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COMPREHENSIVE ASSESSMENT OF 5G TECHNOLOGY

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Abstract

Huge advancement has been made in the field of wireless communication from 1G to long term evolution (LTE) and more. Now, the technology is trending towards a full wireless network communication system, namely 5G. The advancement in wireless network communication system as led to higher data rates and has shifted to all IP network principles. With these advancement a lot of challenges such as high peak expectations, high-data rate, low latency, reliability, mobility and low latency comes into place. Thus to get a good understanding of the upcoming 5G wireless technology we have comprehensively evaluated the 5G wireless technology and marked out the importance of this technology for the future of the wireless network communication. Now, as to make the 5G technology as efficient and powerful, a number of technologies are collaborated. Thus, to get an overview over these new technologies and concepts, we have reviewed these technologies and highlighted the main advantages of these technologies.

Keywords:Internet Protocol;Caching;target multiple access;wireless networks;

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1. Introduction

Phenomenal advancement has been made in the field of wireless and mobile technologies over the year, starting from 1G cellular network, 3G mobile network, Long Term Evolution (LTE),Wi-Fi (IEEE 802.11 wireless networks), WiMAX (IEEE 802.16 wireless and mobile networks) and now tending to futuristic fully wireless network connectivity i.e. 5G wireless network. Thus, drifting the mobile network to all Internet Protocol (IP) principles. Leading all data and call volume transmission over Voice over IP (VOIP) concept [1]. The most important and prominent motive of the next generation of network is to exploit the potential of Internet Protocol (IP), which is an unifying technology between the different Radio Access Technologies (RATs) existing today. Focusing on IP at present, individual IP address are assigned to a device to track the flow of data. But with the 5G technology the mobile devices will be assigned with a permanent care of address and their actual location can be identified by using the home IP address associated with them. Hence, once a desktop is connected to internet it can further connect with mobile phone by sending data packet to IP address of the mobile phone and as a result server present on IP address send acknowledgement packet to real location through message forwarding mechanism [2]. Also the 5G technology will be practice the use of cloud computing mechanism in their mobile phones, leading to central data repository and applications maintaining internet connectivity. The main motivation of this review research paper is to comprehensively evaluate the 5G wireless technology and to understand the latest technologies derived to make the 5G technology as efficient as it can be.

2. Concept of 5G Technology

<table>
<tr><td>Application Layer</td><td rowspan="2">Application
(Services)</td></tr>
<tr><td>Presentation Layer</td></tr>
<tr><td>Session layer</td><td rowspan="2">Open Transport Protocol (OTP)</td></tr>
<tr><td>Transport Layer</td></tr>
<tr><td rowspan="2">Network layer</td><td>Upper network layer</td></tr>
<tr><td>Lower network Layer</td></tr>
<tr><td>Data link Layer(MAC)</td><td rowspan="2">Open Wireless Architecture (OWA)</td></tr>
<tr><td>Physical Layer</td></tr>
</table>

Figure 1. *Protocol Model for 5G* [3].

2.1 Physical/MAC layers

These are the first two layers of the OSI model that defines the wireless technology. For 5G mobile network these two layers are most likely to be founded upon the Open Wireless Architecture [4].

2.2 Network layer

The network layer will have the Internet Protocol, formed by the combination of IPv4, IPv6 and Mobile IP for mobile networks in 5G. Having a combination of Internet Protocol for the network layer makes it a very versatile system that can handle severe problems such as Qos supportability, limited address space and mobility. Now, in 5G a mobile terminal will be the Foreign Agent while keeping the Care of Address (CoA) mapping between its CoA address and IPv6 address. However, a mobile terminal can be connected to more than one wireless network simultaneously [4]. So, for such a case for each radio interfaces the mobile terminal will have different IP addresses. Now, for maintaining a virtual multi-wireless network environment in the 5G mobile phones, the network layer is sub divided into two sub layers i.e. Lower network layer and Upper network layer. By doing this it gives the system to be more versatile, as their will be a middleware between the two layers that will be used for address translation between IPV4 and IPv6.

2.3 Open Transport Protocol (OTA) layer

To overcome the drawbacks of the TCP version of the transport layer, that assumes that due to network congestion the segments get lost, and due to higher bit error ratio the wireless networks gets lost. Thus, the 5G mobile terminal has been suited to have a transport layer that can be downloaded and installed as per correspondence with the specific wireless technology installed in the base station. This concept is called as Open Transport Protocol (OTP) [5].

2.4 Application layer

Presently, in mobile phones the wireless interface for internet service is manually selected by the user. But, if the mobile phones become intelligent enough to select a wireless connection by using QoS history for a service the system will be more sufficient. Thus to facilitate such intelligence into the devices, intelligent algorithms will be running in the mobile devices which

can measure QoS parameters like losses, jitter, bandwidth and store it into the in-build database, which in turn will provide the most efficient wireless connection for the user. Thus leading for a wireless network infrastructure that has low complexity and an efficient means of negotiation between the end users and the wireless infrastructure [3].

Key terms of 5G Technology:

1. It is aimed to establish complete wireless communication without almost no limitations.
2. On the go multimedia services such as television programs with high definition clarity.
3. Very high speed data transfer rates as comparable with existing wireless network.
4. Enhancing wearable devices with artificial intelligence capabilities.
5. High altitude stratospheric platform station (HAPS) systems.
6. Sharing of same spectrum by different radio technologies efficiently by adaptively using unused spectrum and adapting to the transmission technologies currently sharing the spectrum.
7. Exploiting the potential of internet protocol version 6 (IPv6).
8. Flexibility of the user to be connected to more than one wireless network and seamlessly interchange between access technologies like 2.5G, 3G, 4G, Wi-Fi or any other upcoming technologies.

3. Need for 5G

As the internet generation is growing rapidly, it is drifting towards making mobile broadband a reality. To facilitate this system High Speed Packet Access (HSPA) and Long Term Evolution (LTE) networks play a very important role. There is strong evidence supporting the increase of mobile broadband usage and the current requirements are being satisfied by LTE advance itself. Nevertheless, LTE advance provides wide range of growth for the wireless network system, it is not been used in a very effective manner by the people. Most of the industrial and commercial sector are actually using the LTE advance in an efficient manner, whereas for the common people it is only used for multimedia purposes such as downloading movie or making video calls. Thus to provide an immense way to make people feel the real development in the wireless system the introduction of 5G is necessary [6].

4. Beam Division Multiple Access (BDMA) for 5G

The biggest challenge that the mobile communication system faces is to provide advanced and flexible service to a growing number of mobile phones user in a very affordable price, as there is a limited frequency spectrum provided. Thus to satisfy the above many types of target multiple access techniques are required such as Time Division Multiple Access (TDMA), are Frequency Division Multiple Access (FDMA), Code Division Multiple Access (CDMA), Orthogonal Frequency Division Multiple Access (OFDMA) techniques, etc. However, since the use of frequency and time for the system is limited. The industry is demanding for a better technique that can harvest the other resources than frequency and time. Thus the new concept of Beam Division Multiple Access is introduced. This technique is mainly focused for the application on 5G wireless network. At the time of communication between a base station and multiple mobile stations, for each of the mobile station an orthogonal beam is allocated. Now, using the BDMA technique the antenna beam is divided according to the location of the mobile station, providing each mobile station with multiple access. Thus, considerably increasing the system capacity.

With respect to the base station the mobile station are located at different angles. Thus to transmit data with the mobile stations the base station transmits beams at different angles.

- Now, mobile station located in very less distance to each other share one beam to communicate with the base station.
- These mobile station use orthogonal resources to divide the same beam on the basis of frequency or time.
- This beam transmitted by the base station can be three dimensionally divided, to maximize the spatial reuse of frequency or time resource.
- In the initial stage of the communication between base and mobile station both do not know each other's locations. Thus, mobile station detects its location and sends the information to base station.
- Now, based on the information received by the base station from the mobile station. The base station computes a direction and width of the downlink beam.
- Then, the downlink beam is transmitted to the mobile station from the base station. As the mobile station receives the downlink beam it track down the path of the beam and sets a path for the uplink beam, which is transmitted to the base station.

Here, TDD-BDMA frame is almost identical as the FDD-BDMA frame. Except for that the mobile station information is slotted by dividing frequency resource for FDD-BDMA and time resource for TDD-BDMA [7].

5. Proactive Caching.

To satisfy the unparalleled traffic demands for wireless networks this approach gives a new and advanced solution of small cell network (SCNs) deployment, namely Proactive Caching [8]. SCNs is a novel network paradigm based of deploying low cost base stations that are short ranged and consume low power. The current small cell networking paradigm are not able to satisfy the peak traffic demands as for such problem new site are needed to be established which is quite expensive. Thus with the use of proactive caching networking paradigm which is proactive in the manner that uses users context information, anticipate users demands and have predictable capabilities to guarantee excellent quality of service and low cost, energy expenditure [9]. Thus by ingesting big data and predictive analysis into the system, the system can proactively reduce the traffic demands by serving user with predictable result [10].

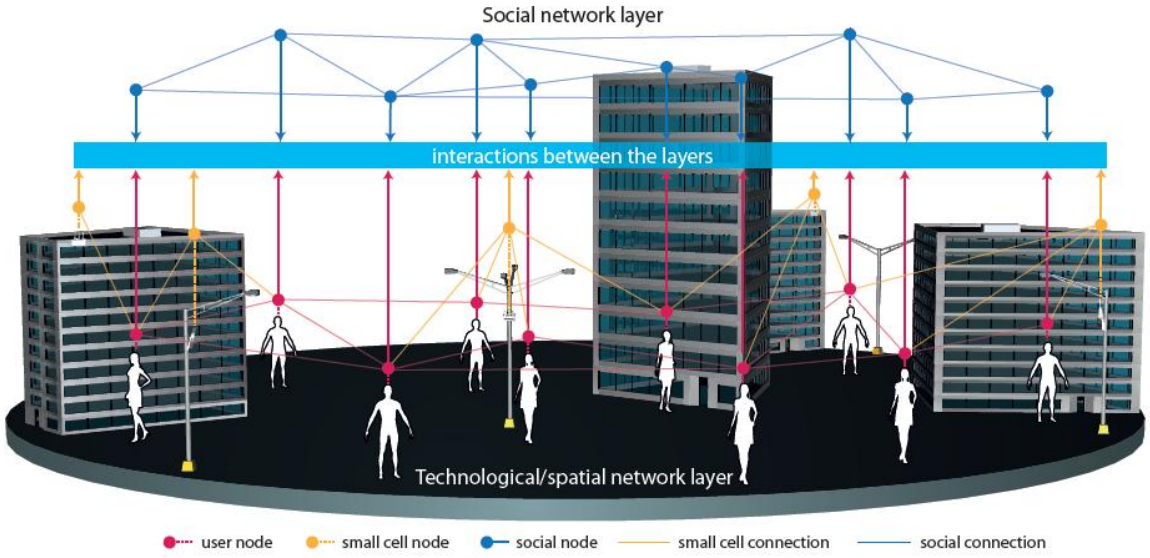

Figure 2. *Shows an abstraction of the technological/spatial network layer overlaid with the social networklayer* [11].

Further, by exploiting user context information and statistical traffic pattern the predictive capabilities of the proposed paradigm can be more efficient. Thus, by having a proactive network the network itself becomes more familiar with users demand and the data, which interns make predictable capabilities of the network more intelligent [11].

6. Mix-Bandwidth Data Path for 5G.

The convergence architecture issued by the CDMA development group for 4G in which global areas, macro cell, micro cell and pico cell are all combined as shown in figure 3. This architecture shows that in pico areas four wireless network are covered, in micro cell areas three wireless network are covered and in macro areas two wireless areas are covered. But, the issue with this architecture is that for any user at a certain location uses only one wireless network service, whereas the others wireless network resources are wasted. To overcome this disadvantage mix-bandwidth data path is designed for 5G wireless network.

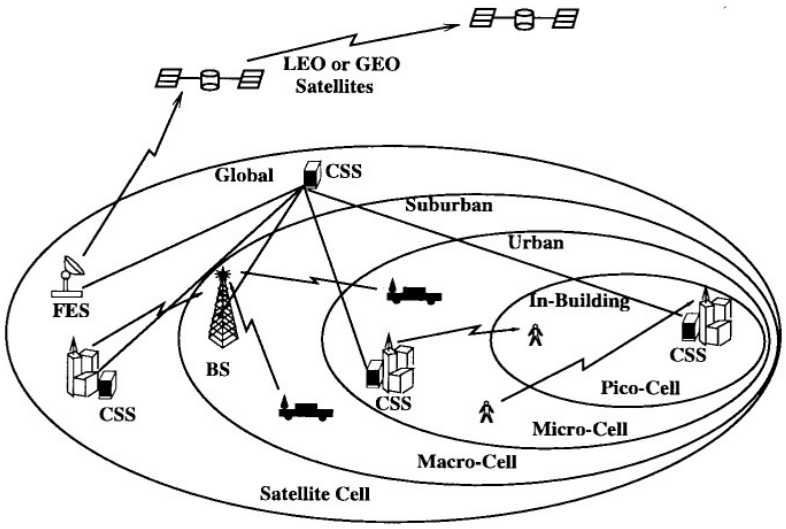

Figure 3. *4G Convergence Architecture* [12]

The designing of the mix-bandwidth data path is based on the following ideas:

1. Two different networks will support mix-bandwidth data path simultaneously.
2. Bandwidth optimization using bandwidth reselection, which make rerouting from one wireless network to another [13].

Thus, the mix-bandwidth data path model is based on overlay area of any two network, in which when a mobile device comes into the overlay region of two networks, at that time those networks will supply service to the mobile device simultaneously. Where, one network can be used for data request and the other network can be used for data reply. Accordingly, the MN request goes through the path (MN → BS → PDSN → CN) and the reply can come from the path (CN → PDSN → AP → MN) [12].

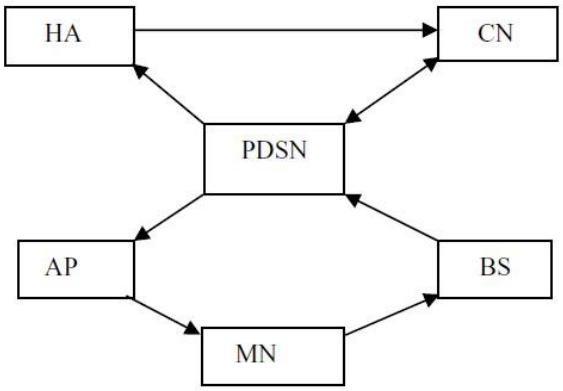

Figure 4.*Mix-bandwidth Data Path Model* [12].

Furthermore, the PCF (Packets Control Function) is used to control the data request in CDMA2000 network and PDIF (Packet Data Interworking Function) is used to control data reply in WlAN network. The mix-bandwidth data path also uses PDSN to route the data traffic from CDMA2000 network to WLAN network. But, the part at which mix-bandwidth data path lacks is that it does not considers the issues such as re-negotiated QoS, congestion relief and the movement pattern of the mobile node. Thus, mix-bandwidth data path need a detection algorithm that can support network integration in a broad level.

7. METIS PROJECT

METIS (Mobile and wireless communications Enablers for the Twenty-twenty Information Society) is a 5g project having an aim to lay down the foundation for the 5G systems. The approach over which the METIS project is build is based upon the evolution of existing technologies supplemented with the new radio concept that are adept to overcome the problem faced by the existing radio network. The collaboration of these new radio concepts such as Ultra

Dense Networks, Massive MIMO, Ultra Reliable and Moving Networks will support the 5G with the expected increase in the mobile data volume. Hence, widening the range of application domain supporting the mobile communication.

Furthermore, it is generally predicted that as the society will develop the way the mobile and wireless communication system is used will get changed. Essential day to day services like e-learning, e-banking, on-demand information and multimedia entertainment will become more mobile. These development will course to an avalanche of mobile and wireless traffic volume. Additional to that some more important applications will be imposed and these applications may require very diverse requirement over the wireless communication system that the 5G will have to support. Thus to support such huge requirements the 5G system should have the followings:

1. Wide range of data rates, up to multiples of Gbps and tens of Mbps with a very high reliability.
2. More stringent reliability and latency requirements should be necessary to facilitate applications like security, automation, healthcare etc.
3. Network flexibility and scalability is required to facilitate a large no. of devices.

Thus to satisfy all of the requirements METIS (Mobile and wireless communications Enablers for the Twenty-twenty Information Society) should not be built on the foundation of the new radio access technology which will not be able support the systems requirement.

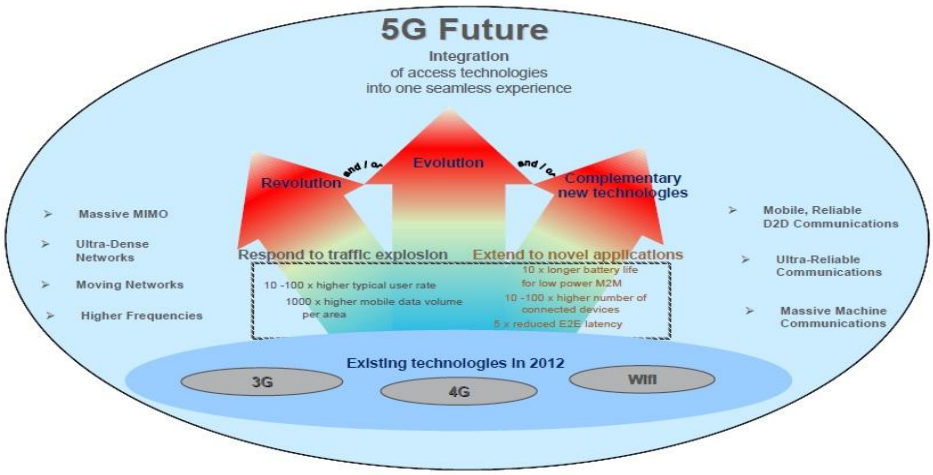

Figure 5. *Combination of evolved existing technologies* [14].

Instead, METIS is based on a combination of evolved existing technologies and new radio concepts, as illustrated in Figure 5. Thus project METIS will be able to deliver the necessary versatility, efficiency and scalability.

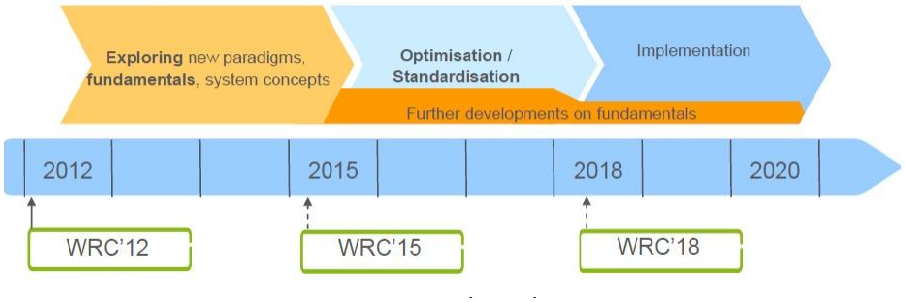

Figure 6. *Time line of project METIS* [14].

The METIS project is part is divided into three phases, as shown in the figure 6:

1. The ongoing exploratory phase which consists of laying the foundation for the 5G system.
2. The optimization phase which consists of system optimization and standardization.
3. The implementation phase which consists of precommercial trials.

The METIS project started with developing related scenarios from which requirements and vital performance indicators were deduced. Thus identifying network, multi-link and radio link issues and enabling corresponding technology components. Further, these components are being combined into a system concept and then are been examined using system-level and link-level simulators [14].

8. Conclusion

In this paper we have comprehensively evaluated the 5G wireless technology and marked out the importance of this technology for the future of the wireless network communication. The new 5G technology will bring a huge revolution in the wireless networks. The 5G mobile will have a flexible accessibility to more than one wireless technology. With the commencement of 5G technology the consumer will experience day to day services like e-learning, e-banking, on-demand information and multimedia entertainment with more efficiency and mobility. Furthermore, to make the 5G technology as efficient and powerful, a number of technologies are

collaborated. Thus, to get an overview over these new technologies and concepts, we have reviewed these technologies and highlighted the key advantages of these technologies.

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