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5th GENERATION MOBILE COMMUNICATION: A COMPREHENSIVE STUDY

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ABSTRACT

Currently, the fourth generation cellular communication provides a low latency that is insufficient. It is unable to cope up with the future requirements. The future is the enhanced version of today. Various aspects that are to be considered in the next generation of mobile communication are enormous unprocessed raw facts and figures, better data rates, increment in mobile devices etc. This technology is termed as 5G. This paper draws its attention on the advancements towards the improvement considered as the improved version of 4g i.e.5g. We discuss the comparative study that tells the evolution of previous generations in the case of cellular communication as well as the major limitations of 4g. Diverse implementation issues such as the quality of service (QoS), Handoffs, Load Balancing etc. are considered. The techniques that played a major role in the overall improvement towards 5g will be Large Scale Antenna System (MIMO), Device to Device (D2D) and Cognitive Radio (CR) etc. All of these features will improve the performance scenario and will result in a better tomorrow.

Key words: *5th Generation, Large Scale Antenna System, 3-D Spectrum, Progression.*

I. INTRODUCTION

It appears from the current rate of requirement growth that the immense requirements of the wireless data transmissions will never be fulfilled. During the last 2 decades, the globe has experienced an expeditious advancements in cellular disclosures i.e. from the Global System for Mobile (GSM) i.e. Second Generationmobile networks to the Long Term Evolution Advanced System (LTE) i.e. Fourth Generation mobile networks[1]. The genuine rationale has been the requisite of additional bandwidth as well as latency. It is still in the evolving juncture. Even if, the data transmission pace have increased by a 1000 times in comparison with the 1st generation of cellular communication, the service requirements still faces a number of problems. The latency element entirely depends on the processing swiftness of the unprocessed facts that is being carried by the nodes in the traversal procedure from the beginning to the end spectrum. The throughput parameter completely depends on the performance enhancement criterion such as scalability, interference, jitter, compatibility scenariosetc.

By the end of 2020[4], the statistics believed that the cellular web/network services would be used by more than 50 billion connected devices and smart objects/devices are in the Internet of Things (IOT) scenario. This would certainly raise the traffic concerning to data to an extreme. There is a 3-D spectrum (Fig.1) containing **D**evice, **D**ata, **D**ata Transfer rate that heads to the enlargement of 5th generation of mobile communication.

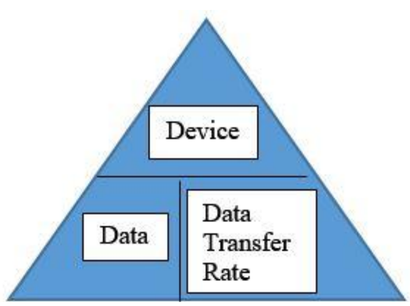

Fig.1 the 3-D Spectrum responsible for 5G

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According to the forecasting department, billions of global networked devices will be there in between the year (2014-2019)[2]. The Fig.2 is depicting the CISCO's Visual Network Index (2015) concerning forecasting of billion global networked devices.

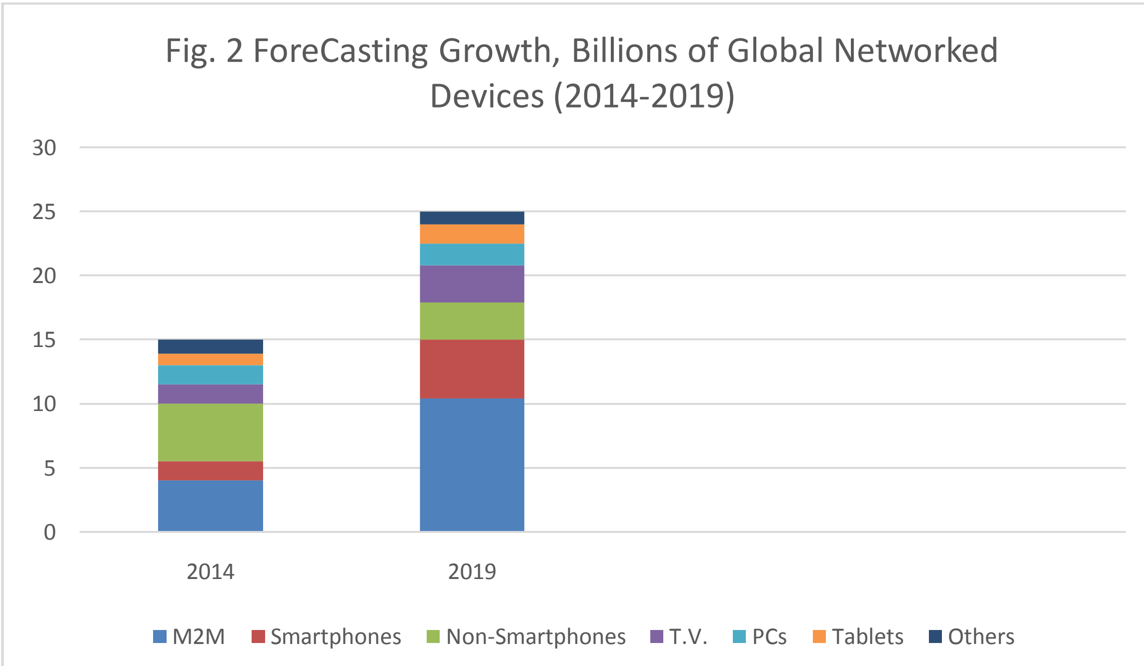

Fig. 2 Forecasting Growth, Billions of Global Networked Devices (2014-2019)

The vision of Fig.2 pertaining succeeding years depicts that the world will follow a networked culture that will allow the accessibility of the unprocessed raw facts and figures any moment and by anyone [5]. The future essentials will be fulfilled with the incorporation of present world technologies such as Long Term Evolution, Wireless fidelity, High Speed Packet Access or 3rd generation Partner Ship Project abbreviated as LTE, Wi-Fi, HSPA, 3GPP, respectively.

II. PROGRESSION OF WIRELESS NETWORKS:

It can be depicted with the following illustration (Fig.3) that tells about the mobility (Low Speed, Medium Speed and High Speed) as well as the data rates [6]. The Mobility is covered on the y-axis dimension and the data rates are covered on the x- axis dimension.As the generations are emerging the data rate are also improving that is directly proportional to the mobility [7].

When the 1g data rate was finalized that is 14.4 kbps (depicted in Fig.3), then it was hard to believe that one day it will exceed the 100 mbps case.

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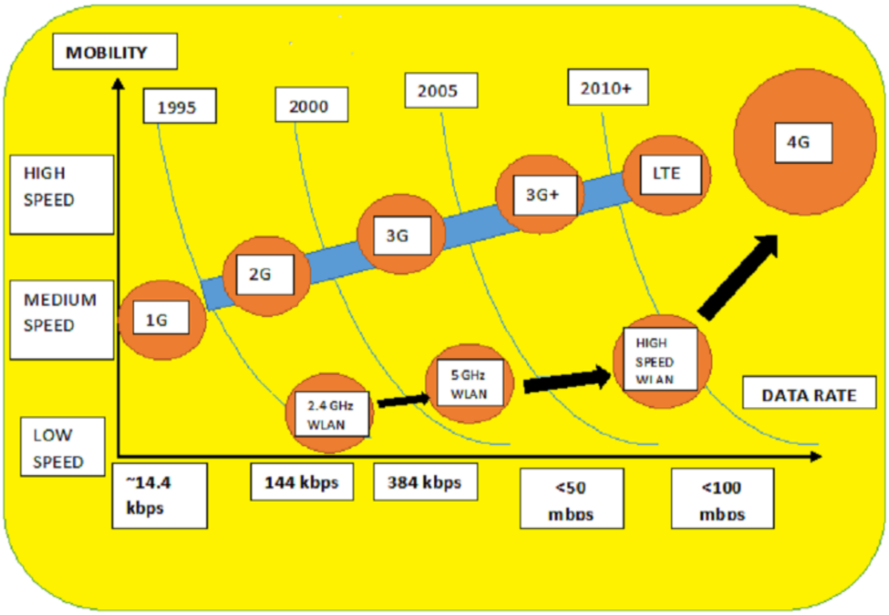

Fig. 3 EVOLUTION OF WIRELESS COMMUNICATION

Important features of various generations:

1G: First Generation
It was disclosed in the early 1980s. 1G was introduced with 2.4 kbps data rate.
Important members of thefirst generationmobile networks are-

- Advanced mobile phone system
- Nordic mobile telephone
- Total access communication system

Commonly abbreviated as AMPS, NMT and TACS respectively.

Drawbacks of the first generationmobile networks are-

- Low in range
- Careless handoff
- Low quality of voice association
- No reliability

Gathering and playing of voice callsuse to take place in radio tower.Therefore, the chances of overhear of calls by unauthorized person was possible.

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2G: Second Generation

In the late 1990s, the second generation concerning mobile communication was publicizethat used digital mechanism in the mobile phones [8]. The first system of 2G was Global system for mobile communication abbreviated as GSM that provides 64 kbps data rate especially in voice communication. Low powered Radio signals are used in 2G mobile phones due to which batteries last for prolonged time. The significant mechanism provided by 2G are as follows -

- SMS (Short Message Service)
- E-mail (Electronic Mail)
- GSM (Global system for mobile communication)
- CDMA (Code Division Multiple Access)
- IS-95 (Interim Standard – 95)

2.5G:Advancement in Second Generation of mobile networks (2G + General Packet Radio Service)

It uses a 2G framework along with a packet service known as General Packet Radio Service (GPRS)**.**A combination of both the switching techniques are used i.e. switching as well as packet.In this, the data rate can perform well up to 144 kbps.Enhanced data Rate for Global System for Mobile Evolution(EDGE) [9]. Code Division Multiple Access (CDMA)also act as a main technology coping with the 2.5G.

Architecture of GPRS:

The fig.4 depicts the architecture of GPRS.

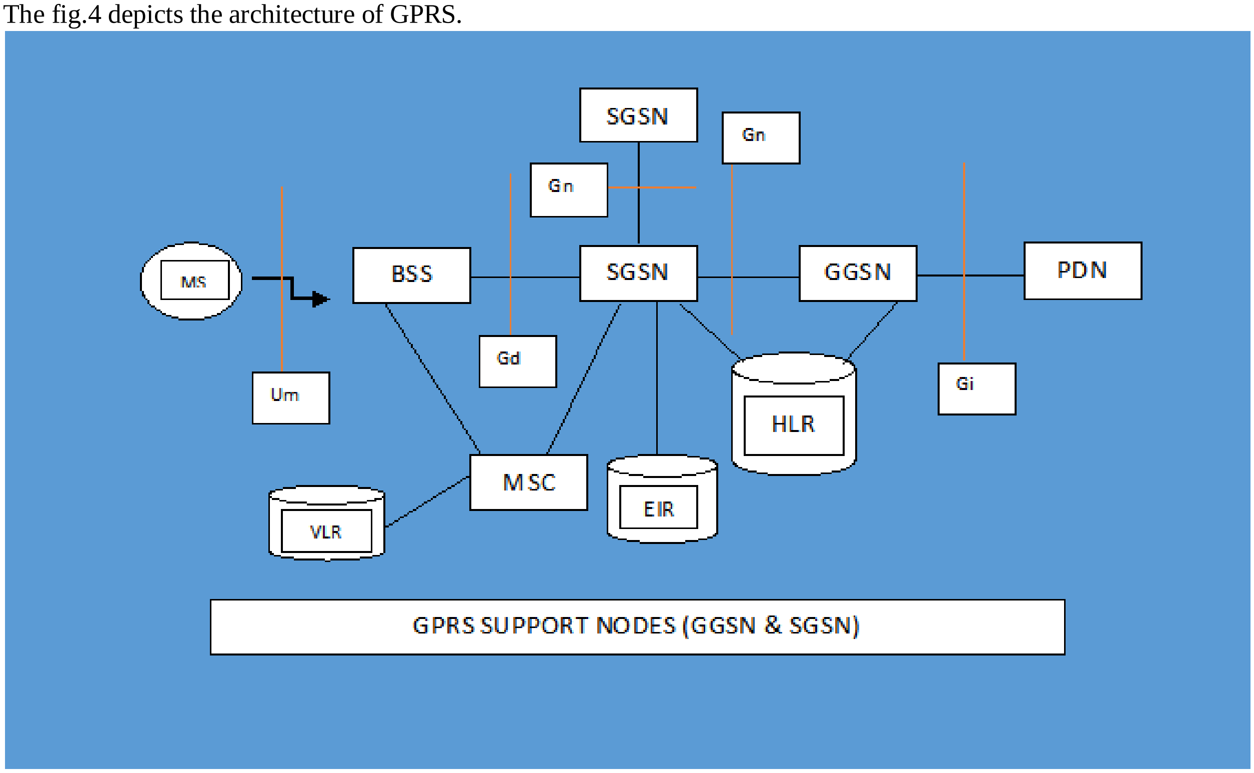

Fig.4 GPRS Architecture

Terms used in Fig.4:
- SGSN : Serving GPRS Support Nodes
- GGSN : Gateway GPRS Support Nodes

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- MS : Mobile Station
- BSS : Base Station Subsystem
- PDN : Packet Data Network
- VLR : Visitor Location Register
- HLR: Home Location Register
- EIR : Equipment Identity Register
- MSC : Mobile Switching Center
- Um, Gn, Gd, Gi : Interfaces

3G: Third Generation

In the year 2000, a technology named 3G was introduced. 3G mobile technology provides data rate of 2MBPS.In 3G mobile technology structure, IP i.e. internetprotocol played a major role. For maintenance of quality of services in 3G, an unusual development was made.

Properties such as global roaming and enhanced voice quality made 3G structures incredible. In 3G structure there is requirement of more power as compared to 2G structure [10].

This is important drawback of 3G structure. The plans introduced in 3G are more expensive as compared to 2G. 3G involves implementation of following mechanisms-

1. WCDMA : Wideband Code Division Multiple Access
2. UMTS : Universal Mobile Telecommunications Systems
3. CDMA 2000 : Code Division Multiple Access

Mechanism such as HSUPA/HSDPA and EVDO has evolved to new wireless services known as 3.5G with better data rate of 5-30 MBPS.

- HSDPA stands for High Speed Downlink Packet Access.
- HSUPA stands for High Speed Uplink Packet Access.
- EVDO stands for Evolution Data Optimized network of technology.

3.75G: Advancement in Third Generation Mobile Networks

The future of mobile data facilities depends on the current technologies and their advancements supporting this world i.e.Long Term Evolution (LTE) as well as Worldwide Interoperability for Microwave Access (fixed) (WIMAX) [11]. Technologies like thesehave the capability to have the add-ons in network capacity and provide high speed services to the users such as on request video and P2P sharing of a data file on the vast dimension. 3.75G provides better performances in comparison to previous generations but with low in cost.

4G: Fourth Generation

4G is the successor of 2G and 3G structure family. The 3rdGeneration Partnership Project generally known as 3GPP, is currentlymaturing the Long Term Evolutiontechnology as forthcoming 4G standard along with WIMAX technology. The Internet Protocol is capable of providing a secure and full solution to some problems arising in 4g communication networks. The desirable properties that users are provided with on daily basis arevoice, data and multimedia with high speed of data rate as compared with previously introduced structures (1G, 2G and 3G). The different applications of 4G structure are-

- MMS (Multimedia Message Service)
- DVB (Digital video Broadcasting)
- Video chat
- High definition TV content
- Mobile TV

5G: Fifth Generation

The demand is increasing exponentially in a day to day basis because of which the 4th generation of communication can be substituted with the 5th generation in corporation with BEAM Division Multiple Access (BDMA) as well as

Filter Bank Multi Carrier (FBMC) [12]. When the base station communicates with the mobile station, the BDMA technology performs its respective function. For this procedure, a beam that is orthogonal in nature is allocated to every mobile station, The BDMA technique will segment the beams of antenna according to the location considering multiple accesses and will help in enhancing the size of the system [13]. There are 6 factors that were not appropriately addressed by the 4G mobile network scenario and that leads to an emerging concern of 5g that includes:

- Higher Capacity
- Higher Data Rate
- Lower end to end latency
- Massive Device Connectivity
- Reduced Cost
- Consistent Quality of Experience.

The diverse challenges, facilitators as well as fundamentals of design concern are typically mentioned in Fig.11. It will be 10x faster in comparison to 4g [14]. It will have a lower cost than the previous versions. Various standards whose approaches are considered as the basic elements and leads for the effective functioning of 5g are:

- IEEE 802.11ac
- IEEE 802.11ad
- IEEE 802.11af

III. COMPARISON DIMENSION

Table (Fig. 5) showing: Comparison of all Generations of Mobile Communications in Tabular Format

Technology ⇨ Future ⇩	**1G**	**2G**	**3G**	**4G**	**5G**
Begin/Deployment	**1970-80**	**1990-2004**	**2004-10**	**Now**	**2020 onwards**
Data Bandwidth	**2 kbps**	**64 kbps**	**2 mbps**	**1 gbps**	**>1 gbps**
Technology	**Analog Cellular Technology**	**Digital Cellular Technology**	**CDMA -2000 UMTS,EDGE**	**Wi-Max LTE, Wi-Fi**	**WWWW (Coming Soon)**
Service	**Mobile Telephony (Voice)**	**Digital Voice, SMS, Higher Capacity packetized data**	**Integrated High quality audio, video & data**	**Dynamic Information Access, Wearable devices**	**Dynamic Information Access, Wearable devices with Artificial Intelligence capabilities**
Multiplexing	**FDMA {frequency}**	**TDMA,CDMA {Time & Code}**	**CDMA {Code}**	**CDMA {Code}**	**CDMA {Code}**
Switching	**Circuit**	**Circuit, Packet**	**Packet**	**All Packet**	**All Packet**
Core Network	**PSTN {Public Switched Telephone Network}**	**PSTN {Public Switched Telephone Network}**	**Packet (N/W)**	**Internet**	**Internet**

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Applications provided by wireless technologies:

- 1G: Voice
- 2G: Voice + Data
- 3G: Voice + Data + Video Calling
- 4G: Online Gaming + High Definition Television
- 5G: Ultra High Definition Video + Virtual Reality Applications

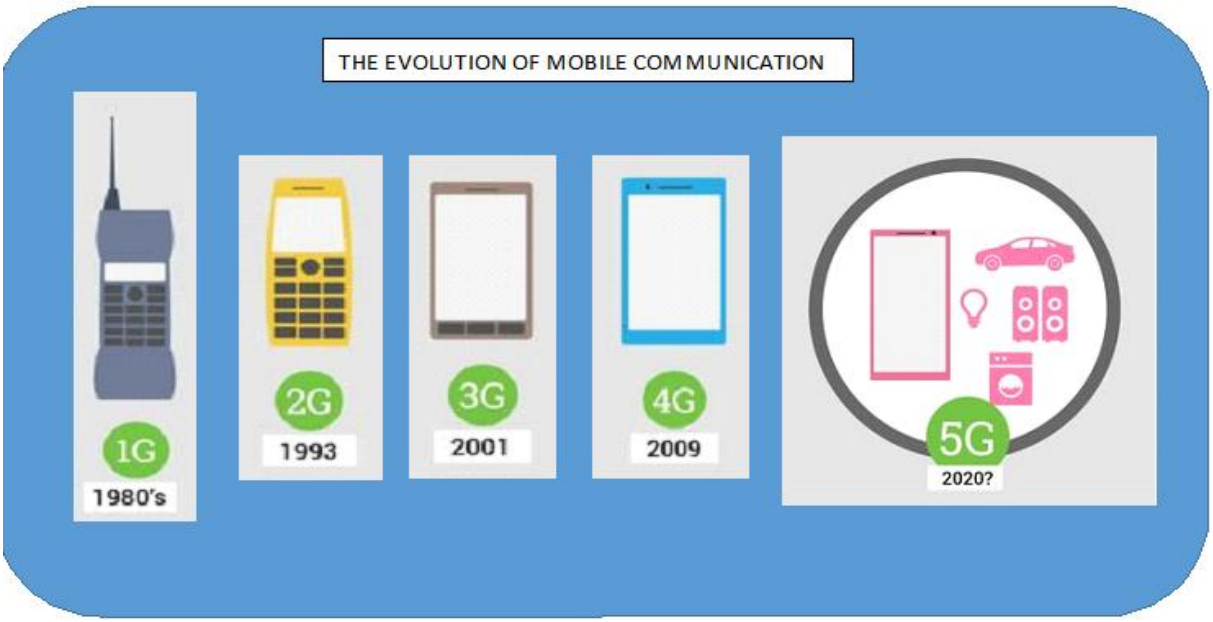

Fig. 6 Evolution of Mobile Communication

IV. WHY 5G IS NEEDED?

If we contrast the other wireless communication technologies with the 5th generation then, it's certain that it's better than the previous versions. The points which illustrates the pros of 5G mobile networks are as follows [15]:

- Greater Coverage sector
- Battery saving is more
- Singularly Reliable
- Eminently Secure
- High Resolution for cell phone users
- The speed of uploading as well as downloading will touch the peak
- Enhanced and Available Connectivity
- 25 Mbps connectivity speed
- Bidirectional large BW
- Energy as well as Spectral Effectiveness is appropriate.

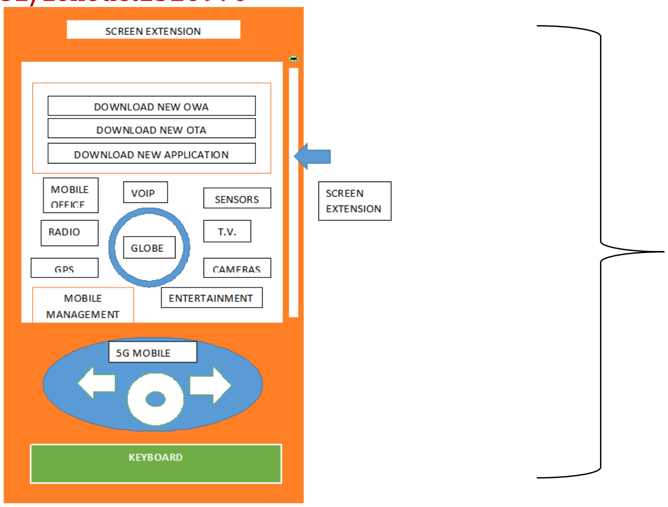

Fig. 7 THIS ILLUSTRATION DEPICTS A REPRESENTATION OF 5G MOBILE

Index:

- OWA- Open Wireless Architecture
- OTA- Over The Air Programming
- VOIP- Voice Over Internet Protocol
- GPS- Global Positioning System

V. THE ARCHITECTURES OF 5TH GENERATION MOBILE COMMUNICATION

A) General architecture

The architecture of any model is generally considered as its backbone. This is depicted in the mentioned figure below:

Various Elements of the General Architecture that enhances its functionalities are as follows:

- Macro cell
- Inter Vehicular or Vehicle to road communication
- Massive Machine Type Communication
- Device to Device Communication
- Mm Wave and Tera Hertz Communication
- LTE-A / Wi-Fi Integration
- Multi Steam/ Multi flow Carrier Aggregation
- HSPA : HSUPA/HSDPA

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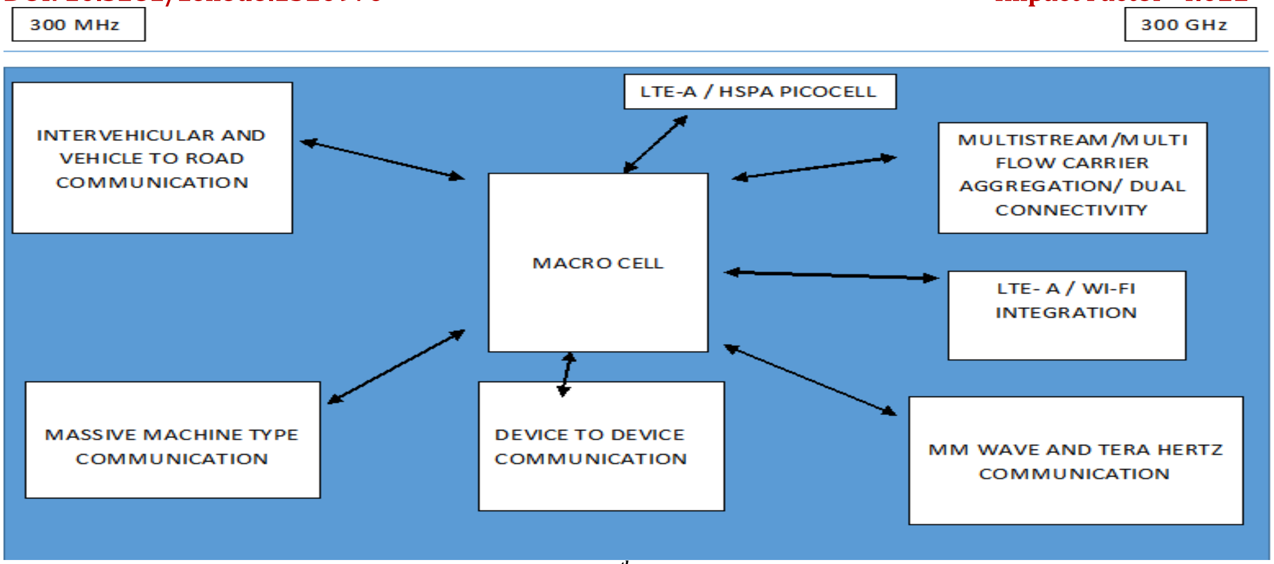

Fig. 8 the General Architecture of 5th Generation Communication System

This tabular form illustrates the methodologies as well the technologies used in the 5th generation of Mobile communication.

Table (Fig. 9): Methodologies for 5G Networks

Method	Increased data rate	Increase network capacity	Massive Device support	Energy Efficient	Low latency	Economic	Security & privacy	Interference	Mobility Support
Small-Cell	X	X		X		XP2			
Mobile Small-Cell	X	X		X		XP			X
CRN		X				X			
D2D	XP		XP	X		XP		XP	
C-RANs	X	X	X	X		X		X	X
Full Duplex Radio		X						X	
Advance Receiver		X						X	
SIC		X			XP			X	XP
DUD		XP		X					
Mm Wave	X	X	X	X	X				
M MIMO	X	X	X	X	X			X	
VLC	X			X	X	X	X		
CCN-Based Caching						X			

B) Functional architecture: 5g network

This figure given below illustrates the functional view of the 5th network architecture.

The User Terminal incorporated architecture is essential in this functional architecture. Radio Access Technologies primarily abbreviated as "RAT" that are unconventionally independent plays a unique role. The outside world considers these RAT as the set of rules governing internet links. In this terminal scenario, for every RAT technologies there should be a unique radio medium [16]. If we consider to access 6 RATs that are different or independent then there must be 6 access specific interfaces and all these interfaces should be in active state at the same time.

If we talk about the Open System Interconnection model all the layers plays an important role whether it may be physical layer, data link layer, network layer, transport layer etc. The physical layer can be termed as OSI-I, the data link layer can be termed as OSI-|| and so on. The quality of service is maintained by the first two layers i.e. physical and data link. The 3rd generation and WiMAX have the external QoS support while WLAN have no support for QoS. The Routing scenario is controlled by the network layer. Segmentation and reassembly of packets is considered in the transport layer. The managing of a session, i.e. opening as well as ending of a session is done by the 5th layer (session layer). The syntax layer presents the data to the application layer [17]. The application layer controls the end user scenario.

The last layer of the architecture comprises of the servers such as streaming, data, control, real time communication.

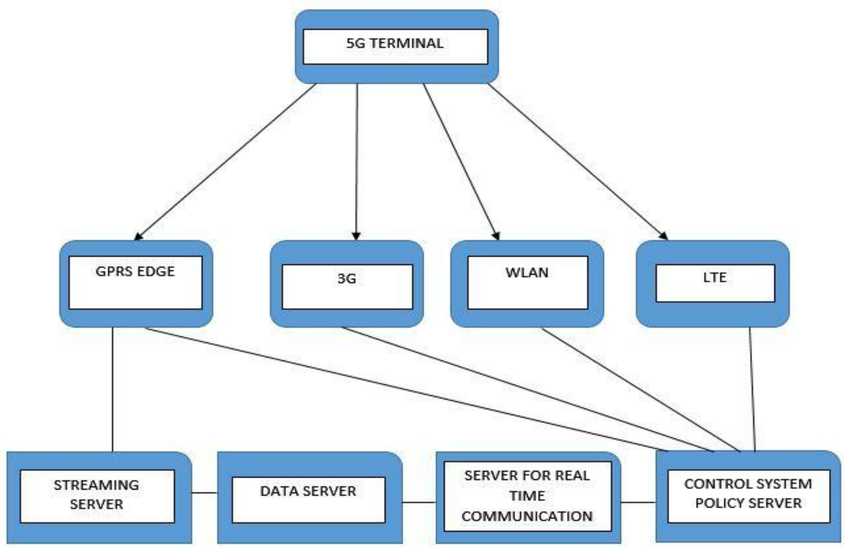

fig. 10 Functional architecture: 5g network

C) Cloud based architecture

The Cloud Based Architecture works on the 3 major terms-

- Control Layer
- Very High Speed Connections
- Data Layer

Control layer focuses on-

- Congestion Control
- Mobility Management
- Security & Privacy
- QoS Management

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- Handoff Management
- Network Management
- Baseband Unit
- Channel Access

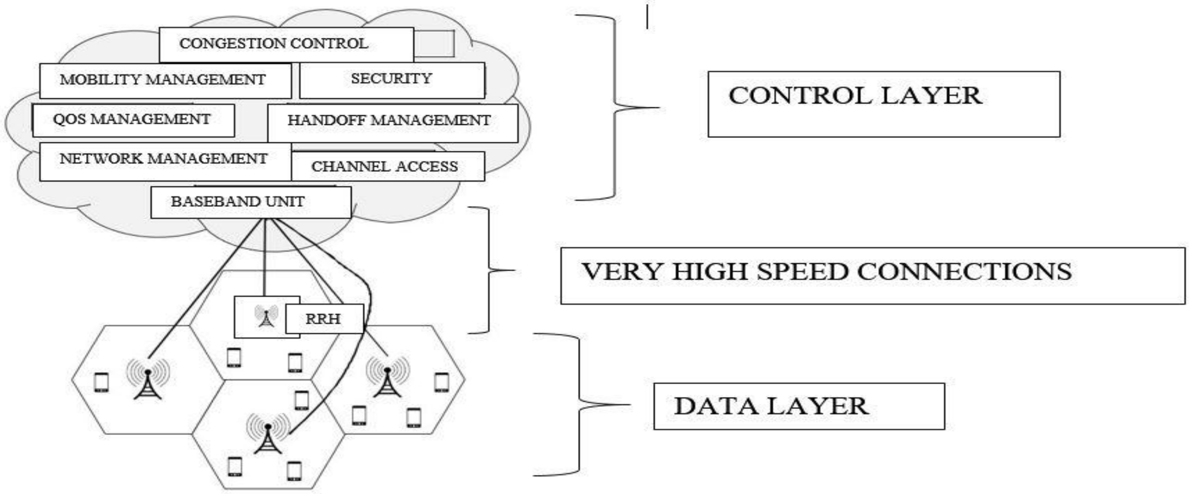

Fig. 11 Cloud Based Architecture

Cloud based architectures have an alias known as Cloud based Radio Access Networks (C-RAN) [4]. The first C-RAN was given by China Mobile Research Institute. The main motivation behind any CRAN is to execute as many functions of MBS in cloud. The functionalities of it is bifurcated into control and data layers. It is dynamic in nature. The two main types of CRAN's are as follows:

- 2- layered CRAN architectures
- 3-layered CRAN architectures

The 2 layered architecture contains the layers such as data and control, whereas the 3 layered approach contains an extra layer known as Software Defined Service layer. There can be fully centralized as well as partially centralized mechanism [18]. In 2 layer approach, Data layer performs the signal processing tasks. The Control layer performs the baseband and resource management.

The disadvantages that are present in the two layered approach are removed in the 3 layered approach by a mechanism known as CON-CERT.

In 3 layer approach, the control layer perform the following functions such as Radio InterfacingManagement, Wired Networking Management, and Location-aware Computing Managementto the data layer [19].
The 3rd layer that is the software defined service layer that acts as the virtual BS and provides the services such as Application delivery, Quality of Service, Security , Network Management, Seamless Mobility, Power control, and Regulations to the data layer. Some advantages of CRAN in 5G mobile networks are as follows:

- An Easy Network Management
- Less Cost
- Save Energy
- Improved spectrum utilization

VI. CHALLENGES, FACILITATORS & DESIGN FUNDAMENTALS

Every System has some challenges, facilitators as well as some design fundamentals on which that system depends. This illustration is depicted in this Fig.12.

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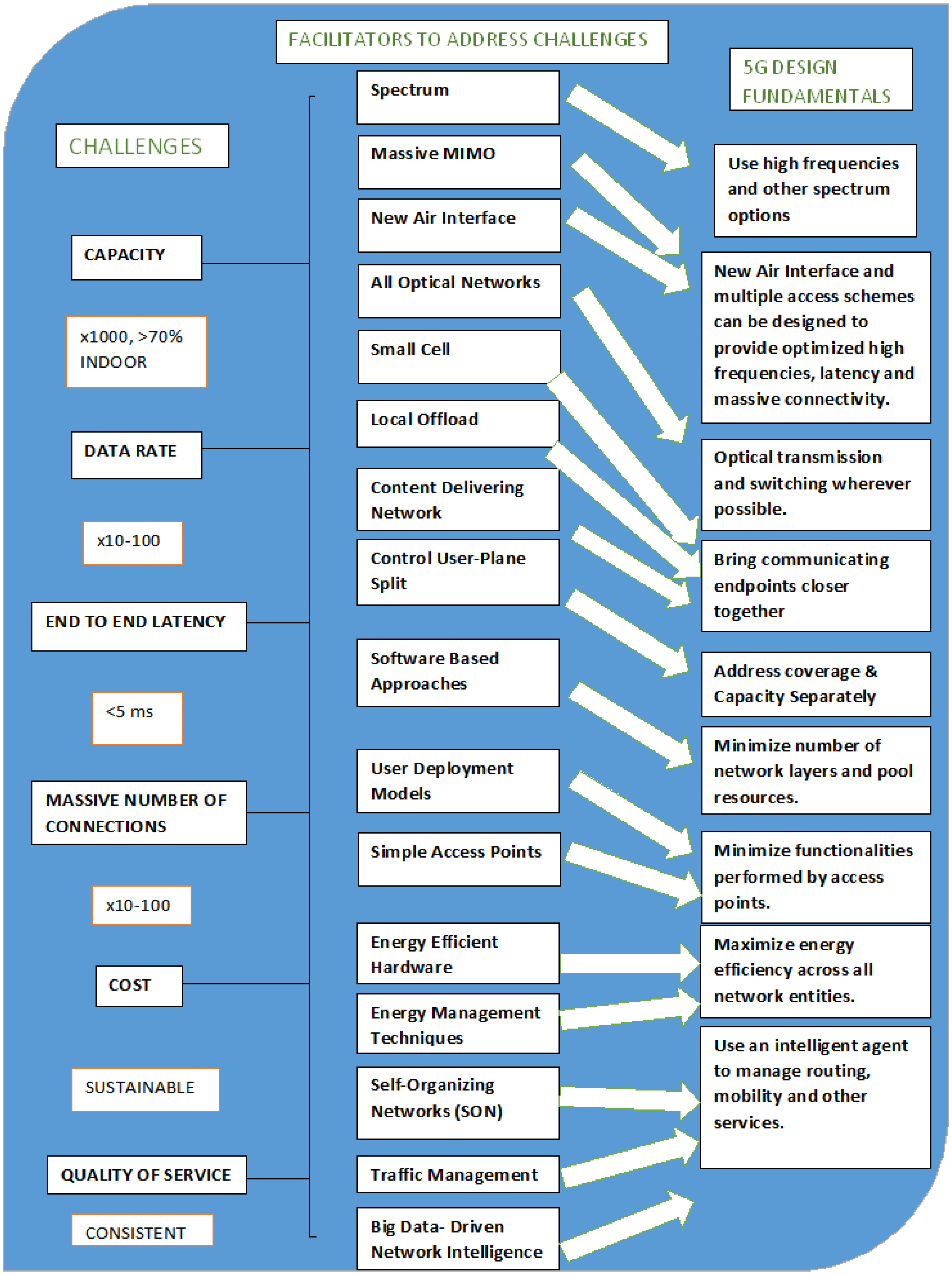

Fig.12 5G Challenge, Facilitators, and Design fundamental

VII. EMERGING TECHNOLOGIES in 5G

Some Emerging Technologies that are present in the developing phase of 5G.

- MIMO
- Cognitive Radio

a) MIMO:

Large Scale Antenna Systems or Multiple Antenna Systemstechnologies (MIMO) arebecoming fully fledged for wireless scenarios. Ithas been applied into techniques such as Long Term Evolution as well as Wireless Fidelity. The point is that if a large number of antennas will be present then certainly the transmitters or the number of receivers will be large, and if this happens there will be a greater number of paths concerning signals.The Performance will also be enhanced when it is chosen to be the reliability of the links or the rate of data.

Massive MIMO has a large number of aliases:

- **Large-Scale Antenna Systems**
- **Very Large MIMO**
- **Hyper MIMO**
- **Full-Dimension MIMO**
- **ARGOS**

A number of antennas are used in this technique that are operating in a coherent as well as adaptive manner. The number can be hundred or thousand, there is no compulsion in that. There are extra antennas that performs the process of receipting as well as transmitting even in the smaller sections of area [20].The throughput as well as the efficiency concerning energy can be incremented to a huge extent, and performs the scheduling operations appropriately in this case.

Originally this technique was a priority for the time division scenarios but it has a potential for covering the frequency dimension too.

Some Uses of Large-Scale Antenna Systems:

- Large scale utilization of low-power components.
- Lessen Latency
- Resolution of MAC Layer
- Strength to interference as well as intentional jamming.

b) Cognitive Radio:

The range of frequency is always less for the wireless dimension.For the conventional approaches, they have always been underutilized[21] .For the spectrum utilization, it is one of the best approach. It has 4 important functionalities:

- Spectrum Sensing
- Spectrum Management
- Spectrum Sharing
- SpectrumMobility.

If the requirement of bandwidth is considered up to 1GHz, then this situation is enough in making spectrum crisis even worse. Multi-RAT heterogeneous network is also an aspect in spectrum utilization. With the help of Cognitive Radio technique, the 5g can use the frequency band that were previously allocated to previous generations such as 2G/3G/4G communication [22]. The small cells are capable of using the frequency spectrum of Macro Cell and the Device to Device (D2D) can make use of the frequency components concerning networks.

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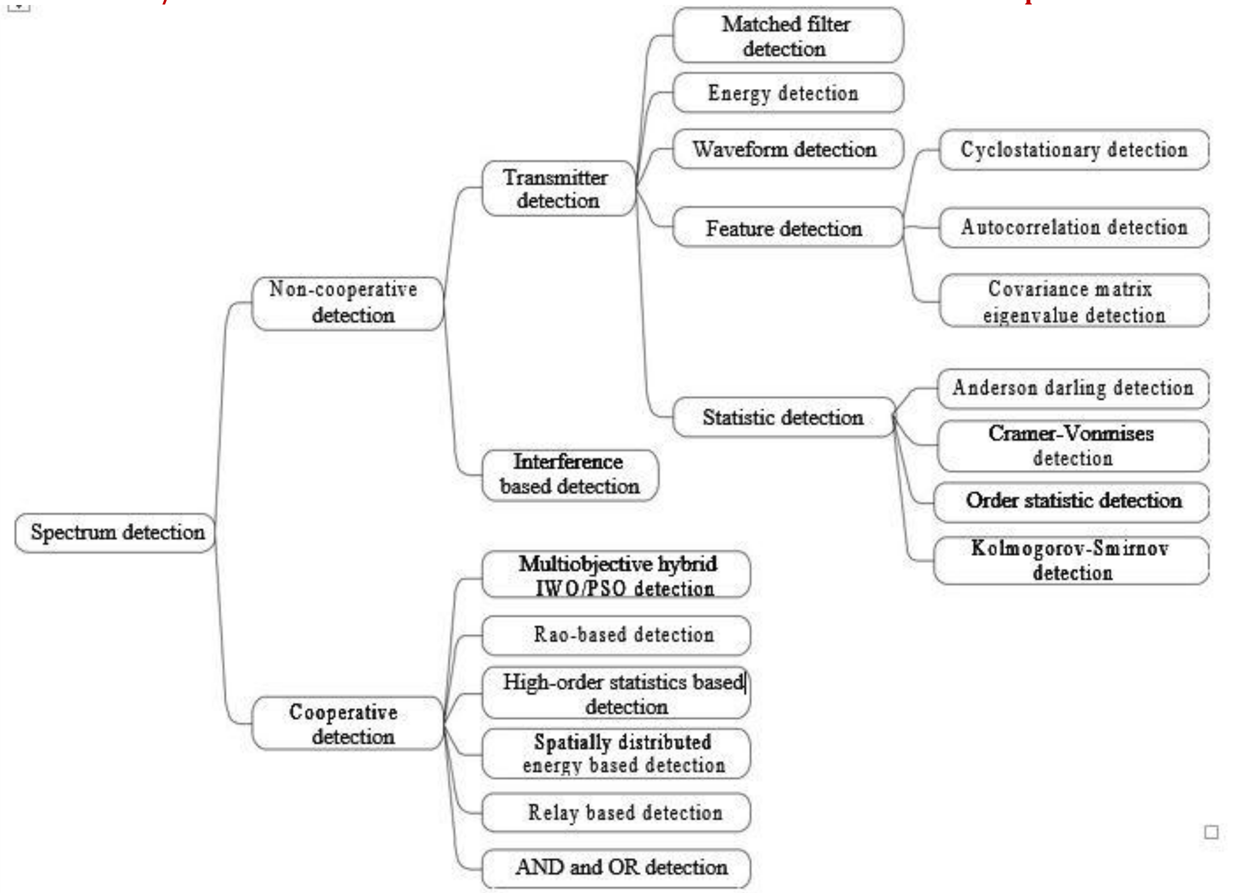

fig. 12 Spectrum detection methods

Other key enabling techniques that enhances the scenario of 5G mobile networks:

- Green Communications
- Automated Network Organizations
- Millimeter Wave Communications
- Device to Device Communications
- Full Duplex
- Relaying &Network Coding
- NOMA & SCMA

VIII. FUTURE REACH OF 5G

When it comes to the Nano-core dimension, the output of it could be drastically impeccable when it is combined with the superset of machine learning that is termed as Artificial Intelligence commonly abbreviated as (AI). A decade ago, no one has imagined that when it comes to the section of automatic messaging but with the technology originating in 2020 termed as 5G with addition to AI, this is possible. That is, when our brain will think it will automatically write our messages. Operating of robots can also be done with the Artificial Intelligence in combination with 5g.

ARTIFICIAL INTELLIGENCE + CLOUD COMPUTING + 5G = FUTURE OF MOBILE COMMUNICATION

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IX. CONCLUSION

The 5g will create a revolution in the dimension of wireless system and the upcoming future will be the changed one. As the review has illustrated, the carrying out necessity of the 5g communication scenario are Service concerning quality, Rate of data, volume, discontinuity, energy expertise.The framework of 5g is also presented in this paper, and it included the diverse technologies such as Enormous Scale Antenna-System, Network function Virtualization (NFV) cloud, Device to Device communication (D2D) etc. The Minuscule automation includes Wireless-Fidelity, Small Cell, MM Wave Communication have also been illustrated that will certainly improve the future in the technological dimension. The Progression of Wireless Transmission is also presented in this paper.

In Conclusion, We would consider that the prototype of 5G infrastructure is ongoing by now and will be launched by 2020.The 5G mobile network is defined by 8 features:

- Data Rate up to 10Gbps
- Latency of 1milli second
- 1000x bandwidth concerning per unit area
- 100x number of connected devices in comparison to 4G LTE.
- Availability- 100%
- Coverage- 100%
- Network Energy Usage will be reduced by 90%.
- Up to 10 years battery life for low powered Internet of Things devices

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