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5G Technology

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***Abstract*: In this paper, an attempt has been made to review various existing generations of mobile wireless technology in terms of their portals, performance, advantages and disadvantages. The paper throws light on the evolution and development of various generations of mobile wireless technology along with their significance and advantages of one over the other. In the past few decades, mobile wireless technologies have experience 4 or 5 generations of technology revolution and evolution, namely from G to 4G. Generations of technology revolution and evolution, namely from G to 4G. Concentrates on advance implementation of 4G technology and 5G technology. Currently 5G term is not officially used. In 5G research is being made on development of World Wide Wireless Web (WWWW), Dynamic Adhoc Wireless Networks (DAWN) and Real Wireless World. In this paper we propose novel network architecture for next generation 5G mobile networks. In the proposed architecture the mobile terminal has the possibility to change the Radio Access Technology - RAT based on certain user criteria.**

***Keywords*: Why is 5G required?, 5G Technology and Spectrum Requirements, Need of 5G.**

1. Introduction

5G is the fifth generation of cellular mobile communications, with evolutionary and revolutionary services, which succeeds the 4G (LTE-A/ WiMAX), 3G (UMTS) and 2G Global System for Mobile Communications (GMS) system. 5G being the next generation of mobile networking standards, promises to deliver improved end user experience by offering new applications and services through seamless coverage, high data rate, low latency, and significantly improved performance and reliable communications. It will increase energy efficiency, spectrum efficiency, network efficiency as well as efficiency of other systems. 5G enhances the variety & scope of the use cases that Long Term Evolution(LTE) is able to minimally address today, and brings new revenue streams to operators by leveraging new solutions that LTE was not able to serve.

5G is the 5th generation of mobile networks, a significant evolution of today's 4G LTE networks. 5G has been designed to meet the very large growth in data and connectivity of today's modern society, the internet of things with billions of connected devices, and tomorrow's innovations. 5G will initially operate in conjunction with existing 4G networks before evolving to fully standalone networks in subsequent releases and coverage expansions generation.

In addition to delivering faster connections and greater capacity, a very important advantage of 5G is the fast response time referred to as latency.

Latency is the time taken for devices to respond to each other over the wireless network. 3G networks had a typical response time of 100 milliseconds, 4G is around 30 milliseconds and 5G will be as low as 1 millisecond. This is virtually instantaneous opening up a new world of connected applications.

Fig. 1. Connected community

The commercial deployment of 5G was earlier expected in 2020. However, the completion of the first 5G New Radio (5G NR) standards for a Non–Standalone (NSA) solution in December 2017 and for Stand Alone (SA) standard in June 2018 has set the stage for the global mobile industry to start full scale development of 5G NR for large scale trials and commercial deployment as early as in 2019. In preparation for the launch of 5G over the years to come, operators have many tasks to accomplish for 5G technology transformation. ITU is continuously developing and updating "IMT (International Mobile Telecommunications) for 2020 and beyond", setting the stage for 5G research activities emerging around the world. 5G systems in line with IMT-2020 specifications are expected to provide enhanced device and network-level capabilities, tightly coupled with intended applications.

The fifth generation wireless mobile multimedia internet networks can be completely wireless communication without limitation, which makes perfect wireless real world – World Wide Wireless Web (WWWW). Fifth generation is based on

4G technologies. The 5th wireless mobile internet networks are real wireless world which shall be supported by LAS-CDMA (Large Area Synchronized Code-Division Multiple Access), OFDM (Orthogonal frequency-division multiplexing), MCCDMA (Multi-Carrier Code Division Multiple Access), UWB (Ultra-wideband), Network-LMDS (Local Multipoint Distribution Service), and IPv6. Fifth generation technologies offer tremendous data capabilities and unrestricted call volumes and infinite data broadcast together within latest mobile operating system. Fifth generation should make an important difference and add more services and benefits to the world over 4G. Fifth generation should be more intelligent technology that interconnects the entire world without limits. This generation is expected to be released around 2020. The world of universal, uninterrupted access to information, entertainment and communication will open new dimension to our lives and change our life style significantly.

2. 5G Technology and Spectrum Requirements

Radio spectrum, backhaul, softwarization of core networks and radio access networks will be vital in early deployment of 5G networks particularly where enhanced mobile broadband is concerned.

A. Radio Access Networks

Most outdoor 4G mobile network deployments are currently based on macro-cells. However, macro-cells that cover large geographical areas may struggle to deliver the dense coverage, low latency and high bandwidth required by some 5G applications (shown in fig. 2).

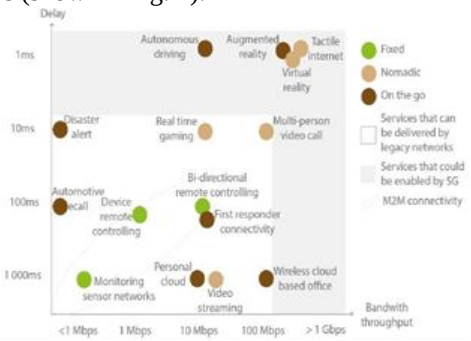

Fig. 2. Bandwidth and latency requirements for 5G applications

To deliver the dense coverage and high capacity network required by 5G, wireless operators are now investing in the densification of their 4G radio access network (RAN) – particularly in densely populated urban areas – by deploying small cells. Small cells, while serving a much smaller geographical area than a macro cell, increase network coverage, capacity and quality of service.

The deployment of small cells is one way of boosting the capacity and quality of existing 4G networks while laying the foundation for commercial 5G networks and early eMBB services. Small cells are already being used by some wireless operators to boost the capacity and coverage of their existing 4G networks particularly in a dense urban setting. Small cells boost network capacity without the need for additional spectrum, making them attractive to operators with a low spectrum holding or where spectrum is scarce. Furthermore, the industry view is that the deployment of small cells in dense urban to boost existing 4G network quality is likely to support the anticipated high capacity requirements of 5G networks and early eMBB services.

Due to the dense coverage that small cells need to provide, small cell antennae need to be installed onto street furniture like – bus shelters, lampposts, traffic lights, etc. These are often accompanied by a street cabinet to accommodate the operator radio equipment, power and site connectivity.

Massive MIMO (multiple input, multiple output) scales up to hundreds or even thousands of antennae, increasing data rates and supporting beam forming, essential for efficient power transmission. Massive MIMO increases spectral efficiency and in conjunction with dense small cell deployment, will help operators to meet the challenging capacity requirement of 5G.

B. Core networks

End-to-end flexibility will be one of the defining features of 5G networks. This flexibility will result in large part from the introduction of network softwarization where the core network hardware and the software functions are separated. Network softwarization – through network functional virtualization (NFV), software defined networking (SDN), network slicing and Cloud-RAN (C-RAN) – aims to increase both the pace of innovation and the pace at which mobile networks can be transformed.

NFV – replaces network functions on dedicated appliances – such as routers, load balancers, and firewalls, with virtualized instances running on commercial off-the-shelf hardware, reducing the cost of network changes and upgrades.

SDN – allows the dynamic reconfiguration of network elements in real-time, enabling 5G networks to be controlled by software rather than hardware, improving network resilience, performance and quality of service.

Network slicing – permits a physical network to be separated into multiple virtual networks (logical segments) that can support different RANs or several types of services for certain customer segments, greatly reducing network construction costs by using communication channels more efficiently.

Cloud RAN (C-RAN) – is presented as a key disruptive technology, vital to the realization of 5G networks. It is a cloud-based radio network architecture that uses virtualization techniques combined with centralized processing units, replacing the distributed signal processing units at mobile base stations and reducing the cost of deploying dense mobile networks based on small cells.

Other technology enhancements being considered include signal-coding techniques, which provide improved spectral efficiency and the high-speed performance required by 5G. In addition, edge computing is increasingly important for real-time and very latency-sensitive applications. Edge computing

brings data closer to end-user devices, providing computing power with very low latency for demanding applications. This speed up the delivery of actionable data, cuts down on transport costs and optimizes traffic routes.

C. Backhaul

Backhaul networks connect the radio network (RAN) to the core network. The ultra-high capacity, fast speeds and low latency requirements of 5G require a backhaul network capable of meeting these high demands. Fiber is often considered the most suitable type of backhaul by mobile operators due to its longevity, high capacity, high reliability and ability to support very high capacity traffic. However, pulling fiber to every cell site is practically not feasible due to cost, time and logistical challenges. In this case, a portfolio of wireless backhaul technologies should be considered in addition to fiber, including point-to- multipoint (PMP) microwave and millimeter wave (mmWave). PMP is capable of downstream throughput of 1Gbit/s and latency of less than 1ms per hop over a 2-4 km distance. MmWave has significantly lower latency and is capable of higher throughput speeds (1-10 Gbps). In comparison to fiber, microwave is cheaper, scalable option and can be deployed quickly.

While most focus is being given to terrestrial technology, there is also a role for high altitude platform systems (HAPS) and satellite technology in 5G. HAPS and satellite systems (including non-geostationary constellations) can deliver very high data rates (>100 Mbit/s – 1 GBit/s) to complement fixed or terrestrial wireless backhaul networks outside major urban / suburban areas (remote areas) and can deliver video transmission to fixed locations. HAPS and satellites may be integrated with other networks rather than function as a standalone network to provide 5G, thereby augmenting the 5G service capability and addressing some of the major challenges regarding the support of multimedia traffic growth, ubiquitous coverage, machine-to-machine communications and critical telecom missions.

In summary, a realistic 5G backhaul strategy is likely to consist of a portfolio of technologies. Each approach should be considered on its own merits in light of the performance needs, available infrastructure and viability on investment.

D. Front haul

Conventionally in a 4G wireless network, the front haul link exists between radio frequency (RF) function and the remaining layer 1, 2 and 3 (L1/L2/L3) functions. Recommendation ITU-T Y.3100 defines front haul as “a network path between centralized radio controllers and remote radio units (RRU) of a base station function”. This architecture allows for the centralization of all high layer processing functions at the expense of the most stringent front haul latency and bandwidth requirements. The increase in data rates in 5G makes it impractical to continue with the conventional Common Public Radio Interface (CPRI) front haul implementation. Allocating more processing function to RRU would relax the latency and bandwidth requirements – but fewer processing functions can then be cen- tralized. It is thus critical that the new functional-split architecture take into account technical and cost-effective tradeoffs between throughput, latency, and functional centralization.

E. Spectrum for 5G

Spectrum is the lifeline for any wireless communications. More spectrum bandwidth will be required to deploy 5G networks (than 4G) to the high capacity requirements, increasing the need for spectrum. In consequence, the industry is making concerted efforts to harmonize 5G spectrum. ITU-R is coordinating the international harmonization of additional spectrum for 5G mobile systems development. ITU’s Standardization Sector (ITU-T) is playing a key role in producing the standards for the technologies and architectures of the wire line elements of 5G systems.

5G use cases could potentially be met by a variety of spectrum frequencies. For example, low-latency and short-range applications (suited to dense urban areas) are likely to be suitable for mmWave frequency (above 24 GHz). Long-range, low-bandwidth applications (more suited to rural areas) are likely to be suitable for sub-1 GHz frequencies. While the lower frequencies have better propagation characteristics for better coverage, the higher frequencies support higher bandwidths due to the large spectrum availability at mmWave bands. The three key spectrum frequency ranges required for 5G can be summarized as shown in figure 3.

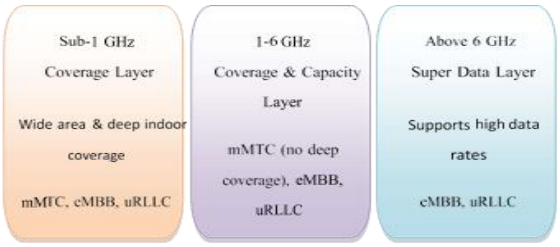

Fig. 3. Spectrum for 5G

URLLC: Ultra Reliable and Low Latency Communication
eMBB: Enhanced Mobile Broadband
mMTC: Massive Machine Type Communication

The challenge will be to select globally harmonized spectrum bands for 5G. The best way to achieve this goal will be to take into account the WRC-19 relevant decisions for higher bands, as well as WRC-07 and WRC-15 decisions for lower bands.

3. Why is 5G Required?

The major difference, from a user point of view, between current generations and expected 5G techniques must be something else than increased maximum throughput; other requirements include:

- Lower out age probability; better coverage and high data rates available at cell edge.

- Lower battery consumption.
- Multiple concurrent data transfer paths.
- Around 1Gbps data rate in mobility.
- More secure; better cognitive radio/SDR Security.
- Higher system level spectral efficiency.
- World Wide wireless web (WWWW).
- More applications combined with artificial intelligent (AI) as human life will be surrounded by artificial sensors which could be communicating with mobile phones. Not harmful to human health.
- Cheaper traffic fees due to low infrastructure deployment costs [9].

4. Characteristics of 5G technology

- The technology 5G presents the high resolution for sharp, passionate cell phone every day and give consumers well shape and fast Internet access.
- The 5G technology provides billing limits in advance that the more beautiful and successful of the modern era.
- The 5G technology also allows users of mobile phones, cell phone records for printing operations.
- The 5G technology for large volume data distribution in Gigabit, which also maintains close ties to almost 65,000.
- The technology gives you 5G carrier distribution gateways to unprecedented maximum stability without delay.
- The information from the data transfer technology 5G organize a more accurate and reliable results.
- Using remote control technology to get the consumer can also get a 5G comfort and relax by having a better speed and clarity in less time alone
- The 5G technology also support virtual private network.
- The uploading and downloading speed of 5G technology touching the peak.
- The 5G technology network offering enhanced and available connectivity just about the world.
- 5G network is very fast and reliable.

5. Applications of 5G Technology

- Real wireless world with no more limitation with access and zone issues.
- Wearable devices with AI capabilities.
- Internet protocol version 6(IPv6), where a visiting care-of mobile IP address is assigned according to location and connected network.
- One unified global standard.
- Pervasive networks providing ubiquitous computing: The user can simultaneously be connected to several wireless access technologies and seamlessly move between them these access technologies can be a 2.5G,3G, 4G or 5G mobile networks, Wi-Fi, WPAN or any other future access technology. In 5G, the concept may be further developed into multiple concurrent data transfer paths.
- Cognitive radio technology, also known as smart radio: allowing different radio technologies to share the same spectrum efficiently by adaptively finding unused spectrum and adapting the transmission scheme to the requirements of the technologies currently sharing the spectrum. This dynamic radio resource management is achieved in a distributed fashion, and relies on software defined radio.
- High altitude stratospheric platform station (HAPS) Systems. The radio interface of 5G communication systems is suggested in a Korean research and development program to be based on beam division multiple access (BDMA) and group cooperative relay techniques

6. Conclusion

5G technology promises to be revolutionary which is expected to play a key role in digital economies, improving economic growth, enhancing citizens' life experiences and creating new business opportunities. Larger bandwidth and low latency times will allow the development of new services and the improvement of existing ones.

A 5G investment decision must be backed by a sound business case, as deployment of 5G network will require substantial investment in the core, Radio Network and Spectrum. However, the 5G services will open-up many new revenue generating streams also as it will cater to variety of solutions to new verticals besides enhanced mobile broadband solutions.

Fifth generation technologies offer tremendous data capabilities and unrestricted call volumes and infinite data broadcast together within latest mobile operating system. Fifth generation should make an important difference and add more services and benefits to the world over 4G. Fifth generation should be more intelligent technology that interconnects the entire world without limits. This generation is expected to be released around 2020. The world of universal, uninterrupted access to information, entertainment and communication will open new dimension to our lives and change our life style significantly.

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