5G Evolution

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Abstract **- The 5G System is being developed and enhanced to provide unparalleled connectivity to connect everyone and everything, everywhere. The first version of the 5G System, based on the Release 15 version of specifications developed by 3GPP, comprising the 5G Core (5GC) and 5G New Radio (NR) with 5G User Equipment (UE), is currently being deployed commercially throughout the world both at sub-6 GHz and at mm Wave frequencies. Concurrently, the second phase of 5G is being standardized by 3GPP in the Release 16 version of specifications which will be completed by March 2020. While the main focus of Rel-15 was on enhanced mobile broadband services, the focus of Rel-16 is on new features for URLLC (Ultra-Reliable Low Latency Communication) and Industrial IoT, including Time Sensitive Communication (TSC), enhanced Location Services, and support for Non-Public Networks (NPNs).Finally, the number of use cases, types of connectivity and users, and applications running on top of 5G networks, are all expected to increase dramatically, thus motivating additional security features to counter security threats which are expected to increase in number, scale and variety. In this paper, we discuss the Rel-16 features and provide an outlook towards Rel-17 and beyond, covering both new features and enhancements of existing features. 5G Evolution will focus on three main areas: enhancements to features introduced in Rel-15 and Rel-16, features that are needed for operational enhancements, and new features to further expand the applicability of the 5G System to new markets and use cases.**

Keywords **- 5G System, 5G-NR, UMTS, W-CDMA, LTE, LTE-Advanced, GPRS and EDGE, HSPA, IMS, NAS Protocol, SON, Evolved Packet Core.**

1. INTRODUCTION

5G provides a highly flexible and scalable network technology for connecting everyone and everything, everywhere. It provides a resilient cloud-native core network with end-to-end support for network-slicing. It enables new value creation through support for new services based on three major use case domains, namely enhanced mobile broadband (eMBB), URLLC, and massive machine type communications (mMTC).

The initial commercial deployments of NR are already under way during 2019, focusing on eMBB using the Release 15 ("Rel-15") version of the 3GPP specifications.

The basis for URLLC is inherent in the Rel-15 version of the 5G System, especially in respect of support of low latency.

For the mMTC component, NR is complemented by the machine-type communications technologies known as LTE-M and Narrow Band IoT (NB-IoT) already developed by 3GPP in Rel-13, which provide unrivalled low-power wide-area performance covering a wide range of data rates and deployment scenarios.

Subsequent releases of the 3GPP specifications will build in a backward-compatible manner on the foundation provided by Rel-15, as illustrated in Figure 1. In that spirit, the second phase of 5G is currently being standardized as Rel-16 and is scheduled to be completed by March 2020.

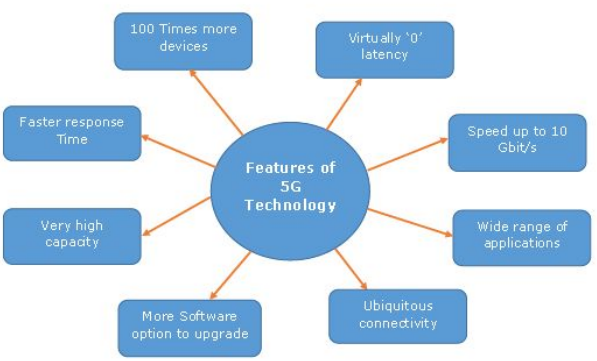

Fig 1. Features of 5G Technology

The 5G core network architecture is at the heart of the new 5G specification and enables the increased throughput demand that 5G must support. The new 5G core, as defined by 3GPP, utilizes cloud-aligned, service-based architecture (SBA) that spans across all 5G functions and interactions including authentication, security, session management and

aggregation of traffic from end devices. The 5G core further emphasizes NFV as an integral design concept with virtualized software functions capable of being deployed using the MEC infrastructure that is central to 5G architectural principles.

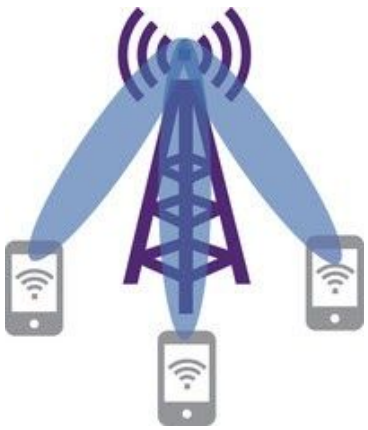

Fig 2. Beamforming

With 5G data transmission occupying the millimeter wave, free space propagation loss, proportional to the smaller antenna size, and diffraction loss, inherent to higher frequencies and lack of wall penetration, are significantly greater. On the other hand, the smaller antenna size also enables much larger arrays to occupy the same physical space. With each of these smaller antennas potentially reassigning beam direction several times per millisecond, massive beamforming to support the challenges of 5G bandwidth becomes more feasible. With a larger antenna density in the same physical space, narrower beams can be achieved with massive MIMO, thereby providing a means to achieve high throughput with more effective user tracking.

2. DESCRIPTION OF THE EXISTING PARADIGM

Millimeter Wave'. Living in the space above 24Ghz, millimeter wave 5G has access to huge chunks of data allowing speeds in excess of 1Gbps. Referred to as high-band by the FCC, and mmWave by Qualcomm and AT&T, this is the current spectrum utilized by Verizon for 5G as well as part of T-Mobile and AT&T's 5G networks. One issue with these frequencies is immediately apparent when it comes to coverage.

Sub-6'. Sub-6 5G references any 5G NR deployed on frequencies under 6GHz. Sub-6 5G will have better coverage than millimeter wave but isn't as available making the potential top speed lower.

Low band'. The FCC Says that low band frequencies are those at 600Mhz, 800Mhz, and 900Mhz. Lower frequency signals are less susceptible to interference from things like walls and atmospheric conditions, which makes them a great choice for covering a lot of geographic space.

These frequencies were preferred by many cell providers for years since they allow for large coverage areas with fewer towers. Today, however, people are using more data than ever and the high value of these lower bands means that there isn't any growing room and even with newer tech like 5G, they won't be able to keep up with the growing demand for data. For that, you need more frequency, and that is found in higher bands.

T-Mobile and AT&T have deployed a low-band 5G network at 600MHz and 850MHz respectively. This has helped increase 5G coverage massively over millimeter wave deployments.

Mid Band'. Mid-band refers to the frequencies under 6GHz but above the low-band frequencies. This currently includes 2.5Ghz, 3.5Ghz, and 3.7-4.2Ghz. As time passes, more frequencies can be utilized that were previously reserved for defunct technologies like over the air television.

Sprint has been deploying 5G service on its 2.5Ghz bands which is currently the lowest of any provider, allowing it to leapfrog its competitors in coverage. This also means that this deployment of 5G will likely never match the top speeds on offer from providers that use millimeter wave, thanks to narrower bands of available frequencies available.

C band'. There is a constant battle for spectrum between every industry that needs it. And there are quite a few industries that need it. The C-band is a communications band between 3.7 and 4.2 GHz that is being cleared for use with 5G. This mid-band spectrum will help 5G providers more quickly expand service with enough spectrum for high speeds, approximately 300 MHz.Since it's part of the mid-band, this C-band spectrum is essential to quick 5G deployment thanks to its ability to deliver high speeds while still offering better building penetration than millimeter wave.

3.BRIEF DESCRIPTION OF A POSSIBLE MODIFICATION

Now high band and low band introduced by the companies. But the mid band technology never introduced. We can expect the launching of 5g technology in mid band.T-Mobile low band 5g peaks at somewhere in the neighbourhood of 225 megabits per second (Mbps), which is six to seven times faster than common 4G speeds in the United States today.

4. 5G ARCHITECTURE

Architecture of 5G is highly advanced, its network elements and various terminals are characteristically upgraded to afford a new situation. Likewise, service providers can implement the advance technology to adopt the value-added services easily.

However, upgradeability is based upon cognitive radio technology that includes various significant features such as ability of devices to identify their geographical location as well as weather, temperature, etc. Cognitive radio technology acts as a transceiver (beam) that perceptively can catch and respond radio signals in its operating environment. Further, it promptly distinguishes the changes in its environment and hence respond accordingly to provide uninterrupted quality service.

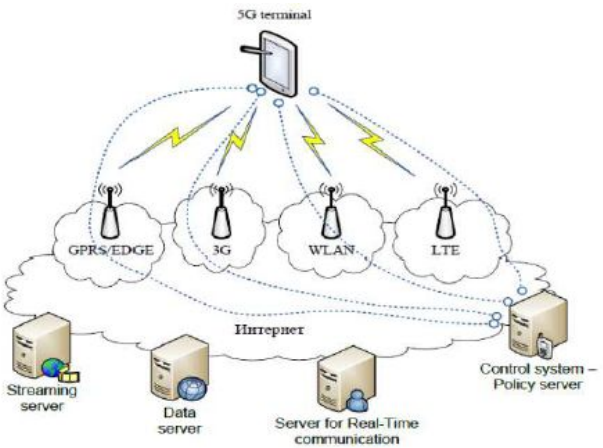

Fig 3. 5G Architecture

The system comprising of a main user terminal and then a number of independent and autonomous radio access technologies. Each of the radio technologies is considered as the IP link for the outside internet world. The IP technology is designed exclusively to ensure sufficient control data for appropriate routing of IP packets related to a certain application connections

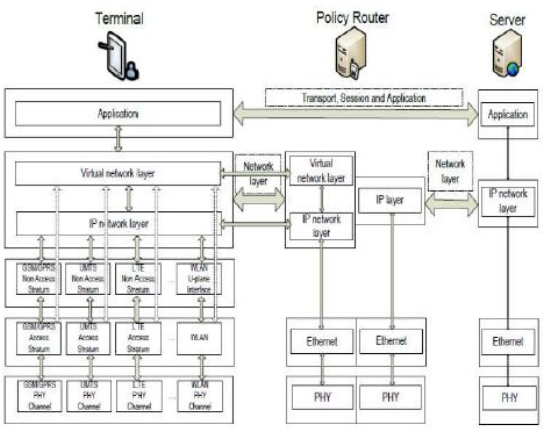

Fig 4. Routing of packets between client and server

5. 5G TIME - PERIOD REQUIRED

Normally, it is expected that the time period required for the 5G technology development and its implementation is about five years more from now (by 2020). But to becoming usable for the common people in developing countries, it could be even more.

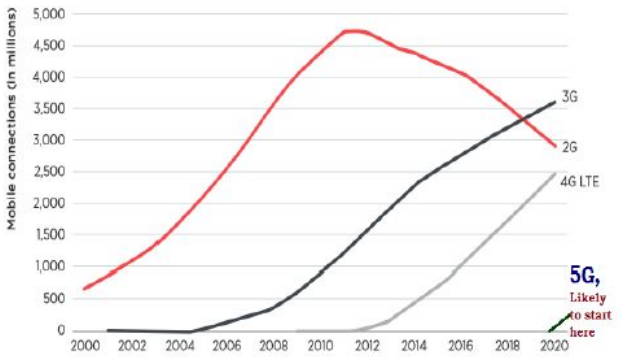

Fig 5. Timeline of all previous generation technologies

6. CURRENT PROGRESS

This report from GSMA Intelligence explores the current landscape and the future outlook for 5G in the US. It focuses on network deployment, spectrum, use cases, and policy and regulation.Following progress led by both the mobile industry and government agencies, the US will launch early 5G commercial services later in 2018. All four national mobile operators – AT&T, Sprint, T-Mobile US and Verizon – are moving fast with 5G and have announced details of their rollout plans.4G and 5G networks will likely co-exist and remain complementary for many years. The US mobile operators are targeting a phased approach to 5G network deployments.The provision of enhanced mobile broadband will be the core proposition in early 5G deployments, with massive IoT and ultra-reliable, low-latency communications gaining scale at a later stage. As the Internet of Things (IoT) and artificial intelligence (AI) are moving towards mainstream adoption, 5G is expected to have a major role in their development. As well as mobile use cases for consumers and enterprises, the analysis covers 5G-based fixed wireless, an area where the US is playing a pivotal role around the world.

7. APPLICATIONS

Some of the significant applications are −

- It will make unified global standard for all.
- Network availability will be everywhere and will facilitate people to use their computer and such kind of mobile devices anywhere anytime.

- Because of the IPv6 technology, visiting care of mobile IP address will be assigned as per the connected network and geographical position.
- Its application will make world real Wi Fi zone.
- Its cognitive radio technology will facilitate different version of radio technologies to share the same spectrum efficiently.
- Its application will facilitate people to avail radio signal at higher altitude as well.

8. ADVANCED

Application of 5G is very much equivalent to accomplishment of dream. It is integrated with beyond the limit advance features in comparison to the previous technologies.

Fig 6. Advanced

In comparison to previous radio technologies, 5G has following advancement −

- Practically possible to avail the super speed i.e. 1 to 10 Gbps.
- Latency will be 1 millisecond (end-to-end round trip).
- 1,000x bandwidth per unit area.
- Feasibility to connect 10 to 100 number of devices.
- Worldwide coverage.
- About 90% reduction in network energy usage.
- Battery life will be much longer.
- Whole world will be in wi fi zone.

9. 5G ADVANTAGES AND DISADVANTAGES

5th generation technology offers a wide range of features, which are beneficial for all group of people including, students, professionals (doctors, engineers, teachers, governing bodies, administrative bodies, etc.) and even for a common man.

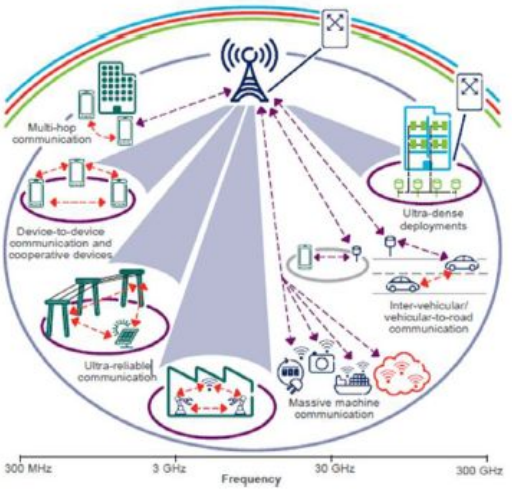

Fig 7 . 5G Network with wide range of features

10. 5G CHALLENGES

Challenges are the inherent part of the new development; so, like all technologies, 5G has also big challenges to deal with. As we see past i.e. development of radio technology, we find very fast growth. Starting from 1G to 5G, the journey is merely of about 40 years old (Considering 1G in 1980s and 5G in 2020s). However, in this journey, the common challenges that we observed are lack of infrastructure, research methodology, and cost.

11. TECHNOLOGICAL CHALLENGES

-> Inter-cell Interference − This is one of the major technological issues that need to be solved. There is variations in size of traditional macro cells and concurrent small cells that will lead to interferences.

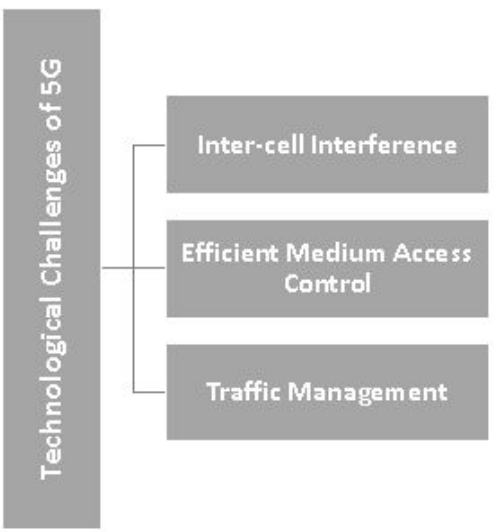

Fig 8. Technological Challenges

-> Efficient Medium Access Control − In a situation, where dense deployment of access points and user terminals are required, the user throughput will be low, latency will be high, and hotspots will not be competent to cellular technology to provide high throughput. It needs to be researched properly to optimize the technology.

-> Traffic Management − In comparison to the traditional human to human traffic in cellular networks, a great number of Machine to Machine (M2M) devices in a cell may cause serious system challenges i.e. radio access network (RAN) challenges, which will cause overload and congestion.

12. COMMON CHALLENGES

- Multiple Services − Unlike other radio signal services, 5G would have a huge task to offer services to heterogeneous networks, technologies, and devices operating in different geographic regions. So, the challenge is of standardization to provide dynamic, universal, user-centric, and data-rich wireless services to fulfil the high expectation of people.

Fig 9. Challenges of 5G

- Infrastructure − Researchers are facing technological challenges of standardization and application of 5G services.
- Communication, Navigation, & Sensing − These services largely depend upon the availability of radio spectrum, through which signals are transmitted. Though 5G technology has strong computational power to process the huge volume of data coming from different and distinct sources, but it needs larger infrastructure support.
- Security and Privacy − This is one of the most important challenges that 5G needs to ensure the protection of personal data. 5G will have to define the uncertainties related to security threats including trust, privacy, cybersecurity, which are growing across the globe.
- Legislation of Cyberlaw − Cybercrime and other fraud may also increase with the high speed and ubiquitous 5G technology. Therefore, legislation of the Cyberlaw is also an imperative issue, which largely is governmental and political (national as well as international issue) in nature.

13. CONCLUSION

5G is the Fifth Generation technology. It has many advanced features potential enough to solve many of the problems of our mundane life. It is beneficial for the government, as it can make the governance easier for the students, as it can make available the advanced courses, classes, and materials online. it is easier for the common people as well, as it can facilitate them the internet everywhere. So, this paper describes the 5G technology, its applications, challenges, etc., in detail.

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