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5G Technology – A Key Evolution for IoT

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Abstract - 5G communications is a revolutionary upgrade from the previous generations of cellular technology envisioned to overcome the bounds of access, performance and latency limitations on connectivity. 5G has a lot of prospective applications in industries and business models. 5G dramatically improves the Quality of Service (QOS) that require high data-rate, ultra-low latency and massive connectivity for extensive applications like e-health, autonomous vehicles, robotic surgery, smart cities, smart homes and IOT**.**

Index Terms - Long Term Evolution, Advanced, Internet of Things, Software Defined Network, Network Virtualization, Mobile Cloud Engine.

I. INTRODUCTION

Wireless technology has grown and advanced significantly through research and innovations. When developing a new mobile generation, parameters like throughput, jitter, channel interference, connectivity, scalability, energy efficiency and compatibility should be considered. During the last two decades, the world has witnessed rapid advancement of cellular technology from the 2G that is Global System for Mobile (GSM) to the 4G that is Long Term Evolution-Advanced (LTE-A). The main inspiration for 5G has been the need of more bandwidth and low latency.

5G communication is expected to tremendously expand the capabilities of mobile network. New technologies and functionalities are being introduced for 5G systems in various domains like Wireless access, cloud application and management systems. 5G majorly targets the traditional mobile users as well as machine type users in order to enable the service for consumers and industries at large scale and it is an eye opener for the Internet of Things (IoT), virtual and augmented reality, autonomous and robotic surgery [1]. The data rate has improved from 64kbps in 2G to 50-100Mbps in 4G. 5G is expected to strengthen not only the data transfer speed but also scalability, connectivity and energy efficiency of the network.

5G wireless access technology is expected to likely provide extreme data rates, ubiquitous coverage supporting cell edge users, ultra-high reliability, ultra-low latency, high energy efficiency, and a massive number of heterogenous connections. The functionalities of 5G are supported in two main application streams they are Human Centric and Machine Centric. The applications for human-centric are Augmented Reality (AR), Virtual Reality (VR) and online gaming. These applications demand high throughput and ultra-low latency. The Machine centric applications are branched into two main segments which are massive IoT and critical IoT. Massive IoT is characterized by low cost device connection, supporting small volumes of data per service with long battery life and deep coverage. The applications of Massive IOT are smart buildings, utilities, transport, logistics, agriculture and fleet management. The critical IoT is characterized by ultra-reliability and ultra-low latency connectivity. The applications of critical IOT are autonomous vehicles, smart power grid, robotic surgery, and industrial control.

As almost every society and industry are looking forward for the 5G revolution with its specific set of design and requirements even though its challenging. It is assumed that 50 billion devices will be connected to global IP network by 2020, which would be an addressing problem [2]. In a true “networked society” remote controlled operation of appliances and critical commercial machine communications over a reliable 5G network will be possible with zero delay. Some of the recent works for 5G standardizations and its survey has been explored in detail. Such works are as follows, Different works on 5G standards by diverse research groups and top telecom industries has been extensively studied recently in [4], which gives an idea and the highlight on the vision that was defined by the researchers and the company. Some of the scientific book like [5] shares lot of recent works on design principle and recent developmental endeavor of 5G and IOT. In the paper [6], the comprehensive survey has been highlighted on 5G challenges and overcoming technology has been discussed but unlike these existing work, this paper highly focuses on various technologies that is being researched for 5G deployment and presents a comprehensive study of 5G technological concepts, system requirements, 5G high level network architecture and how these technologies has been compacted to application wise and additionally this paper also explores some exciting 5G trials which was showcased by various telecom companies.

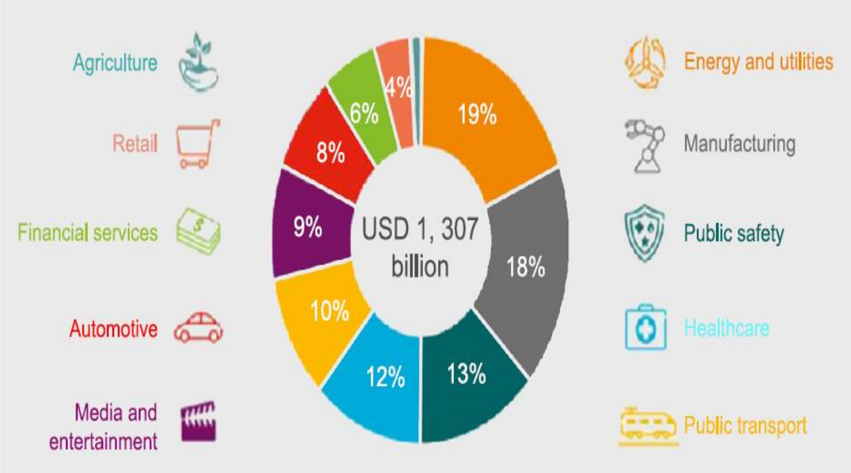

Fig.1 5G enabled industry digitalization (Source: Ericsson [3])

This paper is organized as follows. In Section 2, the cellular evolution towards 5G is discussed where the brief descriptions of various generations are listed. In Section 3, the next generation – 5G and its use cases has been explored. In Section 4, the main challenges and requirements of 5G is listed, in this section various technical ways have been presented and analyzed to overcome these challenges. In Section 5, the overview of technical concepts is briefly explored. In Section 6, high level service driven 5G architecture is discussed. In Section 7, the key indicators and characteristics of 5G is listed. In Section 8 and 9, the 5G field trial and disadvantages of 5G are examined in detail.

II. CELLULAR EVOLUTION TOWARDS 5G

In 1946, the US Federal Communication Commission (FCC) approved first mobile telephony service to be operated by AT&T company. During this first generation, the equipment was heavy and had to be deployed in a vehicle due to weight. It also consumes excessive power. From this era, the cellular communication technology has boomed, and it transformed from analog to digital format of communication which supports high-speed data transfer.

Around mid – 1980s, the first generation (1G) cellular communication, mainly supports voice, which grew up using formats such as Advanced Mobile Phone System (AMPS) and Nordic Mobile Telephone (NMT) in USA and Scandinavia. It was based on analog system and the transmission speed was up to 2.4Kbps. The analog formats were later replaced by 2G – first digital communications scheme around late 1990s, grew up by Global System for Mobile Communication (GSM) and digital-AMPS in Europe and USA. At this generation, the non-voice applications - Short Message Service (SMS) for cellular communications was introduced. Its transmission speed was up to 64Kbps. Enhancement for 2G using enhanced data rate for GSM evolution (EDGE), General Packet Radio Service (GPRS) and Code Division Multiple Access (CDMA) sparked the use of cellular data communication and early mobile internet connectivity in the early 2000's. The main motivation for moving forward from 2G to 3G, is in order to meet the surging demand for cellular communication. 3G was developed by Universal Mobile Telecommunication System (UMTS) based on wideband CDMA (WCDMA) technology.

This was introduced by Third Generation Partnership Project (3GPP) in the middle of 2000's. In this generation, user not only communicate via Multimedia Message Service (MMS) but also can stream video content. Its transmission speed lies between 125Kbps to 2Mbps. Transitioning to 4G – Long Term Evolution (LTE) increased the transmission speed to 100Mbps. The 4G initialization was more reliable compared to earlier generations. It provides high performance in low cost. During this generation, the technique was moving from Code Division Multiple Access (CDMA) to Orthogonal Frequency Division Multiplexing (OFDM) and Time Division Duplex (TDD) / Frequency Division Duplex (FDD). During this 4G era, there were two challenging technologies they are Worldwide inter-operability for Microwave Access (WiMAX) based on IEEE 802.16m standard and LTE-Advanced its an extension of LTE. These technologies are still being researched to explore the capabilities of techniques. LTE-A introduced the technologies like Carrier Aggregation, Co-ordinated Multipoint (CoMP), Heterogenous Networks (HetNet) to improve the Quality of Service (QOS) and support cell-edge users. LTE-Advanced is prevailing as a dominant cellular access technology and it is being the fundamental basis for the transition of 5G communications. The transformation from 4G to 5G will be a breakthrough in cellular communications and will be inspired tremendously by new human-centric and machine-centric service across multiple sectors and industries.

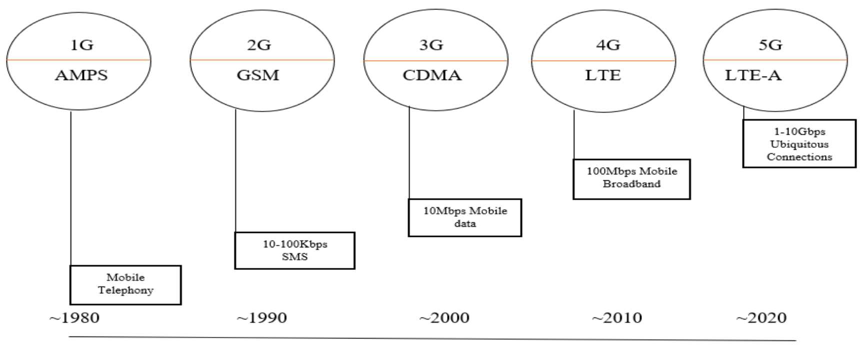

Fig.2 The different generations of Mobile communication

III. THE NEXT GENERATION – 5G/NR

The term 5G is used to refer in much wider context, not just referring to a specific radio-access technology.

A. The 5G Use Cases

According to ITU nomenclature for International Mobile Communications for 2020 (IMT-2020) [7], 5G will target three main use cases with very distinct features:

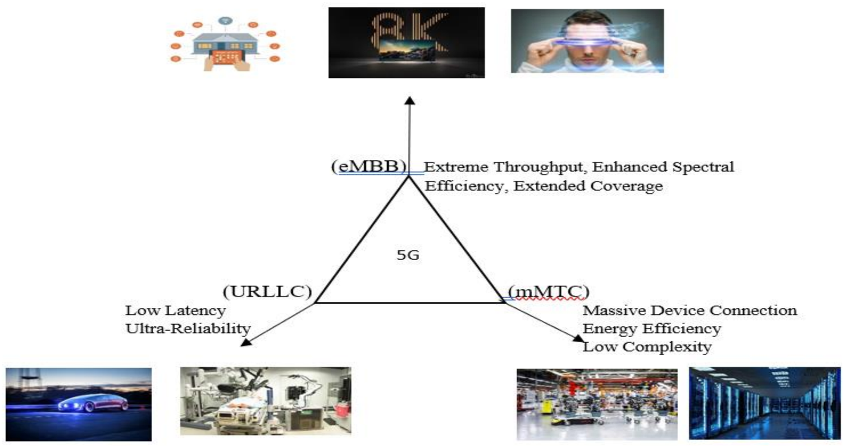

Fig.3 Use cases of 5G

1. Enhanced Mobile Broadband (EMBB) – [10/20 Gbps for UL/DL]

eMBB is an evolution of the mobile broadband services of today, enabling even larger data volumes and further enhanced user experience for example, video streaming, file downloading, online gaming and so on.

2. Massive Machine Type Communications [MMTC] – [10^6 Devices/Km^2]

mMTC corresponds to service that are characterized by a massive number of devices for example, remote sensors, smart meters etc. System is designed based on the specific requirements.

3. Ultra-high Reliable and Low Latency Communications (URLLC) – [>99.999% and <1ms]

URLLC type of service are envisioned to require very low latency and extremely high reliability. Examples such as Autonomous driving, remote surgery, factory automation etc.

IV. CHALLENGES AND REQUIREMENTS

In this section the paper focuses the main challenges, problems and question that arise in the research and design state.

A. Challenges

Capacity crunch problem is the major challenge we face in 5G [8]. Channel Capacity is the upper bound on the rate of information that can be safely transmitted over a communication channel, it is determined by bandwidth *W* and signal-to-interference-plus-noise ratio (*SINR*). This is illustrated as

Channel Capacity $C = W \log_2(1+SINR)$

Other major challenges in wireless transmissions are

- In wireless Communication, multipath is the another major challenge to be considered. Multipath is the propagation phenomenon that results in radio signals reaching the receiver by two or more paths. The effects of multipath are fading, interference, phase shift of the signal.
- Noise is also other major challenges to be considered.

We need to find solutions to address the capacity crunch problem. The techniques involved to address these problems is given below [9].

<u>Solution 1 – Increasing Bandwidth</u>

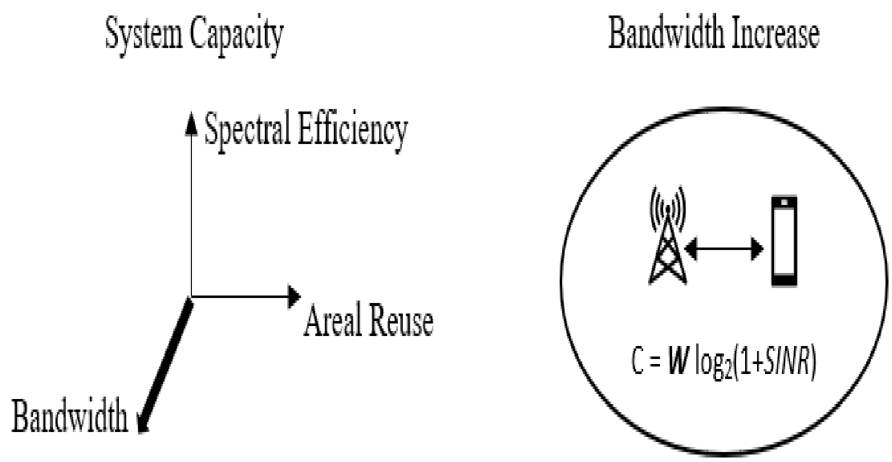

Fig.4 Three-dimensional view of system capacity and illustration of bandwidth increase

Effective ways of increasing bandwidth:

1. Milli-meter wave
2. Full-duplex radio
3. Carrier aggregation
4. New waveforms
5. Non-Orthogonal Multiple Access (NOMA)

Solution 2 – Improving Spectral Efficiency

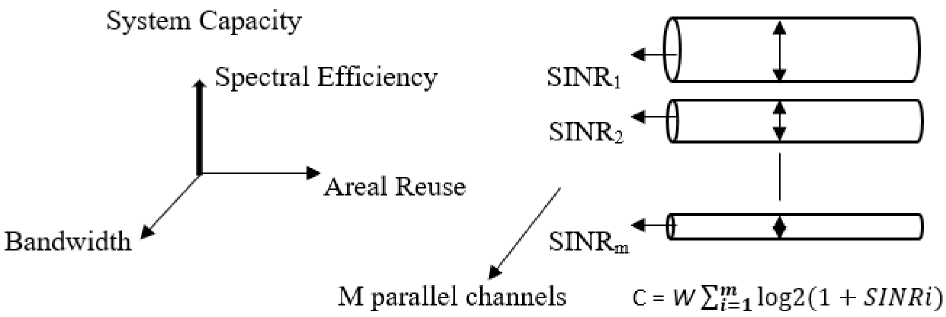

Fig.5 Three-dimensional view of system capacity and illustration of MIMO

The existing spectrum can be fully utilized by maximizing the Spectral Efficiency (SE). SE can be increased by

1. Multiple-input, multiple-output (MIMO) techniques.
2. Interference Mitigation
3. Multi-cell joint processing

Solution 3 – Aggressive spectrum re-use

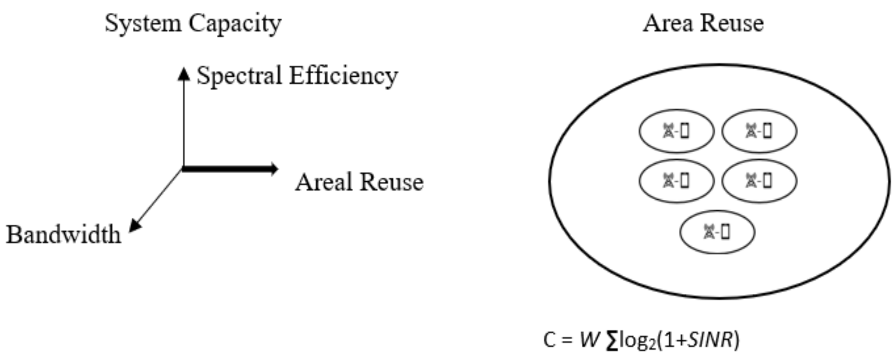

Fig.6 Three-dimensional view of system capacity and illustration of area reuse

Tackling capacity crunch problem is done by Network densification, the techniques are

1. By dense small cell deployment
2. Radio spectrum can be re-used aggressively

B. Requirements

The three fundamental requirements for 5G wireless networks are

- Capabilities for supporting massive capacity and massive connectivity.
- Support for an increasingly diverse set of services, application and users with extremely diverging requirements for work and life.
- Flexible and efficient use of all available non-contiguous spectrum for widely different network deployment scenarios.

V. TECHNICAL CONCEPTS OF 5G

In this section, some important techniques of 5G are discussed as follows,

A. Carrier Aggregation *(CA)*

CA is an important developmental concept and long road to Cognitive Radio. The emergence of CR technology has been regarded as an efficient approach to cope up with spectrum shortage and low utilization approach by dynamically re-use the frequency bands assigned to the licensed users (Primary users). The definition of CA is given by Definition: Integrate the unlicensed carrier (Secondary users) into the cellular system by adapting the cellular air interface in the unlicensed spectrum. In other words, it is a technology to combine two or more carriers into one data channel to enhance data capacity.

Carrier aggregation is an important feature of LTE – A.

The below figure gives an overview of how CA is achieved by using Primary and secondary users.

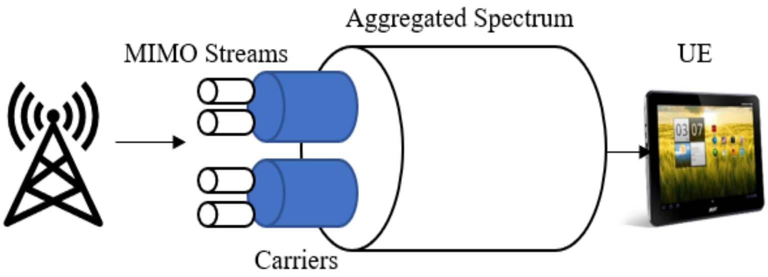

Fig.7 Carrier Aggregation

B. Milli-Meter Wave Communications

Milli-meter wave is the band of spectrum between 30-300Ghz, which is also known as extremely high frequency or very high frequency defined by the International Telecommunications Union (ITU), which can be used for high speed wireless broadband communications. Milli-meter wave allows for higher data rates up to 10Gbps. Milli-meter wave have short wavelengths that range from 10Millimeters to 1Millimeter. They have high atmospheric attenuation and are absorbed by gases in atmosphere, which reduces the range and strength of the wave. Rain and humidity can impact performance and reduce signal strength. To combat these disadvantages there are some techniques to overcome.

1. High Gain Antenna
2. Beamforming
3. Relay

C. Beamforming

This enhances the directivity of transmissions which can dramatically

1. Reduce interference
2. Enhanced Security
3. Extended Transmission distance
4. Save signal power
5. Increase capacity

D. Non-Orthogonal Multiple Access

Non-orthogonal Multiple Access (NOMA) is the one of the important technique in 5G that has recently been recognized as a promising multiple access technology that significantly improves the spectrum efficiency of mobile communications networks. In this technology each subchannel can carry multiple users with different signal power in the frequency domain and time domain. For the Orthogonal Multiple Access (OMA), if the subcarrier channel allocated to users with poor channel conditions, their spectrum efficiency will be relatively low. Conversely, NOMA enables each user to access all subcarrier channels hence the transmission capacity and the spectrum efficiency can be significantly improved by the access of multiple users even when the channel conditions are poor. NOMA is the powerful technique for 5G massive machine type communications.

E. Small Cell Deployment

Small Cells are low power, short range wireless transmissions systems (Base stations) to cover a small geographical area. However, small cells will have the same characteristics of a conventional base station and it is capable of handling high data rate for individual users. It is also called as Cell Densification. Cell densification increases capacity due to aggressive frequency reuse. Small Cells are further divided into three main categories to cover the area, they are

1. Femto cells
2. Pico cells
3. Micro cells

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Main requirements of smalls cells are

1. Enhanced mobile broadband
2. Massive IOT
3. To support Cell-edge users.

F. Multicell Cooperation

Multicell Cooperation is most needed at cell edge in order to achieve uniform user experience and improve cell edge throughput. It is done by Joint processing and Coordinated Scheduling.

Joint processing: Coordinated cells will serve the users together. The base station will exchange the Channel State Information (CSI) and data to each other. Joint Processing requires high backhaul. It is used for high data rate and high mobility scenario.

Coordinated scheduling: Each user is served by single base station. The BS will exchange CSI simultaneously in order to avoid the cell interference. It is used for low data rate and low mobility scenarios.

G. Device to Device Communication *(D2D)*

D2D can form as an ad-hoc network in emergency. It can extend coverage and reduce network load.

H. Massive MIMO

The base stations are equipped with a large number of antennas compared to previous MIMO systems. Some of potential advantages are

1. Increase capacity and improve the radiated energy efficiency.
2. Significant reduction in latency.
3. It simplifies the multiple access layers as the number of antennas increases the channel hardens.
4. Increase robustness against unintended interference.

VI. SERVICE-DRIVEN 5G ARCHITECTURE

In this section, a high-level 5G network architecture is discussed. The 5G network architecture aims to meet the diversified mobile service requirements. The physical infrastructure of 5G is supported by Software Defined Networking (SDN) and Network Function Virtualization (NFV) [10]. The SDN and NFV architecture gives an advantage for intelligent networking according to service requirement.

A. Software Defined Networking(SDN)

Software Defined Networking is an architecture which completely makes the network flexible and agile. The goal of SDN is to improve the network control by completely enabling service providers and enterprises to respond quickly according to business requirements.

SDN encloses several types of techniques, including functional separation, network virtualization and automation through programmability.

SDN is focused mainly on the separation of control plane from data plane in the network.

- Control plane mainly decides how packet should flow through the network.
- Data plane actually moves the packet from one point to other.

In a simple SDN scenario, the control plane decides the route and send the packets to the network switch. Once the packet reached the network switch, the packets are transferred according to the rules which is programmed in the switch, here the switch acts as a data plane.

The virtualization of SDN comes into the play through virtual overlay, which is logical separation of network which is particularly useful for the service providers and operators with multi-tenant cloud environment and cloud services, where they can separate virtually based on specific set of policies for each tenant.

<u>Benefits of SDN</u>

1. It can prioritize, deprioritize or even block specific types of packet as it acts as an administrator for the network.
2. Useful for Multi-tenant architecture
3. It also can virtualize the service and hardware by applying policies.

4. Other benefits are secure network management as it can monitor network traffic instantaneously and has end to end visibility of the network.

B. Network Function Virtualization

Network Function Virtualization is a technique to virtualize services that classically run on dedicated hardware. With the help of NFV, functions like routing, load balancing are packaged as virtual machines. This mainly helps to eliminate specific hardware because it can be moved or changed to server level scenario.

Benefits of NFV

1. Improve scalability and better utilization of network resources.
2. Reduces power consumption and increase physical space.
3. It can help to reduce both operational and capital expenditures.

5G comprehensively cloudifies access, transport and core networks. The advantage of adopting cloud allows for better support for diversified 5G services.

Cloud-RAN (C-RAN) consist of sites and mobile cloud engines (MCE).

C. Mobile Cloud Engine(MCE)

MCE is the logical entity for Cloud-RAN, incorporating RAN real and non-real time functions, WIFI, distributed gateway, service-related applications and cache.

D. C-RAN

This facility coordinates multiple services operating in different standards. Multi-connectivity is introduced to allow on-demand network deployment and implement policy control. Component-based control planes and programmable user planes allow for network computation to ensure that networks can select corresponding control plane and user plane according to service requirement. The transport network consists of SDN controllers and underlying forwarding nodes. SDN controller generate a series of forwarding path data based on network topology and service requirement. The top layer of network architecture implements E2E automatic slicing and network resource management.

E2E network slicing is a foundation to support various 5G services. Based on NFV and SDN, the network architecture accommodates sites and three-layer DC. Sites supports multiple modes (Such as 5G, LTE, and Wi-Fi) in the form of macro, micro, and pico base stations to implement the RAN real time functions.

E. Reconstructing the Ran With Cloud

With Mobile Cloud Engine (MCE), Cloud-RAN can implement flexible computation for RAN real time and non-real time functions based on different service requirements and transmission resource configuration to adopt Cloudification of RAN.

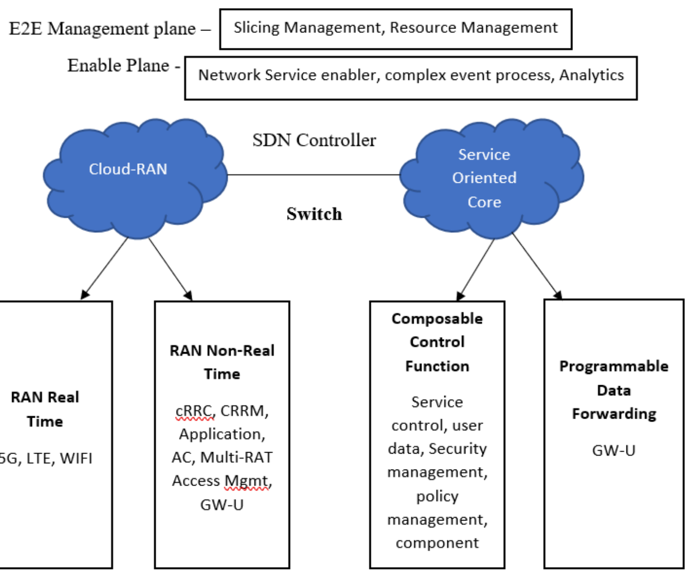

Fig.8 High Level view of 5G Architecture (Source:5GPPP [11])

The RAN real time functions include network scheduling, link adaption, power control, interference coordination, retransmission, modulation and coding. The RAN non-real time functions include intercell handover, cell selection and reselection, user plane encryption and multiple connection convergence. A universal processor can be deployed in an MCE. MCE can implement complex management while coordinating multiple processing capabilities based on time, frequency band, and space. This upgrade allows Cloud-RAN to support 4G, 4.5G 5G, Wi-Fi which supports coordination and scheduling of macro, micro, and pico site types. The figure 8 High-level view of 5G architecture

VII. 5G KEY PERFORMANCE INDICATORS

Table 1: Key performance Indicators for 5G

Indicators	Characteristics
User Experienced Data Rate	100Mbps-1Gbps
Peak Data Rate	10Gbps-50Gbps
Mobility	Up to 500Km/h
Latency	~1ms
Connection Density	10^6-10^7 per km^2
Energy Efficiency	50~100 times efficient than IMT-A
Spectrum Efficiency	5~15 times efficient than IMT-A

VIII. 5G FIELD TRAILS

This section briefly presents some of the world’s most exciting 5G trails, which shows the potential of 5G to unlock new and exciting opportunity, which are explained below

A. 5G for Virtual Reality Entertainment System

The experimental trial for Virtual Reality (VR) entertainment was conducted in collaboration with Tobu Railway co., Ltd, Tobu Tower Sky tree co., Ltd., and Panasonic corporation from Dec 8th to 10th, 2017 [12]. The images were captured with a 4K high resolution 360 ˚ live camera. The bandwidth needs to transmit a high-quality live video is of about 70Mbps. The trial proves that by using 5G wireless transmission, it is possible to transmit images to multiple users in real time with stable data rate.

B. 5G for Flying Drones

In 2016, Ericsson and China Mobile, carried out world’s first 5G trail for flying drones on a commercial network with help of 5G enabled technologies on cellular network [13]. In this trial, a drone was made to fly across multiple sites, and it was found that the handovers between sites were faster even when the base stations are highly busy. The applications of drones are emerging in agriculture, public safety, search and rescue and goods delivery.

C. 5G for High-Speed Connectivity

In 2017, Ericsson and Verizon tested the 5G capabilities by proving that the 5G can support 360˚ 4K video streaming with 6+Gpbs throughput and ultra-low latencies even in high mobility scenario [14]. In this trial, the car was operated by a driver by wearing a set of virtual reality glasses relying solely on the video captured from the camera which is placed on the top of the car. This was achieved by using multi-antenna technologies and beam tracking a high-speed car.

D. 5G Delivering 10+GBPS Worldwide

Ericsson and Korea Telecom demonstrated the world’s first 5G achieving 25.3Gbps throughput [15]. The trial was performed by implementing the milli-meter wave technology.

E. 5G Making Remote Driving a Reality

During the Mobile world congress held in 2017, Telefonica, Ericsson, The Royal Institute of Technology and Applus Idiada showcased the world first remote driving car with the help of 5G [16,17]. The driver gets an in-car experience with 4K video streaming in the uplink, In the downlink, 5G provides ultra-low latency and high reliability to communicate driving decisions to the car. Such applications are remote parking etc. Up to now the paper discussed about the advantages of 5G and its application in various domain. In addition to this, the paper will discuss some of the disadvantages when 5G is deployed.

IX. DISADVANTAGES OF 5G

Researchers and scientist clearly proved that 5G will be unsustainable to life forms and it is a serious problem for occupational health, public safety and personal safety [18]. When 5G is deployed there will be broadcasting boxes for every 3 to 10 homes down every street, all over the world. At these high frequencies (24Ghz to 90Ghz) and very dense wireless radiations will cause lot of problems to human bodies like DNA damage, cancer, cardiomyopathy and period.

For an instance Milli-meter wave is used to scatter crowds, when they put out this frequency in much higher power which makes the person to get a feel like the skin is on fire because the human body, including the skin is an antenna. When seeing all these cons of 5G, still you have a thought of talking Internet of Things? It’s worse than a nightmare.

X. BEYOND 5G: THE ROADMAP TO 6G AND BEYOND

Some proposal for 6G is to integrate terrestrial wireless network with satellite systems for ubiquitous broadband global network coverage. Other trends predict 6G will include ultra-dense cell networks, reconfigurable hardware, fast spectrum reallocation, quantum computers and quantum networks, security and safety, virtual operator’s explosion, enhanced optical-wireless interface, Intelligent networking and technologies to enable full immersive experience for users. 6G will include increased demands for M2M communications, including robotic technology and autonomous drone delivery.

XI. CONCLUSION

The concepts and applications of 5G evolution are outlined. Some of these techniques are likely to be the part of future release for 5G deployment. However, as always when trying to predict the future there are lot of uncertainties, not-yet-known requirements or technologies, which is always an encouragement to motivate evolutions into directions. It is clear that 5G is very flexible platform, capable of evolving in a wide range of directions and diversified applications. It is an attractive path to future wireless communications.

References

[1] Ericsson White Paper, 5G systems, 2017, Jan.
[2] Ericsson Mobility Report, June 2018.
[3] Ericsson, The 5G business potential, 2017, Oct.
[4] Nath Mitra, Rupendra & Agrawal, Dharma. (2016). 5G mobile technology: A survey. ICT Express. 1. 10.1016/j.icte.2016.01.003.
[5] Internet of Things (IOT) in 5G technologies, Springer, 2019.
[6] V. S. Pandi and J. L. Priya, "A survey on 5G mobile technology," *2017 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI)*, Chennai, 2017, pp. 1656-1659. doi:10.1109/ICPCSI.2017.8391995
URL: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8391995&isnumber=8391768
[7] ITU-R, Recommendation ITU-R M.2083-0: IMT vision–framework and overall objectives of the future development of IMT for 2020 and beyond, 2015.
[8] S. Chen, J. Zhao, "The Requirements Challenges and Technologies for 5G of Terrestrial Mobile Telecommunication", *IEEE Comm. Magazine*, vol. 52, no. 5, pp. 36-43, 2014.
[9] Pei Xiao, “5G Air Interface Candidate Techniques for Advanced 5G wireless technologies”, 2018
[10] Huawei Technologies White paper, 5G Network Architecture – A high Level View, 2016, https://www.huawei.com/minisite/hwmbbf16/insights/5G-Nework-Architecture-Whitepaper-en.pdf
[11] 5GPPP Architecture working group white paper, View on 5G Architecture, December 2017,https://5g-ppp.eu/wp-content/uploads/2018/01/5G-PPP-5G-Architecture-White-Paper-Jan-2018-v2.0.pdf.

[12] Y. Okumura, S. Suyama, J. Mashino, “Overview of 5G field trails towards social implementation and experimental trials of 5G in the entertainment area”, NTT Technical Review, vol.16, no.10, Oct.2018.

[13] Ericsson and China Mobile conduct world’s first 5G drone prototype field trial, Ericsson, 2016.

[14] The 5G race is on, Ericsson, 2017, https://www.ericsson.com/en/news/2017/5/ericsson-and-verizon-test-the-limits-of-5g.

[15] KT demonstrates world’s first 5G performing at 25 Gbps, Business Korea,2016,http://www.businesskorea.co.kr/news/articleView.html?idxno=13896.

[16] 5G can make remote driving a reality, Telefónica and Ericsson demonstrate at MWC, Telefonica, 2017.

[17] 5G can make remote driving a reality, Telefónica and Ericsson demonstrate atMWC, Ericsson, 2017.

[18] Wireless Radiation: Stop the 5G Network on Earth and in space, Devasting Impacts on Health and the environment, Global Research, December 2018.