

# 5G Technology: An Overview of Applications, Prospects, Challenges and Beyond

Maryam Fizza<sup>1</sup>, Munam Ali Shah<sup>2</sup>

<sup>1,2</sup>Department of Computer Science, COMSATS Institute of Information technology,  
Islamabad, Pakistan.

<sup>1</sup>fizzo.fm@gmail.com.

<sup>2</sup>mshah@comsats.edu.pk.

---

## Abstract

This paper provides a comprehensive overview of an emerging mobile wireless communication technology, i.e., 5G. We provide a concise view of the advancements which are currently being investigated to deploy 5G wireless technology in an effective and beneficial way. We aim to provide an easy and state of the art view of architectures, applications and challenges of the 5G technology. We group existing approaches and provide a critical overview of the underlying details adapted by the 5G technology.

---

**Keywords:** Wireless generations (1G, 2G, 3G, 4G), 5G network, architecture, coding strategies for 5G network.

## 1. Introduction

The last few decades have observed tremendous changes in communication technologies. From 1G to 4G, the area of telecommunications has seen a number of improvements along with improved performance are developed. All previous generations are different from each other due to their improved specifications. 5G technology is on its way to change the whole telecommunication history in near future [1]. Looking back at the development of the wireless communication networks from 1G to 4G, which lead the communication history at high edge.

The evolution of wireless communication is stated as “generation”, started from early 1980’s known as first generation 1G mobile wireless communication system. This generation was based on analog technology known as Advance Mobile Phone Service (AMPS). 1G has channel capacity of 30 KHz and frequency band was 824- 894 MHz [2]. This generation uses circuit switching and totally designed for voice calls without data services. After 1G, in 1990’s the 2G second generation mobile communication system was the first digital cellular system launched. This generation uses two digital modulation schemes: TDMA (time division multiple access) and CDMA (code division multiple access). Three types of advancements in wireless communication system are 2G, 2.5G and 2.75G. These are family members of second generation [2]. 2G has speed of 64 kbps with bandwidth of 30 to 200 KHz. Next to 2G, 2.5G system uses packet switched and circuit switched domain and provide data rate up to 144 kbps [3].

The third generation 3G technology introduced in the year 2000, is seen more as pre 4G. Packet Switching is the technique for data sending in 3G networks. For video chatting and for high speed internet service, this network allows 15-20MHz bandwidth at a range of 2100MHz [3]. The evolution of GSM is also a part of this generation. 3G, 3.5G and 3.75G are also family member of this generation. High speed internet service, video chatting are main advantages of 3G. A very new service in this generation is GLOBAL ROAMING is launched [4].

In early 2011, fourth generation 4G technology is presented. 4G offers a downloading speed of 100Mbps to 1Gbps. This generation focuses on additional gaming services, HD mobile TV, video conferencing and 3D Television. This generation includes wireless broad band access, Multimedia Messaging Service (MMS) and Digital Video Broadcasting (DVB) [3]. The technologies under the 4G umbrella are; LTE (Long term evolution) and Wi-MAX (Worldwide Interoperability for Microwave Access)[2, 5]. Main advantage of 4G is that 4G systems are more cheaper than previous generations as it does not require to redesign and structure the scenario, there are already tools are present so 4G is built on the top of existing network [6]. 4G provides global mobility to support different services and devices [6].

5G is the fifth Generation Mobile Technology, it would be on ground by year 2020. 5G technology has a very high bandwidth nobody experience this high speed ever before. The 5G technologies include all type of advanced features which makes 5G technology most powerful and in huge demand in near future, as it provides high speed streaming. 5G technology includes, MP3 recording, video player, large phone memory, dialing speed, audio player and much more user never imagine [3]. With the launch of 5G a new revolution is about to begin. Pico net and Bluetooth technology has made data sharing very easy and accessible by everyone who connected with 5G [1].

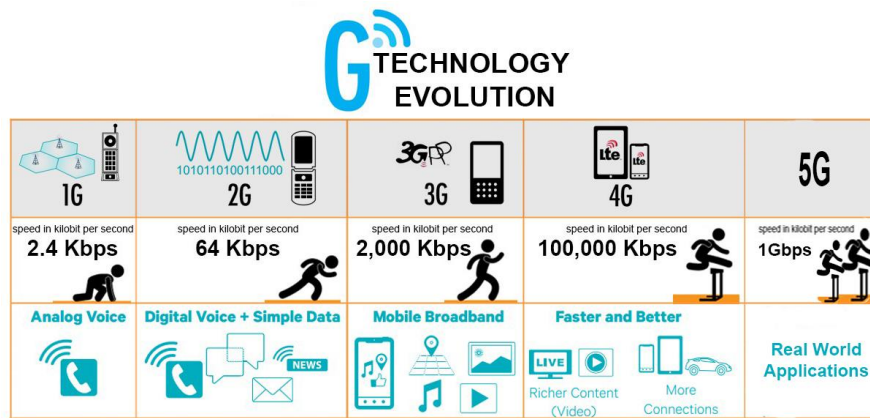


Fig. 1. Wireless Communication Technologies

In Fig. 1, all wireless technologies and their evolutionary measures are shown which also presents a better picture of the advancements in the wireless technology.

The existing research does not provide a critical analysis of the available wireless generation’s protocols and techniques to differentiate from each other. This lack in existing literature motivated us to write a review paper in which we could provide detailed analysis and overview of the latest emerging wireless technology, its architecture, feature and challenges that could help us to understand the new wireless schemes. The rest of the paper is organized as follow. Section 2 presents the related work where we review features, future and need of the 5G technology. The architectural details have been provided in Section 3. Section 4 summarizes salient features of the 5G technology. The upcoming technologies such as 6G and 7G are briefly discussed in Section 5. The paper is concluded in Section 6.

## 2. Related Work

The whole world practices the different wireless communication and mobile networks, the end-user experiences the enhanced capabilities of each new generation and developers design each generation to satisfy the end-user.

### 2.1. 5G Technology

Few decades back, there are remarkable changes in the telecommunications industry. Different wireless communication technologies from 1G to 4G, all these technologies differ from each other based on four main aspects: radio access, data rates, bandwidth and switching schemes. Now all these previous generations expanded the way to explore the most advance cellular technology that is 5G [7]. The whole history of wireless technology has changed just because the launch of 3G, 4G and 4G-LTE. A 4G system provides wireless access to users on an "Anytime, Anywhere" basis and at much higher data rates compared to previous generations. LTE and LTE-Advance, main requirement specifications are: Higher average user throughput and Optimized coverage and deployment in local areas[7].

Besides all benefits from 4G, another revolutionized 5G (Fifth Generation) mobile network is seen as user-centric concept instead of operator and service-centric. The main focus of 5G is keep the end user on top of all. Error-control schemes, radio and modulation schemes are defined in 5G networks. Due to its high bandwidth the usage of cell phones are totally change nobody can imagine this revolutionized changes. After the launch of 5G, a revolution is going to start in the whole mobile market. Some modified schemes such as Software defined radios, modulation and error control schemes are involved to enhance the end user terminal, as a main focus of 5th generation mobile network. Through 5G mobile network terminal, it is possible to access different wireless technologies at the same time[8]. In short, the evolution of wireless and cellular systems focusing on the four main key factors: radio access, data rates, bandwidth and switching schemes that leads the additional

change in network architecture[9]. We continue our discussion on vendors of the future wireless technologies;

Nokia: The Nokia shows greater interest on mobile communication evolution for 5G beyond 2020 for larger traffic volume and higher data rates [10].

Intel: Intel’s mobile and wireless group defined a specification for 60 GHz as a local-area network. The team is researching 28 GHz and 39 GHz as access links to mobile devices [9].

Samsung and Hawaii: Samsung is more suitable for modification because satellite services are easily implemented by Samsung so in launch of 5G, Samsung is much interested [9]. All these companies looking at technologies that are 1000 times faster or speed from traditional technology [11].

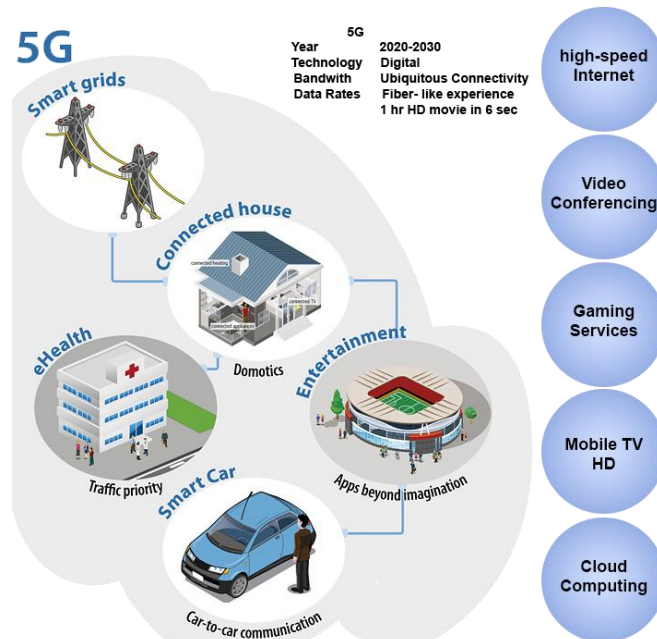


Fig. 2. 5G-Wireless Communication Technology [23]

In Fig. 2, features of 5G are shown that more elaborate necessity of 5G as it provides additional features as compare to its previous technologies.

## 2.2. Need of 5G Wireless Technology

This section of the paper focuses on how a 5G network can provide facilitate environment to a common man. A comparison between generations is provided for better understanding the features of 5G technology. Although LTE provides a circumstances to people that are benefited by effective wide range of present wireless communication technology. Generally LTE is used in commercial areas, it’s not create an environment for a common man who can easily download a movie or do video call, in fact it is a bottlenecked for real time applications. This main cause leads the inventors to design or launch a new wireless technology as 5G emerging technology, which overcome all these previous issues.

5G becomes a basic necessity now a days because of higher growth in video grabbing, minimize the energy requirements and for higher speed data rates. As the presence of 4G, to satisfy the end user 5G provides higher speeds, lower battery consumption and better coverage with wide range [12]. 5G technology has a big platform because it offers their customers ease of use fact. As switching scheme is used in 5G for data transfer, router and switches are also used in 5G network to provide high and better connectivity between nodes. Nodes within buildings ca easily be connected together by 5G network architecture. When 5G technology launch it provides very high speed of data transfer up to 1Gbps [12].

The 5th generation technology is real wireless world network. 5G technology provides a facility of worldwide cellular phone service, in which user can get access to any other country just with a local phone set. 5G creates an environment in which limitations did not exist [12]. One possible area of 5G study is to explore higher carrier frequency, such as millimeter-wave bands (30 to 300 GHz) Two salient features of the millimeter-wave bands are large amounts of bandwidth, enabling very high in coverage throughput, and very small wavelengths enabling a large number of tiny antennas in a given device area [13].

### 2.3. Features of 5G Technology

As 5G is a user centric approach, so to satisfy and facilitate the consumer the key features of 5G are discussed below [7]:

- 5G wireless network is a real wireless world with no limitations [8].
- HD TV is a most fascinating feature of 5G as it provides multimedia features [8].
- Increased data rates as compared to previous generations.
- MIMO and multiple carrier transmission schemes are used for shorter active time of device [14].
- Lower battery consumption is another main goal of 5G technology.
- Efficient security approach to secure communication is possible in coming technology.
- A 5G technology is a way that provide artificial intelligence capabilities to users.
- Smart radio technology to share unused range/bandwidth is a part of 5G networks.
- High resolution applications and large bandwidth can be possible in coming network technology.
- Error control mechanism is a part of 5g networks.
- Remote management environment is presented in 5G for user ease.
- As 5G is totally related with its improved speed so 5G crossing the speed limit for uploading and downloading.
- It provides ubiquitous computing as user can simultaneously access the different wireless technologies like (3G, 4G, and 5G) [7, 15].
- The 5G technology is providing up to 25 Mbps connectivity speed [16].
- Large transmission range by introducing 5G networks [10].
- Worldwide roaming is easily possible in coming technology [16].
- There are smaller number of antennas used in 5G to employ single-user that is fit for current standard of cellular communication [17].

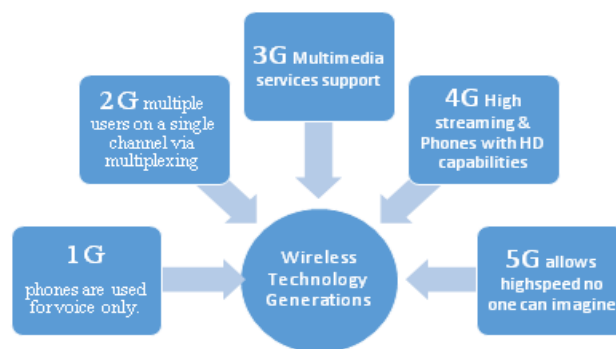


Fig. 3. Features of Wireless Communication Technology

### 2.4. Challenges in Conversion of wireless network 4G to 5G

There are many challenges are occur in migration a 4G wireless network into a coming 5G network. As some are following:

- One of the main challenge to migrate from 4g to 5G is high operational cost because cost is directly related to energy consumed for transmission. To overcome the cost of 5g network is to make the wireless communication technology must be energy efficient [12].

- 5G wireless technology can decrease the transmit energy per bit, but it cannot reduce the operating energy [12].
- In 5G wireless networks, power utilization problems occur in this scenario in which a single terminal that can be operate in different wireless networks [8].
- Wide range and high operability cause a security issue in coming wireless technology [18].
- By using software radio approach, user can access different wireless networks without any restriction of size and cost of device which is much trouble some in previous technology. This leads some security issues in 5G environment.
- It is hard to handle user account information from many service providers. Bugs can be occur during introducing new features of software applications.
- Criminal attacks can be possible in the case of signal transmission that are send from fake in vendor. Data Encryption can be used to avoid this situation [8].
- Wireless networks are relatively less secure than wired network because of easier access of unauthorized persons. So this issue is also present in 5G technology, this can be overcome by using several algorithms of security [19].
- Current 5G technology is focuses on EE (energy efficiency) because it is the main problem to shift wireless LTE into 5G [14].

### 3. 5G Architecture

In 5G wireless network concept, it is remarkable initiative that user terminals are main focus of 5G mobile network. The terminal have access to different wireless technologies at the same time and it can also combine some features or aspects from other technologies. 5G totally focused on user-mobility as a mobile phone or terminal intelligently behave to choose stronger wireless scheme to access wireless networks [18].

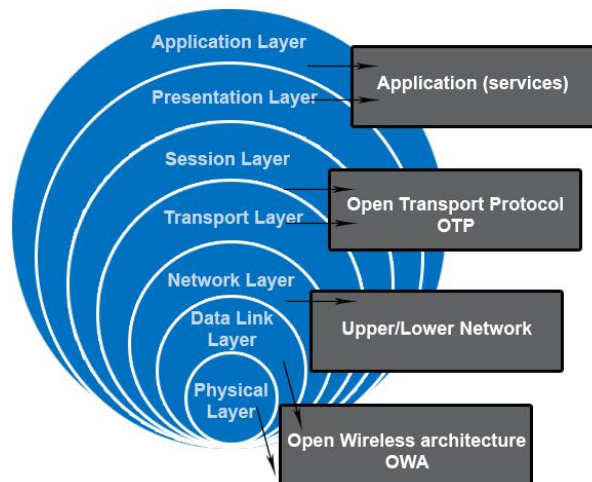


Fig. 4. Layer Stack of 5G

#### 3.1. Physical/MAC Layer

As it is already a standard that top two OSI layers are define as a network environment so now in the case of 5G these two layers define as wireless technology and 5G mobile network is based on open wireless architecture [18].

#### 3.2. Network layer

The network layer is an IP (Internet Protocol). The IPv4 (version 4) is worldwide spread and it has several problems such as limited address space. These issues are solved in IPv6. All mobile networks will use mobile IP in 5G so a mobile can be attached to different wireless networks concurrently. In this scenario different IP addresses must be maintained for each interference [12].

### 3.3. Open Transport Protocol (OTA) layer

The TCP retransmit the lost or damaged TCP segments over the wireless link. In 5G it is important because higher download and installed speed.

### 3.4. Application Layer

5G mobile network provide intelligent behavior to pick a network that selects the best wireless connection for a given service from different networks. In this layer, terminal have access to quality testing and information storage in terminal databases. In 5G mobile phones, different algorithms are used to mold the terminal in intelligent behavior. To switch-in into the different networks there must be number of IP addresses required, IPV6 reduces this issue with the use of effective coding schemes that could help he development of 5G network.

Although all these benefits of IPV6, coming wireless generations open a gateway of IP based network innovation [8].

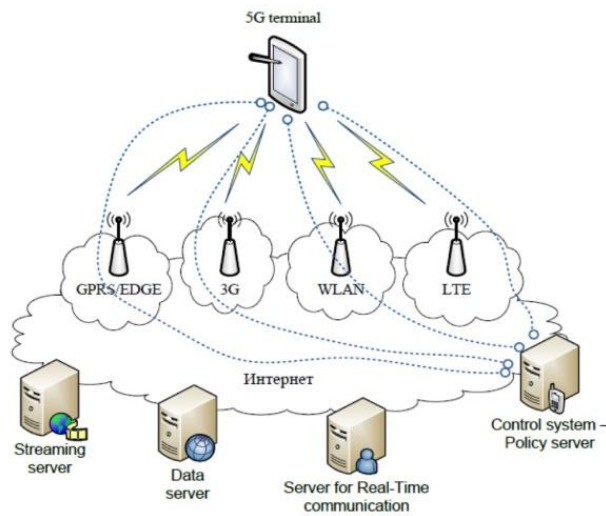


Fig. 5. 5G Architecture[3][20]

In Fig. 5, functional architecture of 5G mobile network is shown. It also presents IP based model of wireless network. The basic scenario is that there is a user terminal and more than one independent radio access technologies. In this architecture, to access the four different mobile terminals, there must be four different access interfaces present between mobile terminals and all must terminals must be active at the same time, so this architecture will be functional [20].

## 4. Comparison and Evaluation

In last year 4G is launched in several countries in Europe and North America and also in some of the Asian countries. In 4G, LTE and WiMAX are two different technologies are implemented. Whereas 5G is a concept only and not officially defined but it is refer to as extended speed instead of 4G. Table 1 shows a comparison of 4G with 5G, how these two technologies are different from each other and which services and schemes are involve in these two networks to make them different and reliable from other one. As this figure shows that 5G is proposed more speed than 4G and provide real applications and AI capabilities from 4G, to prove that coming technology is better than previous.

Following is the comparison table between features of 4G and 5G, this table defines when 4G and 5G have launched and what kind of services they provide and which standards they define.

Table 1. Comparison of wireless generations [6, 21]

Features	4G	5G
Idea Starts	2000	2015
Implementation	2010	2020
Frequency	200 Mbps [6]	1 Gbps or more [20][6]
Services	IP based network, high speed up to 100 MBs[6]	Dynamic information access, Devices with AI capabilities [6]
Standards	IP based LAN/WAN/PAN [20]	IP based LAN/WAN/Pan & WWW[20]
Multiplexing	MC-CDMA, OFAM [20]	CDMA[20]
Technology	LTE, WiMAX [20]	IPv6 [20]

## 5. Future Technologies 6G and 7G

For global coverage, 6G will assimilate all wireless mobile networks by use of satellites. 6G mobile communication networks can incorporate satellite communication networks and 5G to make global coverage[2]. 6G is totally related to satellite communication networks consist of navigation, telecommunication, and Earth imaging satellites networks. These satellite networks are used for global position, global telephony, multimedia video and for earth imaging to monitor weather information. USA, China, EU, and Russia developed these satellite systems. As 6G is not launched yet due to some issues like roaming problem because different satellite systems have different standards so roaming must be between all these networks but it is still a debatable issue[2, 21]. 7G wireless network is a modification of 6G but it also defines satellite functions for mobile communication. Satellite system provide voice and multimedia communication, global positional system (GPS) and weather update information[2, 15]. There are also some issues in 7G like if mobile phone is moving from one country to another then satellite also moving with constant speed. 7G will be launched with enhanced and improved protocols so that everyone enjoys the global communication environment [16, 22].

### 5.1. Evolved Packet Core (EPC)

In IP world of wireless connection, EPC (Evolved Packet Core) is introduced which is IP-based network architecture used in 3G and LTE and now going to be used in 5G. The goal of EPC is to provide all IP architectures behave efficiently to perform various services. EPC is based on flat IP network. The flat IP architectures have emerged with WiMAX, LTE and future networks [12].

## 6. Conclusion

The existing 4G wireless technology has been successfully launched in different countries of the world. The main features and characteristics of the 4G technology are being analyzed and enhanced for the inclusion in the upcoming 5G technology. The 5G architecture makes use of different platforms and different layers. In this paper, an overview of emerging 5G wireless technology is provided. For better understanding of the 5G, all the previous generations are also discussed in the paper. The performance comparison table presents the user centric approach of different generations of the wireless technology. Furthermore, main features, goals and challenges of 5G form part of this paper. As 4G is already launched, the researchers need to focus on the successful development and deployment of the 5G technology by year 2020. 5G network architecture shows the difference of different wireless generations. This paper also highlighted the IP based networks like IPV4 and IPV6, which used in previous generations. We also discussed different features and benefits of the 5G technology which will make the user convinced to adapt the technology. In future, we will explore the wireless technologies which will be used in the year 2030 such as 6G and 7G.



## References

- [1] S. Patil, V. Patil, and P. Bhat, "A Review on 5G Technology," in *International Journal of Engineering and Innovative Technology (IJEIT)* vol. 1, no. 1, pp. 26–30, 2012.
- [2] E. M. Farooq, E. Muhammad, I. Ahmed, and E. U. M. Al, "Future Generations of Mobile Communication Networks," no. October 2012, pp. 15–21, 2013.
- [3] M. G. Kachhavay, "5G Technology-Evolution and Revolution," vol. 3, no. 3, pp. 1080–1087, 2014.
- [4] M. Tuteja, S. Gujral, and B. Kaur, "Redefining Wireless Technology with Spectral Efficiency," vol. 1, no. 4, pp. 257–263, 2014.[5] K. Kumaravel, "Comparative Study of 3G and 4G in Mobile Technology," vol. 8, no. 5, pp. 256–263, 2011.
- [6] A. H. Khan, M. a. Qadeer, J. a. Ansari, and S. Waheed, "4G as a Next Generation Wireless Network," *2009 Int. Conf. Futur. Comput. Commun.*, pp. 334–338, Apr. 2009.
- [7] S. Hossain, "5G Wireless Communication Systems," no. 10, pp. 344–353, 2013.
- [8] A. Gohil, H. Modi, and S. K. Patel, "5G technology of mobile communication: A survey," *2013 Int. Conf. Intell. Syst. Signal Process.*, pp. 288–292, Mar. 2013.
- [9] A. M. Mousa, "Prospective of Fifth Generation Mobile Communications," *Int. J. Next-Generation Networks*, vol. 4, no. 3, pp. 11–30, Sep. 2012.
- [10] S. K. Mohapatra, B. R. Swain, N. Pati, and A. Pradhan, "Road Towards Mili Meter Wave Communication For 5G Network: A Technological Overview," *Trans. Mach. Learn. Artif. Intell.*, vol. 2, no. 3, pp. 48–60, Jun. 2014.
- [11] W. Chin, Z. Fan, and R. Haines, "Emerging technologies and research challenges for 5G wireless networks," *IEEE Wirel. Commun.*, vol. 21, no. 2, pp. 106–112, Apr. 2014.
- [12] R. Talukdar and M. Saikia, "Evolution and Innovation in 5G Cellular Communication System and Beyond : A Study."
- [13] N. Bhushan, J. Li, D. Malladi, R. Gilmore, D. Brenner, A. Damnjanovic, and R. Teja, "Network Densification : The Dominant Theme for Wireless Evolution into 5G," no. February, pp. 82–89, 2014.
- [14] M. Lauridsen, G. Berardinelli, T. B. Sørensen, and P. Mogensen, "Ensuring Energy Efficient 5G User Equipment by Technology Evolution and Reuse," no. DI, 2014.
- [15] S. Singh and P. Singh, "Key Concepts and Network Architecture for 5G Mobile Technology," vol. 1, no. 5, pp. 165–170, 2012.
- [16] A. K. Pachauri and O. Singh, "5G Technology – Redefining wireless Communication in upcoming years," vol. 1, no. 1, pp. 12–19, 2012.
- [17] R. R. Choudhury, "A Network Overview of Massive MIMO for 5G Wireless Cellular : System Model and Potentials," vol. 2, no. 4, pp. 338–347, 2014.
- [18] M. A. Javaid, "5G Technologies: Fundamental Shift in Mobile Networking Philosophy," *SSRN Electron. J.*, 2013.
- [19] M. Popescu and N. E. Mastorakis, "New Aspect on Wireless Communication Networks," vol. 3, no. 2, pp. 34–43, 2009.
- [20] A. Tudzarov and T. Janevski, "Functional Architecture for 5G Mobile Networks," vol. 32, pp. 65–78, 2011.
- [21] S. Mondal, A. Sinha, and J. Routh, "A Survey on Evolution of Wireless Generations 0G to 7G," pp. 5–10.
- [22] B. Bhattacharyya and S. Bhattacharya, "Emerging Fields in 4G Technology , its Applications & Beyond-An Overview," vol. 3, no. 4, pp. 251–260, 2013.
- [23] "Towards 5G Digital Agenda for Europe European Commission." Available Online <https://ec.europa.eu/digital-single-market/>, Last Accessed 15 November, 2015.