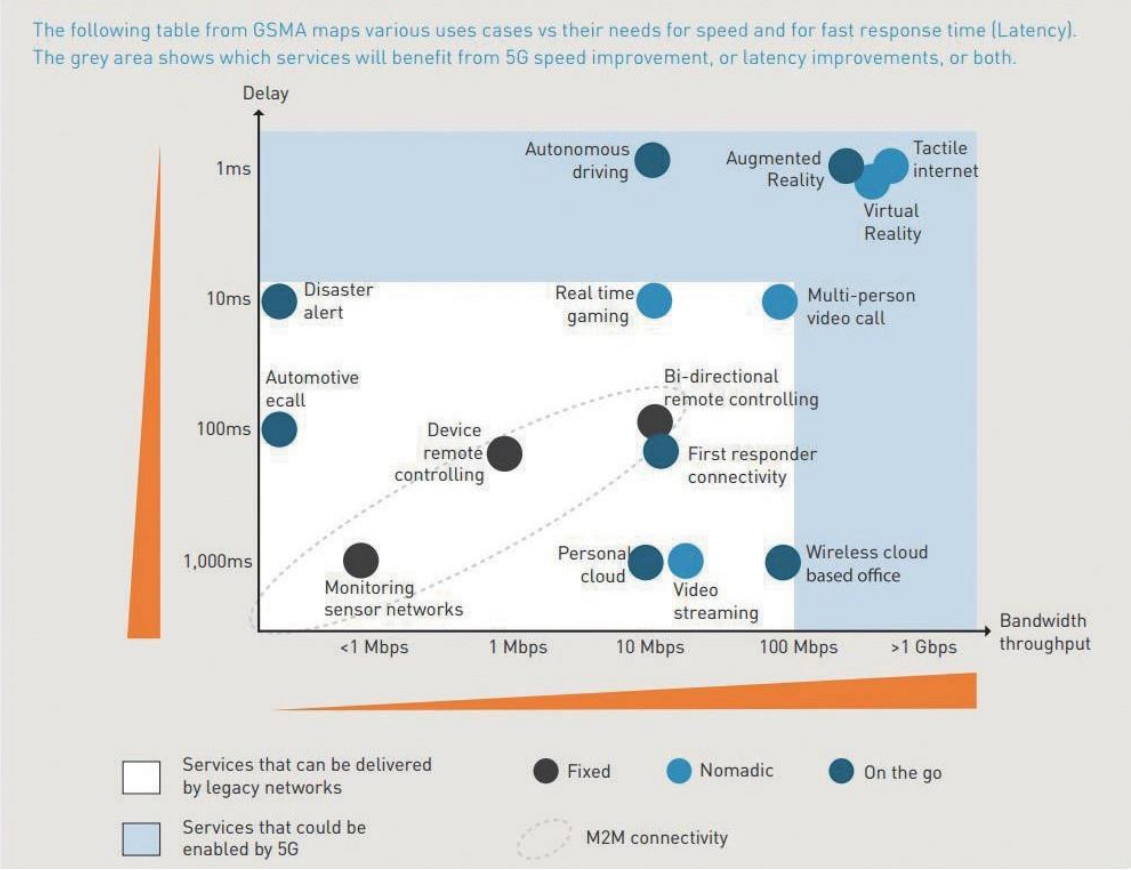
- Megafon, Russia has started to trial 5G networks for eleven cities hosting the FIFA 2018 World Cup, involving machine-to-machine connections and human users.
- Ericsson and Telia Sonera plan to make 5G commercial service available in Stockholm and Talinn by the end of 2018.
- Japan's target is to launch 5G for the 2020 Tokyo Summer Olympics.

# 5. 5G Applications

5G technology will contribute significantly to the growth of many industries, including education, health, information technology, entertainment, automobiles and manufacturing, many of which have links with various SDG goals and targets. Before going into specific use cases of 5G, it is important to understand the relation between the type of services and technology capabilities in various generations.

Figure 5 shows the applications and the speeds that are needed for usage of various applications on a mobile network. In Figure 5, the applications in the blue area will benefit from higher speeds and throughputs that are available in 5G, which makes them the first types of use cases by default. Some key applications like self-driving cars require very aggressive latency (fast response time) while they do not require fast data rates. Conversely, enterprise cloud-based services with massive data analysis will require speed improvements more than latencyimprovements.

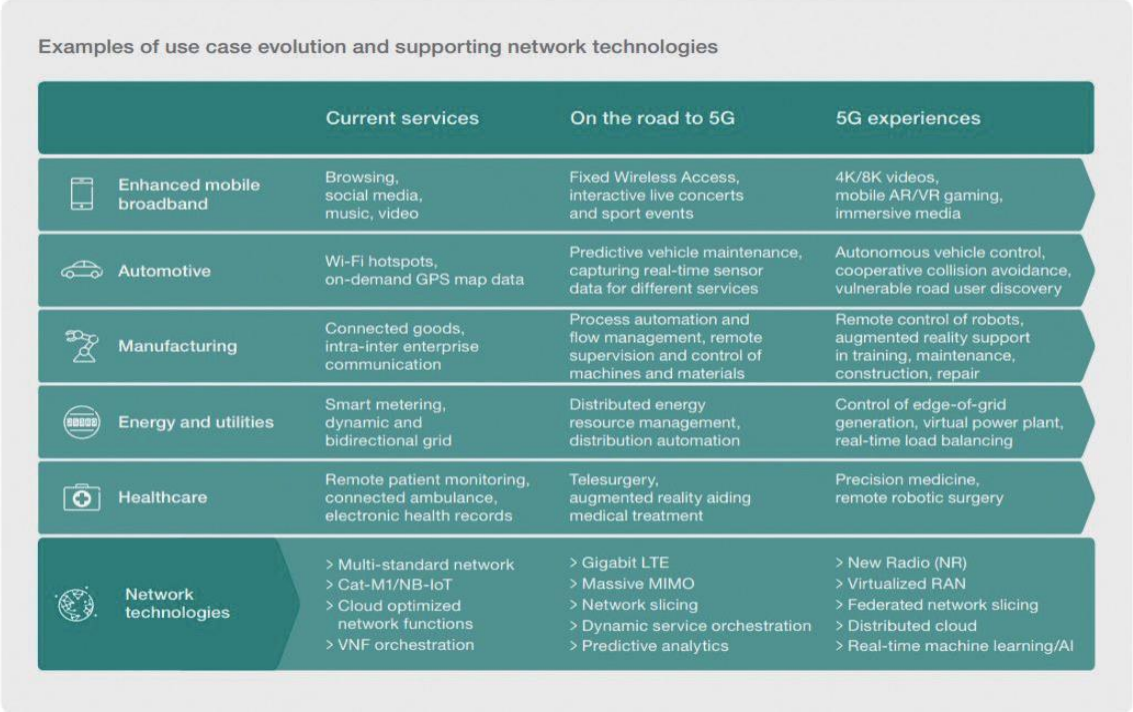
**Figure 5: Applications and Required Speeds**




Source: Gemalto, "Introducing 5G networks – Characteristics and usages", 2016. Available from http://www.gemalto.com/brochures-site/download-site/Documents/tel-5G-networks-QandA.pdf.

Figure 6 gives a good overview of how the current services and new use cases will evolve as a response to the availability of 5G, including the gains that will accrue due to usage of 5G in those services.

**Figure 6: Services and 5G Experiences**




Source: Ericsson, *Ericsson Mobility Report* (Stockholm, 2017). Available from https://www.ericsson.com/assets/local/mobility-report/documents/2017/ericsson-mobility-report-june-2017.pdf.

Some of the applications enabled by 5G are described below.

## 5.1 Virtual Reality or Tactile Internet

An example of the use of virtual reality or tactile Internet technology is the remote-controlled surgery robot, which requires high bandwidth and low latency. Such systems are still in early stages of development and are highly dependent on other systems like motion sensors and displays. They are defined as super-low latency Internet applications to meet human level response time. When available this will find use in critical areas such as medical nano-surgery where surgeons may use intra-body robotics systems to perform microsurgeries. The impact of tactile Internet has the potential to also revolutionize the gaming industry. It may enable new virtual reality user interfaces where applications will meet human senses response time.

## 5.2 Autonomous Cars

Autonomous driving or smart cars and connected cars are automobiles that can communicate with the external environment or with other cars so that the road journey will be safer. The need for 5G specifications for autonomous cars is better explained with an example. A car running at 100km/h will move 27.6m every second, or 2.7cm every millisecond. If the road sensors capture an unexpected event on the road, <1ms network(s) latency specified by 5G means that the information will reach the car from the cloud in a time frame that corresponds to less than 1-metre motion (between the time the event occurred and the time the car control system gets the information).

## 5.3 Drones

Drones and unmanned flying vehicles are finding increasing use in military and civilian applications. Usage of drones for aerial mapping, photography and warfare are established use cases. Amazon is planning to use drones to deliver packages to homes. As the drone-based delivery system is being considered, the issue of managing them, collecting information from them and being able to control them are limited by the latency and bandwidth of today's networks. With 5G, low latency will lead to fast response time, LAN and WAN combination will support fast moving drones, high-speed data rates will allow the exploitation of massive quantities of navigation data, and sensors to actuators communications will enable complex navigation software heuristics.

## 5.4 Internet of Things

IoT is a concept where a number of devices—machines, appliances or systems—are connected to each other and sense, process and transfer data among them without any human control. These could include industry and production systems in automotive, manufacturing and precision services sectors, logistics and distribution, and the consumer goods sector. Such systems require a reliable, high-bandwidth and low-latency network, and will work with the specifications of large bandwidth and high connection density over small areas, which is offered by 5G.

## 5.5 Machine-to-Machine Connectivity

The best example of machine-to-machine communication is in a smart home automation system where different devices like meters, temperature controls, security alarms and smoke detectors are connected and communicate with each other, and work efficiently. Some of the other machine-to-machine communication systems are deployed in consumer electronics, automobile telemetry and automated health monitoring. Most of these connections are still using either 2G or 3G networks. There may not be an immediate transition to 5G technology but eventually all machine-to-machine connections will make use of 5G technology.

## 5.6 Wireless Cloud Computing

A wireless cloud office is where huge amounts of data can be stored and accessed remotely. This is possible with high-bandwidth communication systems. The present 4G network has the potential to deliver this service. However, with user data running into 71 exabytes per month by 2020[28] and content that is based largely on video, such applications need 5G.

## 5.7 Multi-Person Video Calling

Another service where bandwidth and latency are important is multiple-person video conference. The application requires low latency and committed throughputs that the existing 4G technology can barely provide.

28 Ericsson, *Ericsson Mobility Report* (Stockholm, 2017). Available from https://www.ericsson.com/assets/local/mobility-report/documents/2017/ericsson-mobility-report-june-2017.pdf.

# 6. Policy and Regulatory Issues

In the mobile world, regulators have a huge influence on the ability to deliver innovative services to the end users. The value of 5G will be unleashed when regulators respond to the needs of the operators while safeguarding spectrum and ensuring a level playing field for all the service providers.

Customers may be increasingly looking to buy virtualized services, not simple network access, as a dynamic way to enhance their experience. As part of this strategic approach, competitive carriers are looking at technologies like Internet protocol switches that have virtualized components, or other network equipment that is beginning to contemplate virtualization, as well as the spectrum to deliver a 5G experience.

High-band spectrum can carry large data at fast speeds, but its reach is only a few hundred metres. With exponentially more small cells and dense networks, the need for dedicated backhaul will skyrocket as wireless carriers purchase business data services from wireline providers. The regulator plays a significant role in how this market operates, and decisions on these issues could jumpstart deployment or act as a barrier. In addition to backhaul, these new small cells must be constructed, but first cleared for historical and environmental review. Policies must reflect that the “towers” of today and tomorrow may fit in one’s palm in order to be relevant for years to come.

To ensure their citizens and companies can harness the potential benefits of 5G mobile technologies, governments need to act now. In particular, policymakers need to take steps to make sufficient spectrum available once the first commercial 5G networks go live from 2020.

The World Radiocommunication Conference in 2019 is an important conference in this respect. In the process of preparing for the conference, governments have the opportunity to identify harmonized spectrum for 5G. Global harmonization of the frequency bands used for mobile technologies and services enables the industry to develop low-cost devices, support international roaming and minimize cross-border interference. If governments fail to agree to a common set of bands, then 5G spectrum could become fragmented, which could drive up device costs and undermine access to widespread and affordable 5G. Mobile operators will need internationally harmonized spectrum in three different ranges—below 1 GHz, 1-6 GHz and above 6 GHz.

Governments will also need to ensure that regulation, the cost of spectrum and the obligations placed on licence holders support the roll out of 5G and do not create unnecessary roadblocks. Given the large number of small cell sites required to deliver ultra-high speeds, 5G deployments will require significant network investment. An unfavourable regulatory environment and/or excessive fees could compromise the speed of 5G deployments, quality of service and coverage levels.

For smaller carriers serving markets that the largest carriers do not, transitioning to 5G networks can provide new opportunities to work collaboratively with developers and their peers to bring the latest mobile services to the market. Hosted platforms, in whole or in part, may unlock new services and opportunities for carriers at lower costs and faster time to market than if they do it alone.

For carriers, real growth will come from the new and innovative connected services. For instance, in the rural parts of a country where mobile broadband may be the only access to the Internet, how can local carriers provide functionality that allows farmers to monitor crops or livestock via the 5G network? What remote healthcare services will be developed, and how can rural carriers deliver these services via telemedicine?

4G networks today use the universal subscriber identity module (USIM) application to perform strong mutual authentication between the user, his/her connected device and the networks. The entity hosting the USIM application can be a removable SIM card or an embedded UICC chip. Such a strong mutual authentication is crucial to enable trusted services. Security solutions today are already a mix between security at the edge (device) and security at the core (network). Several security frameworks may co-exist in the future and 5G is likely to re-use existing solutions used today for 4G networks and for the cloud. The standard for strong mutual authentication for 5G networks is not finalized yet. The need for security, privacy and trust will be as strong as for 4G if not stronger with the increased impact of IoT services.

5G needs new bands of frequency spectrum and many of these bands have never been allotted before. The allocation size spans many megahertz and as a limited resource, it needs to be shared between many operators in a transparent and fair manner. The prices for spectrum should balance against the development agenda and enable sustainable development.

5G needs ultra-small towers (cells) and these need a completely different method of regulation, far different from that applied to the cell towers today. The frequency reuse and spectral efficiency are achieved only with the right quality of equipment and when power is managed stringently.

The challenge of 5G is much more than the previous generation of mobile communications technology. Until 4G, the devices are limited to mobile devices, tablets, laptop dongles and other similar devices. However, in 5G, machine-to-machine type of networks like IoT, autonomous cars and drones could be involved. The regulation has to go beyond the purview of information and communication technology, and enter into realms of industrial electronics, industrial process and control, and automobiles. The complexity arises from the cross-domain reach that is necessary for both specifications and regulation of the technology in its production as well as its use.

The dangers of fallouts are unfathomable. A drone useful for delivery of a book can well be used for delivery of a bomb. The number of connected subscribers and the reach of the network are overwhelming, and the ability to do anything and everything with the network is an opportunity and a threat at the same time. The use cases involving complex industrial systems in a network open up a Pandora box of issues relating to how the network is secured from the core to the edge from any attacks by hackers.

Every technology wave brings along certain opportunities and threats. 5G is such a technology, which is on the horizon, promising a great deal of value to society, and at the same time opening a set of issues that is completely new for policymakers and government to deal with.

# 7. References


AT&T. AT&T Plans to Bring 5G Evolution to Over 20 Metros by End of Year. 25 April 2017 Available from http://about.att.com/story/5g_evolution_to_over_20_metros_in_2017.html.

Ericsson. *Ericsson Mobility Report*. Stockholm, 2017. Available from https://www.ericsson.com/assets/local/mobility-report/documents/2017/ericsson-mobility-report-june-2017.pdf.

Gemalto. Introducing 5G networks – Characteristics and usages. 2016. Available from http://www.gemalto.com/brochures-site/download-site/Documents/tel-5G-networks-QandA.pdf.

Global Mobile Suppliers Association. The Road to 5G: Drivers, Applications, Requirements and Technical Development. November 2015. Available from http://www.huawei.com/minisite/5g/img/GSA_the_Road_to_5G.pdf.

Goovaerts, Diana. Verizon Announces 5G Customer Trials in 11 Cities with 5G Forum Partners. *Wireless Week*, 22 February 2017. Available from https://www.wirelessweek.com/news/2017/02/verizon-announces-5g-customer-trials-11-cities-5g-forum-partners.

GSMA. *The Mobile Economy 2017*. London, 2017. Available from https://www.gsmaintelligence.com/research/?file=9e927fd6896724e7b26f33f61db5b9d5&download.

Kavanagh, Sacha. What is the 5G Automotive Association? *5G.co.uk*, no date. Available from https://5g.co.uk/guides/what-is-the-5g-automotive-association/.

Money Control. Nokia inks MoUs with Airtel and BSNL to bring 5G network in India. 10 April 2017. Available from http://www.moneycontrol.com/news/business/companies/nokia-signs-mous-with-airtel-and-bsnl-to-bring-5g-network-in-india-2255549.html.

Qin Min and Yang Ge. China Mobile Plans to Launch 5G Trials in 2018. *Caixin Global*, 21 December 2016. Available from https://www.caixinglobal.com/2016-12-21/101029326.html.

Qualcomm. Landmark Study on Impact of 5G Mobile Technology Released. 17 January 2017. Available from https://www.qualcomm.com/news/releases/2017/01/17/landmark-study-impact-5g-mobile-technology-released.

Roberts, Mike. Ovum: 5G will be available in nearly 30 countries by 2021. *Telecom Asia*, 7 February 2017. Available from https://www.telecomasia.net/content/ovum-5g-will-be-available-nearly-30-countries-2021.

The Korea Herald. South Korea mobile carrier KT begins installing 5G network in PyeongChang. 18 September 2017. Available from http://www.nationmultimedia.com/detail/Startup_and_IT/30326959.

# Glossary

**2G** : Second generation of mobile communications technology (GSM, CDMA 1x).

**3G** : Third generation of mobile communications technology (WCDMA/HSPA, TD-SCDMA, CDMA EV-DO, Mobile WiMAX).

**4G** : Fourth generation of mobile communications technology (LTE, LTE-A)

**App coverage** : The geographical area within which an app works as expected by the user. This means that each app has its own coverage map. App coverage can be measured as the probability that a mobile broadband network delivers sufficient performance for a good user experience for that app.

**Smartphones** : Mobile phones with open operating systems, for example, iPhones, Android phones and Windows phones, as well as Symbian phones and BlackBerry phones.

# Acronyms

| | |
|---|---|
| **2G** | Second Generation (of Mobile Communications Technology) |
| **3G** | Third Generation (of Mobile Communications Technology) |
| **3GPP** | 3rd Generation Partnership Project |
| **4G** | Fourth Generation (of Mobile Communications Technology) |
| **5G** | Fifth Generation (of Mobile Communications Technology) |
| **GHz** | Gigahertz |
| **Gpbs** | Gigabits per Second |
| **IoT** | Internet of Things |
| **LTE** | Long Term Evolution |
| **Mbps** | Megabits per Second |
| **USIM** | Universal Subscriber Identity Module |

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