5G: The Next Step in Cellular Telecommunication Journey

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***Abstract*: A brief introduction to Fifth Generation (5G) Cellular Technology. The evolution of technology paved the way for faster communication and emergence of applications based on real time feedback like VR and AR. With 5G claiming to provide 100x faster data transmission speed compared to 4G, the scope of live streaming of 4K videos and innovations in medical science will enable a greater transformation of usage scenarios.**

***Keywords*: 5G, Data Speed, Transmission, Radio, mmWave, eMBB, URLLC, mMTC, MIMO, spectrum, RAN**

Often we think that the future is still far away, yet we need to remember that tomorrow is the future and that we will be living it the moment we wake up in the morning. We moved from having a gadget in our pocket that could be utilized to make or receive calls from (almost) anywhere - 1G innovation - to having the option of messaging as opposed to just calling - 2G innovation - while still being able to make and receive calls on the same device.

Afterward, the desire to have the option to get to the web from any area turned into a reality, because of 3G innovation, which permitted us to do so through our cell phones. This has endured to the current day, with our voracious longing for information reflected in what we presently call "ordinary" web browsing through cell phones outfitted with 4G innovation and the capacity to see live video streaming.

The story continues, this needs to continue, further paving the way for 5G Technology, the next step in our digital transformation and integration of objects around us in the Internet of Things (I.o.T.) web.

So what exactly is the 5G Technology?
5G (Fifth Generation) is the latest version of Cellular Technology enabled with more bandwidth and advanced antenna technology for greatly increasing the speed and responsiveness of the wireless network. This enables data to be transmitted in multigigabit speeds with possible high of 20 gigabits per second (Gbps) by certain estimates, offering latency of less than 5 milliseconds (ms). This helps applications that depends on or require real-time feedback.

5G broadly supports 3 wide classes of use instances:

1. **Enhanced Mobile Broadband (eMBB)**: An expansion of services that takes into consideration a high data rate across a wide coverage area promising to deliver both vastly increased bandwidth and decreased latency.
2. **Ultra-Reliable Low Latency Communication (URLLC)**: Ensures more efficient scheduling of data transfers, achieving shorter transmissions through a larger subcarrier, and even scheduling overlapping transmissions.
3. **Massive Machine Type Communication (mMTC)**: A form of communication between machines over wired or wireless networks where data generation, information exchange and actuation takes place with minimal or no intervention from humans.

Deployment of 5G Network and Services are scheduled to be rolled-out in stages across the country with leading ISPs already showcasing 5G enabled applications to the public in controlled demonstrations.

5G Technology will usher in an era of improved overall performance of industrial applications while allowing new consumer studies and offerings in areas including augmented reality, virtual reality and mixed reality (VR and MR) applications, video conferencing, commercial automation, self-driving vehicles and connected scientific/medical devices.

How does 5G work?
Wireless networks are composed of cell sites divided into sectors that send data through radio waves. 4G LTE (Fourth-generation Long-Term Evolution) wireless technology provided the foundation for 5G. Unlike 4G, which required high-power cell towers to radiate signals over longer distances, 5G wireless signals are transmitted through large number of small cell stations located in places like light poles or building roofs.

The requirement of multiple small cells is necessary because the millimetre wave (mmWave) spectrum – between 30 and 300 gigahertz (GHz) – on which 5G relies for high speed, can only travel short distances and is subject to interferences from weather and physical objects.

Older generations used low-frequency bands for greater reach and coverage. To offset this limitation of 5G, operators are also exploring the use of lower (low and mid) frequency spectrum for increased coverage. These spectrums will have greater reach but speed will be lower than mmWave.

Low-band frequencies operate at around 600 to 700 megahertz (MHz) and Mid-band frequencies operate between 2.5 to 3.5 gigahertz (GHz) compared to mmWave, which operates at approximately between 24 to 39 gigahertz (GHz).

Key components of 5G:

a. **Massive Multiple Input Multiple Output (mMIMO)**: Massive MIMO antennas incorporate huge number of antennas in the multiple of 8s for community coverage and spectral performance.
b. **5G NR (New Radio)**: 5G NR is developed by 3GPP for 5G Mobile Community in December 2017. 5G NR is based on the ideas of ultra-slim design reducing signal and strength intake. 5G NR is designed with a flexible framework to efficiently multiply various 5G offerings and provide superior compatibility for future 5G offerings.
c. **Open Radio Access Network (O-RAN)**: Open RAN is an ongoing variation in cell network architectures that allows telecom operators to use components from a variety of carriers. "The Open RAN architecture virtualizes parts of the cellular network that are traditionally handled by specialized hardware and software. Time-sensitive functions like QoS management, handover control, and load balancing are handled by the RAN Intelligent Controller near-real time layer (RIC near-RT), while policy management and analytics take place in the RIC non-real time layer. Similarly virtualized functionality for radio frequency and baseband processing are provided by the distributed unit (DU) and remote radio unit (RRU) layers." [***Jon Gold, 25th Oct 21, NetworkWorld.com***]
d. **5G Core (5GC)**: The heart of any 5G mobile network. It establishes reliable, secure connectivity to the network for end users and provides access to its services.
e. **5G Transport**: To help new 5G use cases like EMBB, URLLC, and MMTC, a transport network that can support a massive increase in Peak Hour Traffic, as well as a different arrangement of network characteristics for each use case, is required. It should have the option to help a consistently expanding number of devices, services, and new business models. Transport networks should be fit for supporting 25G, N x 25G at the access/pre-aggregation layer, 100G, N x 100G at the aggregation layer, and up to 400G at the service provider core to provide high capacity. Besides, the transport network should stick to rigorous timing standards to enable a latency of fewer than 10 milliseconds.
f. **Management and Orchestration (MANO):** With 5G, the number of connected end-user devices, nodes, and services inside a network increases multi-fold. It becomes practically impossible to manage network operations at the scale and quality required manually. The only way forward to handle this volume and complexity of future cloud and 5G networks is to automate operations, with full support for open APIs that can work across multi-cloud and multi-vendor settings to enable continuous visibility across platforms, AI, and machine learning skills.

Benefits of 5G Technology:
5G have long been forecasted as the network that will change our lives in the next few years. However, they have been sparked quite a few debates on the numerous advantages and disadvantages.

To list a few of the benefits of 5G:

1. Faster Download and Upload Speeds
2. Hyper-connectivity
3. IoT
4. Optimization of various devices and connected services including scientific research and medical services, 4K streaming, VR etc.

These will be enabled by the use of:

1. Higher frequencies
2. High bandwidth
3. Enhanced mobile broadband
4. A lower latency of 5ms
5. Higher data rates
6. The potential to use 5G mobile network made up of low, mid and mmWave frequencies.

Challenges due to 5G:
Move to 5G will render most of the current 4G devices outdated. However, the biggest challenge is the roll-out of 5G which will not be widely available across majority of the country owing to ROW issues, cost of spectrum and feasibility for service operators and cost of 5G-enabled devices for the general population.

The requirement of significantly higher count of small cells will lead to an infrastructure bottle-neck that would inevitable create delay in its deployment.

At present four countries are largely driving the first 5G versions – USA, South Korea, Japan and China.

On October 18, 2018, a team of researchers from ETH Zurich, the University of Lorraine and the University of Dundee released a paper entitled, "A Formal Analysis of 5G Authentication".[***Basin, David; Dreier, Jannik; Hirschi, Lucca; Radomirovic, Saša; Sasse, Ralf; Stettler, Vincent (2018). "A Formal Analysis of 5G Authentication". Proceedings of the 2018 ACM SIGSAC Conference on Computer and Communications Security – CCS '18. pp. 1383–1396***][**"How to Prepare for the Coming 5G Security Threats". *Security Intelligence*. November 26, 2018. Archived from the original on July 22, 2019. Retrieved July**

22, 2019]. It alerted that 5G technology could open ground for a new era of security threats. The paper described the technology as "immature and insufficiently tested," and one that "enables the movement and access of vastly higher quantities of data, and thus broadens attack surfaces". Simultaneously, network security companies such as Fortinet, Arbor Networks, A10 Networks, and Voxility advised on personalized and mixed security deployments against massive DDoS attacks foreseen after 5G deployment.

The United States FAA has warned that radar altimeters on aircraft, which operate between 4.2 and 4.4 GHz, might be affected by 5G operations between 3.7 and 3.98 GHz. This is particularly an issue with older altimeters using RF filters which lack protection from neighbouring bands. This is not as much of an issue in Europe, where 5G uses lower frequencies between 3.4 and 3.8 GHz. Nonetheless, the DGAC in France has also expressed similar worries and recommended 5G phones be turned off or be put in airplane mode during flights.

Difference between 4G and 5G

Every generation of cellular technology uses different encoding methods and differs in its data transmission speeds. 4G has the capability to support data speed up to 2 Gbps and subsequent versions are improving on this limit. Compared to 3G, 4G is up to 500 times faster and 5G can be up to 100 times faster than 4G.

One of the primary difference between 4G and 5G is the latency, with latency reaching as low as 1ms in 5G. 5G uses Orthogonal Frequency-division Multiplexing (OFDM) encoding similar to 4G LTE, however 4G uses 20 MHz channels bonded together at 160 MHz. 5G, on the other hand, will use up to 100 and 800 MHz channels which requires larger blocks of airwaves than 4G.

What 5G phones are available?

A phone or another piece of hardware can't just get a software update on a 4G phone to enable 5G. 5G requires specific hardware. To be able to utilize 5G, a user must have a device that supports 5G, a carrier that supports 5G and be within an area that has a 5G node within range.

Some examples of 5G enabled phones include the following:

- Samsung Galaxy S10 5G
- Samsung Galaxy Note10+ 5G
- Samsung Galaxy A90 5G
- OnePlus 7 Pro 5G
- Moto Z3
- Xiaomi Mi MIX 3 5G
- Huawei Mate X
- Huawei Mate 30 Pro 5G