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"5th Generation Mobile Technology" - A New Milestone to Future Wireless Communication Networks

Satya Prakash Rout

Department of Electronics and Communication Engineering, TempleCity Institute of Technology and Engineering, Bhubaneswar, Odisha, India

Abstract: ***This paper proposes a brief analysis in the future impact of 5G which has a great technology sense. It is achieved by reducingthe 5G technology to the fundamental core basically considering various scenarios like implication of this technology on mobile operators, changes in the network infrastructures and creating many commercial opportunities. This technology holds a promising growth in the applications which holds high and faster economic growth. 5G has promised to provide huge bandwidth with large coverage area to all the mobile users to play with high data rate differentiated services based on voice, video and data.***

Keywords: LTE, LTE-Advanced, 4G, QOS, WiMAX 2, High Order- MIMO, NFV, SDN, HetNets, WWAN, AMPS, WLAN

1. Introduction

The wireless networks have progressed over the past 35 years to support the rising demand of connected devices, from 1G wireless network to LTE- Advanced wireless network.The cellular system employs a different design approach than most commercial radio broadcasting and television broadcasting use [1,2]. Radio and television systems normallyoperate at maximum power and with the tallest antennas allowed by the regulatory agency of the country. In the mobile communication system, the service area is divided into cells. A transmitter is designed to serve an individual cell. The system seeks to make efficient use of available channels by using low-power transmitters to allow frequency reuse at much smaller distances.The number of times each channel can be reused in a given geographic area is the key to an efficient cellular system design. During the past five decades, the world has seen momentous changes in the telecommunications industry. There have been some extraordinaryfacets to the rapid development in wireless communications, as seen by the large expansion in mobile systems. Wireless Communication systems consist of wireless wide area networks (WWAN), wireless local area networks (WLAN) [4], and wireless personal area networks (WPAN). The mobile receivers used in all of these systems have complex functionalities, yet they have become small, lowpower consuming devices that are mass produced at a low cost, which has in turn accelerated their widespread use. The recent advancements in Internet technology have increased network traffic considerably, resulting in a rapid growth of data rates. This phenomenon has also had an impact on mobile systems, resulting in the extraordinary growth of the mobile Internet. Wireless data contributions arenow sprouting to suit consumers due to the simplestreason that the Internet has become a powerful asset and users demand data mobility. Presently, wireless data represents about 20 to 25% of all air time. While success has been concentrated in vertical markets such as public safety, health care, and transportation, the horizontal market (i.e., consumers) for wireless data is growing.

Generation	Primary services	Key differentiator
1G	Analogue phone calls	Mobility
2G	Digital phone calls and messaging	Secure, mass adoption
3G	Phone calls, messaging, data	Better internet experience
3.5G	Phone calls, messaging, broadband data	Broadband internet, applications
4G	All-IP services (including voice, messaging)	Faster broadband internet, lower latency

Figure 1: Key differences between various generations of Wireless Communication

1st Generation Wireless Communication: It is the first public wireless communication system called as Advanced Mobile Phone System (AMPS). It was introduced in the year 1979 in United States. During the early 1980s several cellular systems were introduced (TACS, NMT, C450 etc.) in Western Europe. In 1979, the first analog cellular system, the Nippon Telephone and Telegraph (NTT) system, became operational. In 1981, Ericsson Radio Systems AB fielded the Nordic Mobile Telephone (NMT) 900 system, and in 1983 AT&T fielded the Advanced Mobile Phone Service (AMPS) as a trial in Chicago, IL. Many other first generation analog systems were also deployed in the early 1980s including TACS, ETACS, NMT 450, C-450, RTMS, and Radiocom 2000 in Europe, and JTACS/NTACS in Japan.

2nd Generation Wireless Communication: Second generation (2G) digital cellular systems were developed in the 1980s and early 1990s, and widely deployed throughout the world in the 1990s. These included the GSM / DCS1800 /PCS1900 standard in Europe, the Personal Digital Cellular (PDC) standard in Japan, and the IS 54-/136 and IS-95 standards in the USA.

3rd Generation Wireless Communication: WARC approved a worldwide spectral allocation in 1982 with support of IMT- 2000 (International Mobile Telephone by the Year 2000) in the 1,885–2,200MHz band. The IMT-2000 standard was developed by the International Telecommunications Union Radio Communications (ITU-R) and Telecommunications (ITU-T) sectors. Various standards bodies around the world have provided inputs to the IMT-2000 standard definition. IMT-2000 was envisioned as an ubiquitous wireless system that could support voice, multimedia, and high-speed data communication. The ITU provided no clear definition of the minimum or average rates users could expect from 3G equipment or providers. However, it was generally expected that 3G networks would provide a minimum downlink peak data rate of 2 Mbit/s for stationary or walking users, and 384 Kbits/s in a moving vehicle. Most 3G networks today can offer peak data rates of 14.0 Mbit/s on the downlink and 5.8 Mbit/s on the uplink. IMT-2000 is actually a family of standards. Two of the standards are based on TDMA approaches, namely EDGE and Digital Enhanced Cordless Telephone (DECT). While the EDGE standard fulfills the requirements for IMT-2000, EDGE networks are typically branded as 2.5G networks rather than 3G networks. The most predominant forms of IMT-2000 are cdma2000 developed by 3GPP2 and the Universal Mobile Telecommunications System (UMTS) family of standards, which includes Wideband Code Division Multiple Access (WCDMA), developed by 3GPP. Sometimes WCDMA is used synonymously with UMTS. Mobile WiMAX (Worldwide Interoperability for Microwave Access), developed by the IEEE802.16 working group, is also included under the IMT-2000 umbrella as a 3.5G standard. WiMAX is a multicarrier scheme based on OFDMA.

4th Generation Wireless Communication: IMT-Advanced, also known as “systems beyond IMT-2000” is currently envisioned to provide even higher data rates than IMT-2000 can provide. IMT-Advanced anticipates peak data rates of 100 Mbps in high-mobility applications and 1 Gbps in stationary or low-mobility applications. IMT-Advanced is expected to have the following characteristics:

1) Flexible channel bandwidth, between 5 and 20 MHz, optionally up to 40 MHz
2) A nominal peak data rate of 100 Mbps in high mobility, and 1 Gbps for stationary environments
3) A data rate of at least 100 Mbps between any two points in the world.
4) Bandwidth efficiency of up to 15 bit/s/Hz in the downlink, and 6.75 bit/s/Hz in the uplink.
5) Spectral efficiency of up to 3 bit/s/Hz/cell in the downlink
6) Smooth handoff across heterogeneous networks
7) Seamless connectivity and global roaming across multiple networks
8) High QOS for next generation multimedia support
9) Backward compatibility with existing wireless standards
10) All Internet Protocol (IP) packet-switched network

The 3GPP Long Term Evolution Advanced (LTE-A) and IEEE 802.16e mobile WiMAX standards are often branded as “4G.” However, they do not fully comply with the IMT-Advanced requirements. In all 4G proposals submitted to ITU-R as 4G candidates, the CDMA technology that is prevalent in 3G systems has been abandoned in favor of multicarrier transmission schemes such as OFDMA. Basically, all 4G proposals are based on two technologies, (1) LTE-A as standardized by 3GPP, and (2) IEEE 802.16m as standardized by the IEEE.

2. What is 5th Generation Technology

It's a term used to describe the forthcoming fifth generation of mobile network technology.It's not a reference to any specific standard of that technology, in the way that 4G and LTE have become closely entwined. That's because no such 5G standard has yet been fully agreed upon, though a couple of likely technologies are emerging.Most of us in the India today still connect to the internet on our phones using crispy old 3G technology, while those who live in the right areas can connect via 4G.It offers download speeds that are roughly equivalent to your superfast broadband (around 30-40Mbps) at home. 5G will go well beyond that.It's estimated 5G technology will offer upwards of 1,000 times the capacity of 4G. This means that there'll be more space for everyone to access this advanced network, which should negate the need for mobile operators to throttle or limit your access to their networks. There are two types of horizons of 5G exits today:

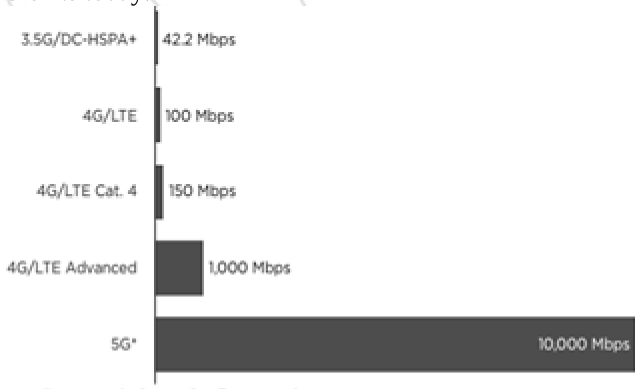

Figure 2: Downlink Speed of 5G in comparison with other generations

Horizon 1 – The hyper-connected vision: In this view of 5G, mobile operators would create a blend of pre-existing technologies covering 2G, 3G, 4G, Wi-Fi and others to allow higher coverage and availability, and higher network density in terms of cells and devices, with the key differentiator being greater connectivity as an enabler for Machine-to-Machine
(M2M) services and the Internet of Things (IOT). This vision may include a new radio technology to enable low power, low throughput field devices with long duty cycles of ten years or more.

Horizon 2 – Next-generation radio access technology*:* This is more of the traditional ‘generation-defining’ view, with specific targets for data rates and latency being identified, such that new radio interfaces can be assessed against such criteria. This in turn makes for a clear demarcation between a technology that meets the criteria for 5G, and another which does not.

Both of these approaches are important for the progression of the industry, but they are distinct sets of requirements associated with specific new services. However, the two views described are regularly taken as a single set and hence requirements from both the hyper-connected view and the next-generation radio access technology view are grouped together. This problem is compounded when additional requirements are also included that are broader and independent of technology generation.

3. Protocol Stack of 5G Technology

Application Layer	Application (Services)
Presentation Layer	
Session layer	Open Transport Protocol (OTP)
Transport Layer	
Network layer	Upper network layer
	Lower network Layer
Data link Layer(MAC)	Open Wireless Architecture (OWA)
Physical Layer	

Figure 3: Protocol Stack of 5G Technology

4. Physical Layer or MAC Layer

Physical and Medium Access Control Layer comes from the 7 layer OSI Model i.e. Physical and Data Link Layer. The two layers are completely base on Open Layer Architecture.

5. Network Layer

The network layer will be IP (Internet Protocol), because there is no competition today on this level. The IPv4 (version 4) is worldwide spread and it has several problems such as limited address space and has no real possibility for QoS support per flow. These issues are solved in IPv6, but traded with significantly bigger packet header. Then, mobility still remains a problem. There is Mobile IP standard on one side as well as many micro-mobility solutions (e.g., Cellular IP, HAWAII etc.). All mobile networks will use Mobile IP in 5G, and each mobile terminal will be FA (Foreign Agent), Application Layer Application (Services) Presentation Layer Session layer Open Transport Protocol (OTP) Transport Layer Network layer Upper network layer Lower network Layer Data link Layer(MAC) Open Wireless Architecture (OWA) Physical Layer 2013 International Conference on Intelligent Systems and Signal Processing (ISSP) 289 keeping the CoA (Care of Address) mapping between its fixed IPv6 address and CoA address for the current wireless network. However, a mobile can be attached to several mobile or wireless networks at the same time.[16] In such case, it will maintain different IP addresses for each of the radio interfaces, while each of these IP addresses will be CoA address for the FA placed in the mobile Phone. The fixed IPv6 will be implemented in the mobile phone by 5G phone manufactures. The 5G mobile phone shall maintain virtual multi-wireless network environment. For this purpose there should be separation of network layer into two sub-layers in 5G mobiles (Fig. 3) i.e.: Lower network layer (for each interface) and Upper network layer (for the mobile terminal). This is due to the initial design of the Internet, where all the routing is based on IP addresses which should be different in each IP network worldwide. The middleware between the Upper and Lower network layers maintain address translation from Upper network address (IPv6) to different Lower network IP addresses (IPv4 or IPv6), and vice versa. Fig.2 shows the 5G network layer.

6. Open Transport Protocol Layer

The mobile and wireless networks differ from wired networks regarding the transport layer. In all TCP versions the assumption is that lost segments are due to network congestion, while in wireless network losses may occur due to higher bit error ratio in the radio interface. Therefore, TCP modifications and adaptation are proposed for the mobile and wireless networks, which retransmit the lost or damaged TCP segments over the wireless link only. For 5G mobile terminals will be suitable to have transport layer that is possible to be downloaded and installed. Such mobiles shall have the possibility to download (e.g., TCP, RTP etc. Or new transport protocol) version which is targeted to a specific wireless technology installed at the base stations. This is called here Open Transport Protocol - OTP. [8]

7. Application Layer

Regarding the applications, the ultimate request from the 5G mobile terminal is to provide intelligent QOS management over variety of networks. Today, in mobile phones the users manually select the wireless interface for particular Internet service without having the possibility to use QOS history to select the best wireless connection for a given service. The 5G phone shall provide possibility for service quality testing and storage of measurement information in information databases in the mobile terminal. The QOS parameters, such as delay, jitter, losses, bandwidth, reliability, will be stored in a database in the 5G mobile phone with aim to be used by intelligent algorithms running in the mobile terminal as system processes, which at the end shall provide the best wireless connection upon required QOS and personal cost constraints. With 4G, a range of new services and models will be available. These services and models need to be further examined for their interface with the design of 4G systems. The process of IPv4 address exhaustion is expected to be in its final stages by the time that 4G is deployed. Therefore, IPv6 support for 4G is essential in order to support a large no. of wireless- enabled devices. IPv6 removes the need for NAT (Network Address Translation) by increasing the no. of IP addresses. With the available address space and number of addressing bits in IPv6, many innovative coding schemes can be developed for 4g devices and applications that could help in the deployment of 4G network and services. The fourth generation promises to fulfill the goal of PCC (personal computing andcommunication)—a vision that affordably provides high data rates everywhere over a wireless network. In the future wireless networks there must be a low complexity of implementation and an efficient means of negotiation between the end users and the wireless infrastructure.

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8. Architecture of 5G Technology

Figure 1 shows a system model that proposes design for a network architecture for 5G mobile systems, which is all-IP based model for wireless and mobile networks interoperability. The system consists of a user terminal (which has a crucial role in the new architecture) and a number of independent, autonomous radio access technologies. Within each of the terminals, each of the radio access technologies is seen as the IP link to the outside Internet world. However, there should be different radio interface for each Radio Access Technology (RAT) in the mobile terminal. For an example, if we want to have access to four different RATs, we need to have four different access-specific interfaces in the mobile terminal, and to have all of them active at the same time, with aim to have this architecture to be functional.in today's communication world, either IPv4 or IPv6, regardless of the radio access technology. The purpose of IP is to ensure enough control data (in the IP header) for proper routing of IP packets belonging to a certain application connections - sessions between client applications and servers somewhere on the Internet. Routing of packets should be carried out in accordance with established policies of the user. Application connections are realized between clients and servers in the Internet via sockets. Internet sockets are endpoints for data communication flows. Each socket is a unified and unique combination of local IP address and appropriate local transport communications port, target IP address and target appropriate communication port, and type of transport protocol. Considering that, the establishment of communication from end to end between the client and server using the Internet protocol is necessary to raise the appropriate Internet socket uniquely determined by the application of the client and the server. This means that in case of interoperability between heterogeneous networks and for the vertical handover between the respective radio technologies, the local IP address and destination IP address should be fixed and unchanged. Fixing of these two parameters should ensure handover transparency to the Internet connection end-to-end, when there is a mobile user at least on one end of such connection. In order to preserve the proper layout of the packets and to reduce or prevent packets losses, routing to the target destination and vice versa should be uniquely and using the same path. Each radio access technology that is available to the user in achieving connectivity with the relevant radio access is presented with appropriate IP interface. Each IP interface in the terminal is characterized by its IP address and netmask and parameters associated with the routing of IP packets across the network. In regular inter-system handover the change of access technology (i.e., vertical handover) would mean changing the local IP address. Then, change of any of the parameters of the socket means change of the socket that is, closing the socket and opening a new one. This means, ending the connection and starting e new one. This approach is not-flexible, and it is based on today's Internet communication

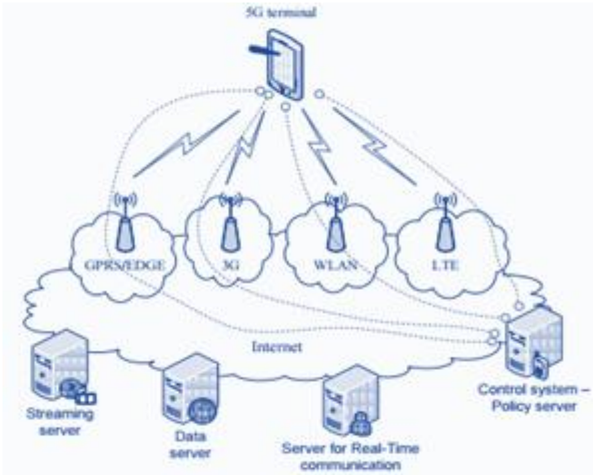

Figure 4: Architecture of 5G Technology

9. Implications of 5G for Mobile Service Providers

The progress from initial 3G networks to mobile broadband technology has transformed industry and society by enabling an unprecedented level of innovation. If 5G becomes a true generational shift in network technology, we can expect an even greater level of transformation. There are varying implications of providing an increased level ofconnectivity or developing a new radio access network (RAN) to deliver a step change in per connection performance, or a combination of the two. This means that the final design of a 5G network could be any one of a range of options with differing radio interfaces, network topologies and business capabilities. While a shift to 5G would be hugely impactful, the industry will need to overcome a series of challenges if these benefits are to be realized, particularly in terms of spectrum and network topology.While there are a number of spectrum bands which could potentially be used in meeting some of the 5G requirements identified to date, there is currently a substantial focus on higher frequency radio spectrum. Operators, vendors and academia are combining efforts to explore technical solutions for 5G that could use frequencies above 6GHz and reportedly as high as 300 GHz. However, higher frequency bands offer smaller cell radiuses and so achieving widespread coverage using a traditional network topology model would be challenging. It is widely accepted that 'beam-forming' - the focusing of the radio interface into a beam which will be usable over greater distances – is an important part of any radio interface definition that would use 6GHz or higher spectrum bands. This however means that the beam must be directed at the end user device that is being connected. Since the service being offered is still differentiated from fixed line connections on the basis.

To further enhance the mobile broadband experience for customers, operators are continuing to develop their 4G networks through the deployment of LTE-Advanced technologies. Many are also deploying technologies such as network function virtualization (NFV), software defined networks (SDN), heterogeneous networks (HetNets) and low power, low throughput (LPLT) networks. These allow different network upgrade paths and expansion of coverage through integration of broader wireless technologies, as well as potentially having a positive effect in the total cost of ownership of the network. The term 5G is sometimes used to encapsulate these technologies. However, it is important to clarify that these technological advancements are continuing independently of 5G. While these are areas that will have significant impact on the mobile industry over the coming years, explicitly including them under the term 5G has the potential to adversely affect progress in the industry between now and the realization of 5G as a commercial service.

a) Network Function Virtualization (NFV) and Software Defined Networks (SDN)

NFV is a network architecture concept that enables the separation of hardware from software or 'function', and has become a reality for the mobile industry due to the increased performance of 'common, off-the-shelf' (COTS) IT platforms. SDN is an extension of NFV wherein software can perform dynamic reconfiguration of an operator's network topology to adjust to load and demand, e.g. by directing additional network capacity to where it is needed to maintain the quality of customer experience at peak data consumption times. A number of operators have built or are building part or all of their LTE networks using NFV and SDN as the basis. These technologies in combination can potentially reduce operator CAPEX as they offer a cheaper and simpler network architecture that is easier to upgrade, while OPEX is also reduced through power savings as network capacity is only provided when and where it is needed. However, shifting from existing structures to IT-based soft functions will bring new complexities for operators in terms of network provisioning and management, as well as requiring a new skill set within operator staff.

b) Heterogeneous Networks (HetNets)

HetNet refers to the provision of a cellular network through a combination of different cell types (e.g. Macro, Pico or Femto cells) and different access technologies (i.e. 2G, 3G, 4G, Wi-Fi). By integrating a number of diverse technologies depending on the topology of the coverage area, operators can potentially provide a more consistent customer experience

compared to what could be achieved with a homogenous network. Small cell deployments are a key feature of the HetNet approach as they allow considerable flexibility as to where they are positioned; however, the use of more cells brings implications in terms of power supply and backhaul, especially when they are located in remote areas. Wi-Fi can also play a significant role in HetNets, both in terms of data offload and roaming.

10. Potentials and Applications of 5G Technology

1) Virtual Reality/ Tactile Internet

These technologies have a number of potential use cases in both entertainment (e.g. gaming) and also more practical scenarios such as manufacturing or medicine, and could extend to many wearable technologies. For example, an operation could be performed by a robot that is remotely controlled by a surgeon on the other side of the world. This type of application would require both high bandwidth and low latency beyond the capabilities of LTE, and therefore has the potential to be a key business model for 5G networks. However, it should be pointed out that VR/AR systems are very much in their infancy and their development will be largely dependent on advances in a host of other technologies such as motion sensors and heads up display (HUD). It remains to be seen whether these applications could become profitable businesses for operators in the future.

2) Autonomous driving/Connected cars

Enabling vehicles to communicate with the outside world could result in considerably more efficient and safer use of existing road infrastructure. If all of the vehicles on a road were connected to a network incorporating a traffic management system, they could potentially travel at much higher speeds and within greater proximity of each other without risk of accident - with fully-autonomous cars further reducing the potential for human error.While such systems would not require high bandwidth, providing data with a commandresponse time close to zero would be crucial for their safe operation, and thus such applications clearly require the 1 millisecond delay time provided in the 5G specification. In addition a fully 'driverless' car would need to be driverless in all geographies, and hence would require full road network coverage with 100% reliability to be a viable proposition.

3) Multi-person videoconferencing

High bandwidth data networks have the potential to make the concept of a wireless cloud office a reality, with vast amounts of data storage capacity sufficient to make such systems ubiquitous. However, these applications are already in existence and their requirements are being met by existing 4G networks. While demand for cloud services will only increase, as now they will not require particularly low latencies and therefore can continue to be provided by current technologies or those already in development. While multi-person video calling - another potential business application - has a requirement for lower latency, this can likely be met by existing 4G technologies.

4) Machine-to-Machine connectivity (M2M)

M2M is already used in a vast range of applications but the possibilities for its usage are almost endless, and our forecasts predict that the number of cellular M2M connections worldwide will grow from 250 million this year to between 1 billion and 2 billion by 2020, dependent on the extent to which the industry and its regulators are able to establish the necessary frameworks to fully take advantage of the cellular M2M opportunity. Typical M2M applications can be found in 'connected home' systems (e.g. smart meters, smart thermostats, and smoke detectors), vehicle telemetric systems (a field which overlaps with connected cars above), consumer electronics and healthcare monitoring. Yet the vast majority of M2M systems transmit very low levels of data and the data transmitted is seldom time-critical. Many currently operate on 2G networks or can be integrated with the IP Multimedia Subsystem (IMS) – so at present the business case for M2M that can be attached to 5G is not immediately obvious.

11. Conclusion

In this paper a brief discussion was made on the features of 5G Technology and its big impact on the future wireless communication arena. This Technology will provide a great milestone to high bandwidth applications by providing huge bandwidth with large coverage area. It's time to wait for the new generation to create huge impact on the mobile operators and users.

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Author Profile

Mr. Satya Prakash Rout received the bachelor degree in Electronics & Communication engineering from Gandhi Engineering College, Bhubaneswar, in 2010. He is also received his master degree in Fiber Optics and Digital Image Processing from Sri Sathya Sai Institute of Higher Learning, Puttaparthi, Andhra Pradesh in 2013. Currently, He is an Assistant Professor at TempleCity Institute of Technology and Engineering, Khurdha. His interests are Digital Communication, Computer Networks, Wireless Computing and Optical Communication system