Understanding 5G Technology and its Implications In Higher Education Sector

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Abstract

The main aim of this article is to understand the latest 5g technology and its potential implications in higher education sector. In this article we have discussed the latest 5g mobile technology which is a successor of 2g, 3g, and 4g has been discussed in detail. The main focus is on the specification requirement for 5g; the speed of 5g networks, the low latency, and the used cases of low latency has been covered. The difference between 2g, 3g, 4g and 5g has been established. Also to study the implications of 5g for mobile operators. The working of 5g technology and its impact on real-world are covered in detail. The applications and services of 5g technology in various sectorsare also discussed. The potential implications of 5g technology in higher education sector have been established by studying various documents and visiting popular authentic websites.

Keywords: *5G, Internet of things, low latency, augmented reality, virtual reality*

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Introduction

The next-generation of telecom networks (fifth generation or 5G) have started hitting the market end of 2018 and will continue to expand worldwide. Beyond speed improvement, 5G is expected to unleash a **massive IoT (Internet of Things) ecosystem** where networks can serve communication needs for billions of connected devices, with the right trade-offs between speed, latency, and cost.

5G technology is driven by 8 specification requirements:

·Up to 10Gbps data rate - > 10 to 100x improvement over 4G and 4.5G networks

· 1-millisecond latency

· 1000x bandwidth per unit area

· Up to 100x number of connected devices per unit area (compared with 4G LTE)

· 99.999% availability

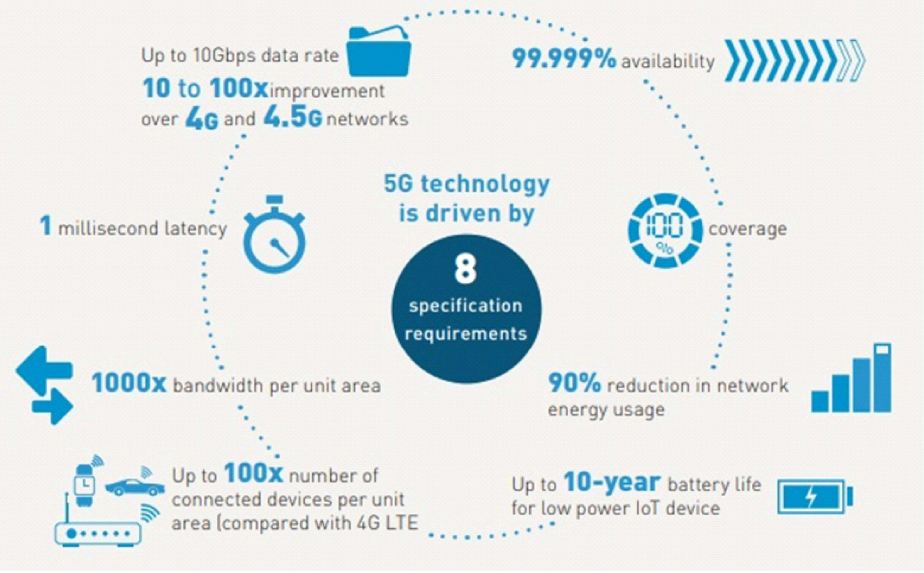
· 100% coverage

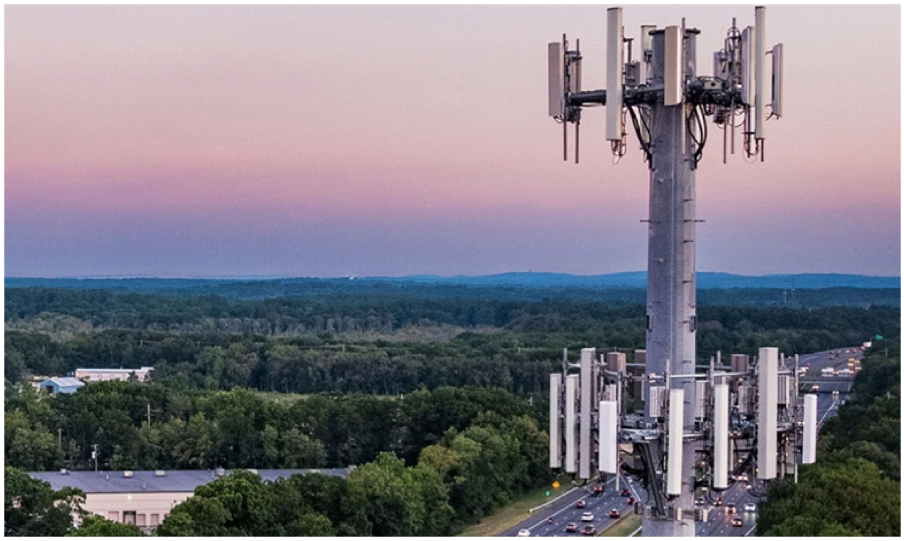
· 90% reduction in network energy usage

· Up to 10-year battery life for low power IoT device

How fast is 5G?

5G tops out at 10 gigabits per second (Gbps). 5G is **10 to x100 faster than** what you can get with **4G**.





(Tower of 5G Network)

What makes 5G faster?

The use of **shorter frequencies** (millimeter waves between 30GHz and 300GHz) for 5G networks is the reason why 5G can be faster. According to communication principles, the shorter the frequency, the larger the bandwidth. But here is the part where you understand 5G is a lot more than that.

What is 5G low latency?

5G technology offers an extremely **low latency rate,** the delay between the sending and receiving of information. From 200 milliseconds for 4G, we go down to **1 millisecond** (1ms) with 5G.

Just think about it.

A millisecond is 1/1000 of a second.

The average reaction time for humans to a visual stimulus is 250 ms or 1/4 of a second. People are capped at around 190-200 ms with good training. Imagine now that your car could **react 250 times faster than you**. Imagine it could react also to hundreds of incoming information and can also communicate its reactions back to other vehicles and road signals all within milliseconds.

At 60 mph (100km/h) the reaction distance is about 33 yards (30 meters) before you pull on the brakes. With a 1ms reaction time, the car would only have rolled a bit more than one inch (less than 3 centimeters).

Use cases associated with low latency are:

· V2X (Vehicle-to-Everything) communication: V2V: (Vehicle-to-Vehicle), V2I (Vehicle-to-Infrastructure), autonomous connected cars

· Immersive Virtual Reality Gaming (5G will bring VR to the masses)

· Remote surgical operations (aka telesurgery)

· Simultaneous translating

The difference between 4G / LTE and 5G?

The 5th generation of wireless networks addresses the evolution **beyond mobile internet** to massive IoT (Internet of Things) from 2019/2020 onwards. The main evolution compared with today's 4G and 4.5G (LTE advanced) is that, beyond data speed improvements, new IoT and critical communication use cases will require a new level of improved performance.

· For example, **low latency** is what provides real-time interactivity for services using the cloud: this is key to the success of self-driving cars for example.

· Also, **low power consumption** is what 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 current wireless technologies (3G, 4G, WiFi, Bluetooth, Zigbee, etc…), 5G networks will be designed to bring the level of performance needed for massive IoT. It will enable a perceived fully ubiquitous connected world. In short, that's what makes it **transformational**.

5G and the previous mobile generations.

In the last four decades mobile phones, more than any other technology, have quietly changed our lives forever. Do you remember how much you loved your 2G Nokia 3310s?

· **1G**, the first generation of telecom networks (1979), let us talk to each other and be mobile

·**2G** digital networks (1991) let us send messages and travel (with roaming services)

·**2.5G** and **2.75G** brought some improvement to data services (GPRS and EDGE)

·**3G** (1998) brought a better mobile internet experience (with limited success)

·**3.5G** brought a true mobile internet experience, unleashing the mobile apps eco-system

·**4G** (2008) networks brought all-IP services (Voice and Data), a fast broadband internet experience, with unified networks architectures and protocols

·**4 G LTE**, starting in 2009, doubled data speeds

·**5G** networks expand broadband wireless services beyond mobile internet to IoT and critical communications segments

Virtual networks (5G slicing) tailored to each use case

5G will be able to support all communication needs from low power Local Area Network (LAN) – like home networks for example, to Wide Area Networks (WAN), with the right latency/speed settings. The way this need is addressed today is by aggregating a broad variety of communication networks (WiFi, Z-Wave, LoRa, 3G, 4G, etc…) and 5G is smarter. 5G is designed to allow simple virtual network configurations to **better align** network costs with applications needs. This new approach will allow 5G Mobile Network operators to catch a larger piece of the IoT market pie by being able to deliver cost-effective solutions for low broadband, low power applications.

3G vs 4G vs 5G

		3G	4G	5G
	Deployment	2004-05	2006-10	2020
	Bandwidth	2mbps	200mbps	>1gbps
	Latency	100-500 milliseconds	20-30 milliseconds	<10 milliseconds
	Average Speed	144 kbps	25 mbps	200-400 mbps

https://www.raconteur.net/technology/4g-vs-5g-mobile-technology

What are the real 5G use cases?

Each new generation wireless network came with all new set of new usages. The next coming 5G will make no exception and will be focused on IoT and critical communications applications. In terms of the agenda, we can mention the following uses cases over time:

· Fixed wireless access (from 2018-2019 onwards)

· Enhanced mobile broadband with 4G fall-back (from 2019-2020-2021)

· Massive M2M / IoT (from 2021-2022)

· Ultra low-latency IoT critical communications (from 2024-2025)

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 base services with **massive data analysis** will require speed improvements more than latency improvements.

When is 5G coming?

Where is 5G technology in terms of roll- out, standardization and how long will this take?

· ITU-R launched "IMT for 2020 and beyond" in 2012, setting the stage for 5G.

· Japan and Korea started to work on 5G requirements in 2013.

· NTT Docomo did the first 5G experimental trials in 2014.

· Samsung, Huawei, and Ericsson started prototype development in 2013.

· South Korean SK Telecom demoed 5G in 2018 at the Pyeongchang Winter Olympics.

· Ericsson and TeliaSonera made commercial services available in Stockholm and Tallinn in 2018.

· North America 5G is available in some locations in 2019. It won't take off in most areas until 2020.

· Deutsche Telekom started 5G in Berlin, Darmstadt, Munich, Bonn, and Cologne in Sept 2019.

· In the UK, many cities will see 5G in 2019 and more in 2020. EE, Vodaphone, and O2 are actively deploying 5G since mid-2019.

· India is targeting 2020 for 5G roll-out

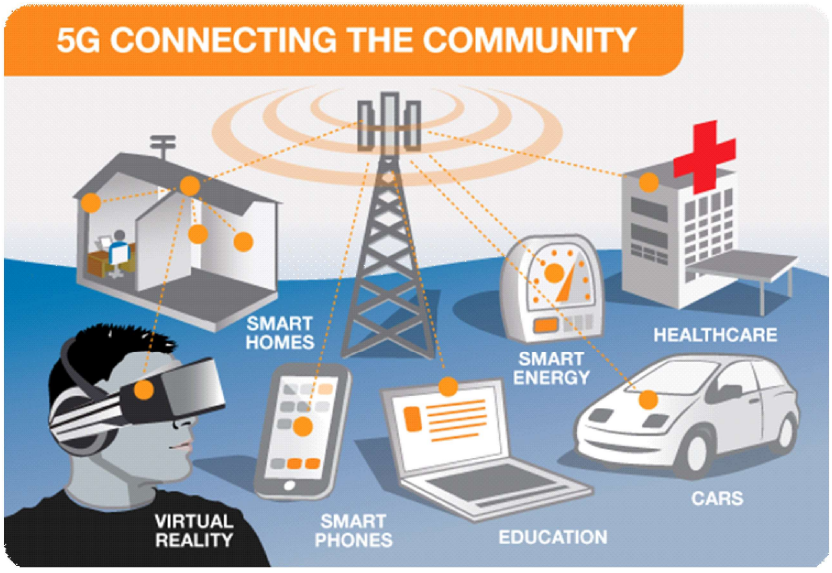
· Japan's target is to launch 5G for the 2020 Tokyo summer Olympics.

· China Unicom has set up 5G in a few locations in 2019. 460 million 5G connections are expected by GMSA in China by 2025.

How fast will 5G take-up be?

The projected adoption rate for 5G differs drastically from all previous generation networks (3G, 4G): while previous technology was driven by mobile internet usage and the availability of "killer apps", 5G is expected to be mainly **driven by new IoT usages**, such as connected and self-driving cars for example.

According to a June 2019 report from Ericsson, 5G will reach 45% population coverage and 1.9 billion subscriptions by 2024, making it the fastest generation ever to be rolled out on a global scale.



The implications of 5G for mobile operators:

5G is still a cellular broadband technology and is a network of networks.

MNOs' **expertise and knowledge** in building and operating networks will be key to the success of 5G.Beyond providing network services, MNOs will be able to develop and operate new IoT services.

The implementation of 5G networks while keeping 3G and 4G networks operational will likely trigger a new challenge for MNOs regarding the ability of frequencies in the spectrum (especially if the forecasted massive volume on IoT occurs). MNOs will need to require then operate a new spectrum in the 6 to 300 GHz range, which means **massive investments in the network infrastructure.** To reach the 1ms latency goal, 5G networks imply connectivity for the base station using **optical fibers.**

On the cost savings side, 5G networks are planned to be capable to support virtual networks such as low power low throughput (LPLT) networks for low-cost IoT. Unlike today where LORA networks address that need, separately from 4G.

What does 5G mean for consumers?

5G for consumers means not just faster mobile internet, but mainly internet connectivity in many more objects than what you see today.

The car and the house are two examples of the big IoT revolution coming ahead, supported by 5G networks. Samsung and other Android OEMs plan to introduce the first 5G smartphones in 2019. 5G SIM cards are making their debut in 2019.

https://www.gemalto.com/mobile/inspired/5G

How does 5G technology work?

5G technology will introduce advances throughout network architecture. 5G New Radio, the global standard for a more capable 5G wireless air interface, will cover spectrums not used in 4G. New antennas will incorporate technology known as massive MIMO (multiple input, multiple output), which enables multiple transmitters and receivers to transfer more data at the same time. But 5G technology is not limited to the new radio spectrum. It is designed to support a converged, heterogeneous network combining licensed and unlicensed wireless technologies. This will add bandwidth available for users.

5G architectures will be software-defined platforms, in which networking functionality is managed through software rather than hardware. Advancements in virtualization, cloud-based technologies, and IT and business process automation enable 5G architecture to be agile and flexible and to provide anytime, anywhere user access. 5G networks can create software-defined sub-network constructs known as network slices. These slices enable network administrators to dictate network functionality based on users and devices.

5G also enhances digital experiences through machine-learning (ML)-enabled automation. Demand for response times within fractions of a second (such as those for self-driving cars) require 5G networks to enlist automation with ML and, eventually, deep learning and artificial intelligence (AI). Automated provisioning and proactive management of traffic and services will reduce infrastructure cost and enhance the connected experience.

What is the real-world impact of 5G technologies?

5G technology will not only usher in a new era of improved network performance and speed but also new connected experiences for users. In healthcare, 5G technology and Wi-Fi 6 connectivity will enable patients to be monitored via

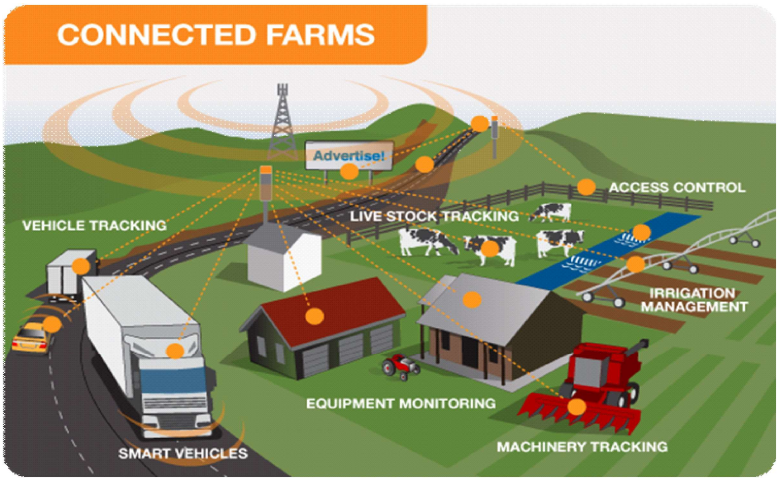
connected devices that constantly deliver data on key health indicators, such as heart rate and blood pressure. In the auto industry, 5G combined with ML-driven algorithms will provide information on traffic, accidents, and more; vehicles will be able to share information with other vehicles and entities on roadways, such as traffic lights. These are just two industry applications of 5G technology that can enable better, safer experiences for users.

https://www.cisco.com/c/en_in/solutions/what-is-5g.html

The 5G applications and services:

The combination of a increase in bandwidth, a reduction in latency, greater range, and greater device density on a network enables service providers to create new mobile services while expanding existing services. In this way, 5G also opens new opportunities with Internet of Things (IoT) devices and technologies.

Over the next decade there will be at least 20 billion to 30 billion IoT devices inundating networks, but some estimates have suggested as many as 1 trillion devices. Many of these devices will offer always-on connections and data processing. Consider these examples of IoT devices that are enhanced by 5G capabilities: autonomous and connected cars, connected wearable, indoor and outdoor mapping apps, and people-tracking devices. Because many of these devices operate outside the traditional corporate network or home network, 5G will enable new types of connectivity and data. For the average consumer, 5G means more streaming video and video calls, faster access to data, and potentially better coverage. In addition, as the Internet speeds may be 1 Gbps or faster, in some cases, many consumers may elect to forgo traditional Wi-Fi systems at home and instead opt for a faster 5G connected device.



When will 5G technologies be enterprise-ready?

5G technologies is coming on the scene and generating legitimate buzz, but that doesn't mean it is enterprise-ready yet. For example, a new 5G-enabled mobile phone may not be here for a couple of years.

What are the obstacles on enterprise-ready 5G technology? First, and most important, the 5G standard has yet to be finalized. While the specification is nearly complete, until it is finalized and agreed on, any 5G device could become obsolete should something change. Second, for the 5G market to be mature and production-ready, it requires new radios and chips in mobile devices as well as software to handle the communications. Radio and transmissions systems will also need to be updated, and enough equipment will need to be deployed and configured to support the use of the technology.

While carriers like Verizon and AT&T are preparing to test 5G technologies on their networks, 5G market won't be ready on devices right away. The radio chips required in mobile phones will likely not start arriving for general consumer usage until sometime in 2019 and the major transitions will likely not start until at least 2020. While consumers will need to wait until 2019 or 2020 to start using 5G, the carriers will work quickly to prepare infrastructure and systems to support the shift to 5G. Of course, this won't stop the marketing teams at the carriers from starting campaigns around 5G technologies, and they will all be vying to get the "best" 5G network in place "first."

What's next for the 5G market?

If 5G is still a couple of years away from any real adoption, what comes next? The 4G specification has additional technologies and capabilities that are available now or will be available soon, depending on the carrier that will expand the performance and speeds of current devices. The Long-Term Evolution (LTE) advanced specification builds on the existing 4G and LTE technologies while offering faster transmission speeds and performance. In addition, several of the 5G technologies are included in LTE Advanced. Expect devices released in 2018 and 2019 to begin supporting LTE Advanced. Carriers may not change existing LTE coverage maps or brand campaigns as they fully adopt LTE Advanced, but consumers will still benefit from faster network speeds with this release.

5G technology on the horizon

The 5G standard and technologies offer a lot of promise and will help pave the way for the next major wave of innovations across most other industries like the auto industry, restaurant industry and other retail industries as well as business-to-

business organizations and many others. Because the average consumer will likely experience 5G around 2020, businesses should begin planning now and considering the offerings they can create. In the meantime, LTE Advanced will continue to improve the existing wireless technologies.

https://www.cisco.com/c/en/us/solutions/enterprise-networks/5g-at-mobile-world-congress-2018.html

Educational Implications

Some of potential possible implications related to Education can be listed as follows:

Tactile Internet & Skillset communication: Having a network capable of transferring our tactile communication through Internet will help us to move from today's content and information delivery Internet to a manual skillset delivery Internet. This will create new ways of Tele-teaching and Tele-mentoring especially for manual training and skill development. The use of Tactile Internet in education can bring new definition and experience for distance learning and distance team-working. In order to have a natural haptic interaction of our limbs with video and audio feedback the response time of service should be very low, i.e., the round trip time of few milliseconds which can be only envisaged by 5G.

Virtual Reality & education: While the initial use case for VR was the entertainment industry, it also has relevance in education and training, and will have a big role in providing quality education and improving understanding-based learning among students. By tailoring these services to education, (e.g. by, having virtual tours of the human body with the possibility of interacting with models and moving the different layers of the body), the learning process can be more fun and much more interesting. This also can bring new experiences for distance learning, enabling the virtual presence of students (e.g., located in suburban area) in the classroom. This type of service needs very high bandwidth (bi-directional) and very low latency (i.e., 2-4ms).

Augmented Reality & education: Similar to the VR, AR has already started to show its relevance and usefulness in education. Providing the necessary information can make contextualized learning ubiquitous and pervasive. AR can be an efficient way of providing the right amount of information at the right time to the right audience. Also, immersive AR can enable new ways of learning and team working in education through services such as mobile cloud classroom and Virtual Presence. Enhancing the learning experience is not the only possible use case for AR. It can also help teachers to get necessary information about each student and be aware of their particular needs and capabilities. The requirements for implementing such services,

including optimized routing, seamless wide-area coverage, virtual presence, low delay speech & video coding, need to be considered**.**

Walled-off classroom: By combining Tactile Internet and VR, the future experience in teaching and learning could go far beyond today's experience. This can remove the physical location constraint for experimental practices, and facilitate and enable the sharing of resources between larger numbers of students irrespective of their current location. The impact would be more significant in hands-on-experience with expensive equipment and facilities.

Personalized learning: Individual access to a mobile device holds the promise to connect each learner into intelligent personalized systems that can suggest learning pathways, enable aggregated analysis and through better data capture of learner experiences enable much better decision making about all aspects of a students' education. Categorizing students in different groups and suggesting different multi-media contents can increase the load on the network. However, in-network caching technologies such as Content Centric Networks (CCN) and Information Centric Networks (ICN) can be used to improve efficiency by reducing the service response time and bandwidth consumption.

Student wireless backpack: Today's cloud-based storage services have made it possible to access files irrespective of device of use. Due to the centralized architecture of cloud providers there is a notable delay in access to the content even with a relatively fast internet connection. Future mobile technology will enable single device content access anywhere by using distributed cloud and mobile edge computing. All the user needs is a device to access any of his personal content and stored files. Using these feature students can resume their work at a convenient time and place through different devices with an impression of immediate response time.

Student with especial needs: Advances in mobile technology and robotics can open new opportunities to assist students with especial needs, making learning easier for them. Cloud-based robots can be considered as a full-time assistant for disabled students, helping them to interact with the education environment and their peers. Rather than having to call a teacher over for help (which can cost both the student and the teacher time they could be using more productively) the students can take care of the issue with the help of their robot.

IoT& Smart Classroom/Smart Campus: IoT applications are affecting all aspect of our life, from smart building to smart healthcare. However, one of the fast growing areas of these applications is in education which can improve our today's teaching, learning and campus operating experience. IoT applications can also help us change

the role of teachers in the classroom, reducing the burden of administrative load on them and allowing them to concentrate more on individuals. Being automatically logged into the classroom as soon as entering to the class, being distracted by a signal as soon as losing concentration during lecture, real-time feedback to a lecturer about areas that students still have problem based on the real-time analyses of their notes, all are just few examples of how IoT and connected classroom can enhance learning and teaching experience.

1 http://www.geant.org/

2 https://www.eduroam.org/

Conclusion

5G technology is the upcoming technology and the bandwidth for this is very high and was having higher data transfer rate. However, now we are using the 3G technology efficiently and in some countries the people are using the 4G but in future we can use the 5G technology. Many big countries are investing huge amount of money on this project as it was having high demand in the future. It will altogether manufacture flexibility, limit, degree, comparability and meeting. Thusly, it will satisfy the growing solicitations of rising bigC data, cloud, machineC toC machine, and diverse applications.

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