



5g technology: A new future wave

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Abstract

5G is a technology vision of the future world. 5G wireless networks will bring 1000-fold gains in capacity and connections for 100 billion devices with extremely low latency and response time. The deployment of these networks will come in 2020 and 2030. Breakthroughs in wireless network will also bring economic and societal growth in entirety. New forms of 5G will lead zero distance connectivity between people and connected machines. The present paper deals with the evolution of mobile generations over the years that has led to the development of the 5G technology. This paper also discusses and analyses the future potential of usage of the 5G technology for selected countries which are testing and aspiring for it. The paper also narrates the companies which have become the world leaders in the development of 5G. It concludes with conclusions preceded by a short description on 5G in Indian scenario.

Keywords: 5G, future potential, subscribers, 5G features

1. Introduction

World in future will be such as is beyond imagination today. It will be a world where not only people but all the things are also connected. Cars on roads are connected, patients are connected to the doctors and medical equipments, smart cities are connected to their residents. Think of a smart glass featuring augmented reality, mobile virtual reality, and much higher quality videos to enjoy. 5G is the key to unlock the world of this internet of things.

5G is the fifth-generation wireless technology, which will not only increase the downloading and uploading speeds but also have ultra-low latency, that is, the time taken by the network to respond or in other words the travel time of data from the source to the destination. The latency can be explained as follows. Suppose a car is running at speed of 100 km per hour, it will move at the speed of 27.6 meter per second or 2.7 cm per second. Now, if the road sensors capture some unexpected event then and in less than 1 millisecond the information will reach from the cloud to the car and preventive action can be taken.

The 5G technology will also provide the speed of download as 1 (one) Gbps, which is hundred times the existing speed. It will also have wide frequency spectrum area which will ensure no network congestion.

2. Review of literature

Many researchers have worked in this field. The major findings of their work are as follows:, Sapakal S.R. *et al.* (2013), have discussed about all the generations of mobile technology, compared them and found the need of 5G. Bhalla M.R. *et al.* (2010) ^[1], have discussed about the development and growth of all generations of wireless mobile know-how along with their significance advantages and disadvantages. Olumuyiwa O.F., (2014), made a comparative study on 3G, 4G, 5G wireless technology, also studied why 5G is favored as future technology and threats of implementation of 5G technology. Rost *et al.* (2014), described machine to machine communication (M2M) where devices and sensors communicate with each other

directly without the user being present all the time. Olsson *et al.* (2013) ^[2], shows the result of IOT and (M2M) communication as at the connection of all the things that are wirelessly connected. Osseiran *et al.* (2014) ^[3], predicted 50 billion connected devices by 2020. Nokia (2014) ^[6] found that device to device communication (D2D) can improve the users experience by reducing latency increasing peak data rates and power consumption. Tehrani *et al.* (2014) ^[4] identified that pricing for device to device services would be a problem for the operators in terms of how to charge and control these device to device services. They mention discounts on monthly bills on the quantum of data as the possible incentives. This seems to be reasonable from the operators point of view as the device relating is profitable to them as it contributes loading at the base stations. NGMN (Next Generation Mobile Networks) (2014), started the business aspects of 5G and expected that the business beyond 2020 would be different from today mainly due to emergence of new Business Models which would be driven by the needs of customers and operators. The study asserted that kick Technologies of 5G economic and business incentives and operational efficiency would make 5G feasible. To quote the study "5G is an end to end ecosystem to enable a fully mobile and connected society. It empowers value creation towards customers and partners, to existing and emerging use cases, delivered with consistent experience, and enabled by sustainable business models". Olsson *et al.* (2013) ^[2], argued for the necessity of offering affordable prices to the end user and the green perspective in terms of power consumption, sustainability and CO2 emissions. The green perspective is related to economics in several ways. The direct connection is that less power consumption is a green objective and also leads to lower utility expenses. Large emissions may be charged with fees which are added to the total cost. Even if there are no fees, large emissions may still have socio-economic consequences, that reduce the social welfare. Nokia (2016), mentions virtual reality as a use case for 5G. VR technology can be applied to design the products before they are built.

This will lead to shorter development time. This will lead to low development cost and 5G is the key enabler for this.

3. Objectives of the study

1. To analyze the evolution of technology from 1G to 5G.
2. To explore the future potential of usage of 5G technology in selected countries.

4. Research methodology

The study is based on secondary data collected from various sources like research journals. It also includes information published in articles and various organisations and other internet sites. The countries which are selected for the study are South Korea, China, Japan, and U.S.A. These countries have been selected as they are the leaders in adopting 5G technology. Statistical tools like graphs and percentages have been used.

The future potential of usage of 5G technology in selected countries has been explored in terms of

- (a) Penetration of 5G technology (in %) by the year 2025.
- (b) New global subscribers by the year 2025.

5. Comparative study of various generations from 1G to 5G

1G: The first-generation technology was introduced in 1980, which worked on radio analog signals and which supported only voice calls. It made the communication by cellular phone possible. The limitation of this generation was that analog was not able to cover long distances.

2G: 2G is the second-generation technology. It came in 1990. It used digital radio signals and transmitted voice and data with bandwidth of 64 Kbps. The second generation gave more efficient and secure phone calls which introduced mobile, text and messaging. Due to digital signals long distances could be covered. The technology was GSM (Global system for mobile) communication for having wireless voice communication. The second thing was data, for that we moved to another technology called 2.5G (GPRS), general packet radio service. We then increased the data rate from GPRS to EDGE technology (Enhanced data rates for GSM evolution). Thus, we had GSM and EDGE technology in 2G.

3G: It is the third-generation technology. We entered 3G in 2015, with a speed of 2 Mbps and could transmit digitized voice, video calls. 3G was a smartphone era. It also had features of video calling which requires more data rate. Then came 3.5 with HSDPA (High Speed Downloading Packet Access). Then we had era of cloud computing, that means we have to work with upload speeds also, so we had HSUPA (High Speed Uplink Packet Access).

4G: It is the fourth-generation technology. It emerged in 2009, with a speed of 100 MBPS to 1 Gbps with 3D virtual reality. 4G/LTE (long term evolution) made possible the high definition videos to stream on phones. The question was why so much data rate is required. It is required for bullet trains and for mobility services.

5G: 5G will bring faster speed of data transfer, shorten delays or latency and increased connectivity. The target is 5 Gbps for which many companies are undertaking research so that we can achieve this data rate. 5G will also provide much more personalized web experience using a technique

called network slicing. It is creating separate wireless networks on cloud allowing users to create their own networks for example in gaming user wants faster response time and greater data capacity.

6. Potential benefits of 5G

1. Massive internet of things (IOT)

5G will lead to massive internet of things like smart homes, consumer electronics, smart vehicles, smart buildings, smart utilities, smart manufacturing, smart city, smart retail, and health and Enterprise. It will have smart grid, smart lighting, smart gas, waste management, logistic tracking, smart parking, pallet tracking, power meters, alarm monitoring, smart agriculture, water meters.

2. Asset tracking

It will help in distribution of assets over large area. People could track high value goods in transit which is now well established M2M markets. 5G will benefit in terms of coverage, low cost because of economies of scale. This will result in optimization of logistics workers' safety and minimum losses.

3. Smart agriculture

5G results in increased use of connected sensor in agriculture that can monitor moisture level, chemical composition, excreta of the soil, watering, growing and harvesting. Schedules can be monitored which will lead to efficiency and less need of manual labor.

4. Smart cities

Smart cities offer opportunities for many applications and potential new business models. Smart city is a very broad term with key technology applications like security, lighting, physical infrastructure utilities, environmental monitoring, energy and transportation. 5G technology will bring low cost reliability, improved quality of service as a benefit.

5. Physical infrastructure

5G technology will help up in monitoring the physical structures like bridges, overpasses elevators, train, tracks, roadways. Geo-tagging can allow AR to be used for tourist in large cities.

6. Smart homes

5G technology could bring revolution in the way home devices can be used to cater to the demands of customers as smart home market is moving towards do-it-yourself model. It will become convenient for the residents to set the different devices according to their own configuration.

7. Remote monitoring with industrial automation

The focus is on maintenance of equipments which currently relies on wired technology which are difficult to maintain. The benefit of 5G technology is that, it can offer an alternative solution for both new and old equipments through sensing. Safety risks like explosions leaks, physical monitoring and maintenance, can become the benefits of such pervasive sensing.

8. Connected Shoppers

5G will create potential not only for retailers but also for the consumers to interact into dynamic fashion. This will lead to

expansion of business and quality goods for the shoppers.

9. Autonomus Vehicles

This category includes both consumer and industrial applications. 5G will be used to enable all extra vehicle communications to first move for advanced driver assistance systems (ADAS) and then to pooling autonomous self-driving vehicles. The benefits which will be obtained from autonomous vehicles are safer roadways, reduced impact on environment, reduced cost, less collisions, injuries, repairs and insurance. Using 5G technology will also reduce cost and investment infrastructure.



Fig 1

10. Drones

Low latency and fast response time, LAN and WAN combination will help sensors to articulate information to navigator's software potential uses of drones by the government. It can include police surveillance anti-terrorism. road control, patrolling, research, tracking, regulation of traffic and weather monitoring. Commercial use of drones will be in transport, agriculture, construction and manufacturing sector.

11. Industrial Automation

Infrastructure in the industry is still dependent on wire connectivity. Creating smarter factories, augmenting workers, wireless solutions can be achieved through 5G. Remote patient monitoring for telehealth, access to imaging medical records, advanced telemedicine that includes remote surgery using robotics and augmented reality (AR), virtual reality (VR) remote clinical are some of the benefits of 5G technology. By increasing the out patient monitoring reduction in hospital stays can be achieved through 5G technology. Emerging faster lifesaving and better coordination of services disaster management, early warning messages are some of the potential benefits of this latest technology.

12. Tactile internet

5G technology has a super low latency. For example, an operation could be performed by a robot who is remotely controlled by a surgeon at the other part of the globe through 5G technology, whose applications would require both high bandwidth and low latency. Augmented reality or virtual reality in gaming industry also will bring revolution. It will create new virtual reality beyond touch, hear, sight, smell and taste. However, AR and VR systems are still in

their infancy stage and their development will depend upon other technologies like motion sensors and heads up display (HUD). Autonomous vehicles will lead to connected cars. If all the vehicles on the road are connected to a network having traffic management system, they could travel at much higher speed and close proximity with accident risk at minimum which will reduce the risk of human error.

13. Wireless cloud-based office

This is potential business application. It requires low-latency which can be achieved through 5G technology. Wireless cloud-based office will store vast amount of data and will lead to reduction of offline offices as the data and information will be accessible at anytime, anywhere across the globe on any device.

5G technology in global arena

5G is expected to hit the market in 2020 which targets a high speed of 1Gbps, low power and low latency. It was launched in South Korea in 2018 while the US, China, UK and others have gone for the trials. China will soon grant commercial licenses for network companies like Samsung and LG to launch their 5G smartphones. According to GSM, the Mobile Network Operators Association, in total 160 billion dollars have been invested annually in the construction of 5G networks. 5G will contribute 2.2 trillion dollars to the global economy in the coming 15 years as per GSM, which is almost equal to the size of UK economy. 1.57 billion people are expected to adopt 5G by 2025 worldwide, which is 18% of total mobile users.

The top five wireless infrastructure suppliers' companies are

1. Huawei, Huawei carrier business group became the world's largest vendor of Telecom network infrastructure.
2. Ericsson of Sweden
3. Nokia of Finland
4. ZTE of China
5. Samsung of South Korea

14. Analysis

In this research work 5G technologies of some of the major countries have been reviewed and compared.

15. South Korea

South Korea was the first country to use the 4G technology. 5G technology was on the priority list of South Korean government. It launched 5G network in December, 2018 which was offered to select persons. 5G development was in the most advanced form in the country. The three South Korean carriers are SK Telecom, LG Uplus and Korea Telecom. Ministry of Science and ICT has predicted that 30 percent of the country's mobile users will be on 5G by 2020 and 90 percent by 2026. SK telecommunications rolled out its 5G network in data traffic concentrated areas in populated places like universities, high speed trains, highways and subways. Their initial launch included 34000 5G base stations in 85 cities. SKT aims to cater to 85 cities covering major transportation routes which include 2 highways, 6 airports and railways. LG Uplus on the other hand has registered 54000 5G subscribers and 50000 base stations in Seoul and surrounding areas.

16. China

Asian countries accelerate the process of commercialization of telecom services. China has started the third phase of 5G technology research and development test ahead of the time period. Chinese companies are putting their maximum efforts to become global leaders in automation robotics and other sectors which form a part of China's 'Made in China' 2025 strategy. Companies including Huawei, ZTE have built 15 base stations in Huairou district in Beijing to support future testing the world's largest mobile operator. China mobile said that it aims to have 10000 5G base stations all over China in 2020. China mobile, China Telecom China Unicorn, and Japanese Telecom operators NTT, Docomo will also be contributing in 2020 as operators.

17. Japan

The major telecom giants NTT, Docomo, KDDI Corporation and Rakuten, Soft Bank Corporation are planning to launch 5G services across the nation in 2020, They would use 5G networks of domestic carriers and will bring 5G nationwide by 2022. In fact, NTT, Docomo have already started a trial service for major cities such as in Tokyo, including, Nagoya and Osaka of commercial 5G in October 2019. Japanese telecommunication carrier Softbank Corporation plans to launch 5G commercial services by March 2020. In fact, it has plans to install 11210 base stations for 5G across Japan which will cover 60% of the country by 2025. The base stations will be made by Sweden's Ericsson and Finland based Nokia.

18. U.S

Many companies are providing 5G connectivity in U.S.A. Major companies are Verizon, AT&T, T-Mobile, Sprint, U.S. Cellular, C-spire, Comcast.

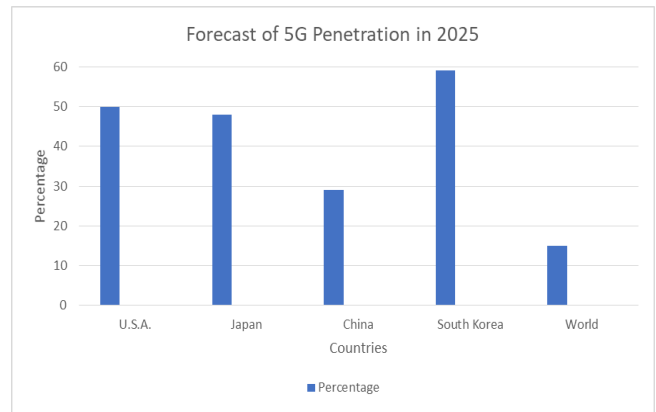
- a. Verizon offers 5G broadband internet called 5G homes in select areas.
- b. AT&T will have country wise 5G reach by 2020.
- c. T-Mobile is offering 5G services in six locations. It will bring metro prepaid services in 5G space in 2019. It plans to cover two third of US population with 5G by 2021.
- d. Sprint started offering 5G mobile in Atlanta, Dallas, Houston and Kansas City.
- e. C-spire, it is the largest privately held wireless provider.

18. Future Potential of 5G (in terms of penetration of 5G technology by 2025)

The following table shows the penetration of 5G technology by 2025 in selected countries viz. China, the United States, Japan and South Korea. Penetration is defined in terms of 5G connections as percentage of total connections in that particular country by 2025. The table is followed by a graphical depiction of the figures as per the tabulated figures. All figures are projected figures and indicate the future potential of the usage of 5G technology.

Table 1: Forecast of 5G Penetration

Countries	Percentage
U.S.A	50
Japan	48
China	29
South Korea	59
World	15



Source: GSMA Intelligence Forecast, 2019

Fig. 2: Forecast of 5G penetration

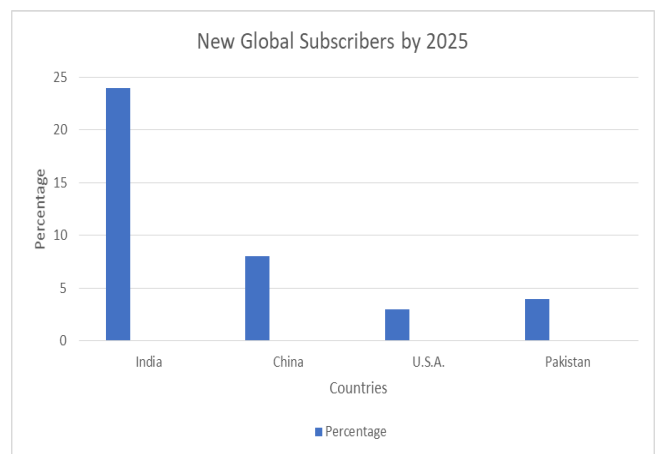
As the table and the graph above show, the four countries namely, China, the United States, Japan and South Korea will dominate the world in 5G technology. Further, it is shown that 59 % of mobile connections will be 5G in Korea followed by 50% in USA and 48% in Japan. China will have 29% 5G connections and the world as a whole will have 15% 5G connections.

19. Future Potential of 5G (in terms of new global subscribers by 2025)

The following table and the corresponding bar chart show the projected figures of new global subscribers by 2025 in selected countries namely, India, China, USA and Pakistan.

Table 2: New global subscribers by 2025

Countries	Percentage
India	24
China	8
U.S.A	3
Pakistan	4



Source: GSMA Intelligence Forecast, 2019

Fig 3: New global subscribers by 2025

The figures above show the addition of new subscribers in selected countries as a percentage of new additional subscribers around the world. The percentage of new global additions as subscribers by 2025 will be led by India with 24%, followed by China with 8%, Pakistan with 4% and USA with 3%.

Table 3: Ranking of smartphone connection (country wise) by 2025

Rank in 2025	Country	Smartphone connections, 2025 (Million)	Change in rank since 2018
1	China	1458	=
2	India	1171	=
3	Indonesia	410	+1
4	U.S.A.	346	-1
5	Brazil	204	=
6	Russia	187	=
7	Japan	162	=
8	Pakistan	146	+14
9	Nigeria	143	+11
10	Bangladesh	134	+11

Source: GSMA Intelligence Forecast, 2019

The two smartphone superpowers which will emerge in 2025 are, China and India, with 1458 million and 1171 million connections respectively. In 2025, the top three ranks of the countries in smartphone connections is grabbed by China, followed by India and Indonesia. U.S.A. will be at 4th position and Japan will stand at 7th position.

Indian scenario

India will have 5G by 2020. A growing number of trials are being held in India. Telecom giant Bharti Airtel and Huawei conducted India's first 5G trial in Manesar, Gurgaon. Vodafone-Idea is also proposing 5G trials with Huawei and Ericsson. Samsung will also conduct 5G field trials along with Jio in New Delhi in 2019. BSNL will conduct field trials with Ciena for launching a commercial 5G by 2020. According to GSM, the first commercial 5G services will be launched in India by 2020. It is predicted that 5G connections in India will reach 88 million by 2025 which is around 7% of the total connections in the country. 5G will help Indian government achieve its recent initiative like digital India, smart cities and smart village missions. Indian government has also launched a program building an end to end 5G test bed for innovations and research into 5G. It is a three-year program which started in 2018. Ericsson installed its first public access 5G test bed at IIT, Delhi.

20. Conclusion

The rollout of 5G technology is underway. It is approaching the world very fast and it is expected to cater to the demands of wireless traffic growth. A new revolution has begun. The benefits of 5G technology are immense. This will directly lead to increased education and educated workforce entering in the global market will trigger economic growth. Not only education but the unprecedented spread of affordable communication will help increase the consumer surplus especially in the developing economies with the golden era of technological change. New business models will revolve around growth and competition in the market and businesses. The analysis in the paper very aptly deduces that the countries of the world are in neck to neck race in achieving the 5G technology and expected to move to the next generation technology at the earliest possible. The countries in question are projected to have great penetration of 5G technology as well as the new additions to the subscribers by 2025.

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