Mathematical Statistician and Engineering Applications
ISSN: 2094-0343
2326-9865

Challenges and Research Opportunities for Next Generation Mobile Communication Network: A Status Review

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Article Info
Page Number: 1972 – 1981
Publication Issue:
Vol. 71 No. 3s2 (2022)

Abstract: In this article, the study has been done for main challenges and opportunities to work with 5th generation (5G) mobile communication network. The next generation wireless networks should be robust, scalable and energy efficient while providing the high-quality and low-cost services to the consumers. The market for high-quality telecommunication networks and software is increasingly exhausting wireless spectrum capacity. The industrial scientific and medical (ISM) bands are facing the increased channel demand and contention, which results in a spectrum scarcity. The spectrum demand utilization and techniques such as use of multi radio Access technology (RAT), multi-antenna(MIMO), multi-carrier schemes, machine learning and most optimized power management algorithms are considered in the design of next generation network typologies like long term evaluation(LTE) and 5G. However, with all the aspects to handle these emerging demands better utilization of spectrum and recourse allocation techniques is the development area for the next generation wireless network designs.

Keywords: 5G, ISM, LTE, RAT, MIMO, MM.

Article History
Article Received: 22 April 2022
Revised: 10 May 2022
Accepted: 15 June 2022
Publication: 19 July 2022

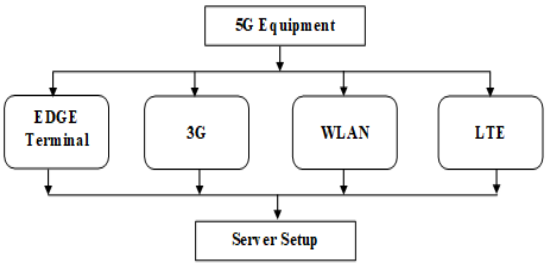
1. Introduction

5th Generation (5G) mobile network is the extensive revolution in the field of mobile communication for getting higher data rates, the improvement in data rates, speed of operation and coverage area are much beyond the expectations of individuals [1]. The meaning of cell phone usability changed of the future generation network by the

ultra-high-speed operational capability [2]. The next generation wireless networks should be robust, scalable and energy efficient while providing the high-quality and low-cost services to the consumers [2].

The next generation of mobile networking standards promises to enhance end-user experience by providing the extremely high data rates and coverage with low latency and improved overall performance in terms of spectral efficiency and node handing network capacity [2]. An improvement in spectral efficiency depends on the data rate with energy used by the particular node to get the optimum solution an algorithm where higher energy consumption with more energy efficient network utilization needs to be deployed; 5G enables the services offered by long-term evaluation (LTE) in more systematic way, as well as bringing new revenue opportunities for the telecom filed by leveraging new solutions that LTE couldn't provide to the society [3].

The significant options of 5G are wider multimedia system choices, zero latency, quicker time interval, superior sound and high-definition (HD) video streaming capability without compromising with the standards and quality of audios and videos. The figure 1 shows the network architecture, the model designed for the wireless and mobile networks by were discussed in [1].



Each of the radio technologies is considered separately because the IP link deals with the external internet world. The IP addressing based systems make sure the adequate control of data frames for appropriate routing of IP packets associated with particular user connections. The figure 2 shows the protocol architecture of 5G where the application layer contains the set of protocols that prominence on process-to-process communication across an IP network and provides a fixed communication interface and services.

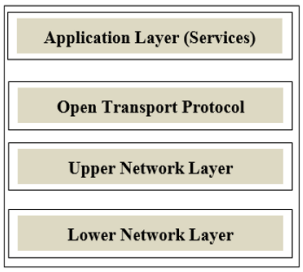


figure 2 5G Protocol Architecture

Network layer define the routing path in the network and is categorized into two sub layers i)

Lower and ii) Upper [4]. Open transport layer performs the operation of managing the different sessions with transparent transfer of information between the nodes, despite the applications, several challenges were addressed by Xiaofei Wang et. al. [4] and Tianqing Zhou et. al. [5] discussed the design constrains of efficient 5G network as summarized; Reduction in interference expecting high demand to work with next generation wireless network [4,5]. Effective traffic shaping for better congestion control and improvement in data rate [4,5]. Extensive implementation of various modulation schemes for enhancing throughput [4,5]. Effective power management scheme to enhance the efficiency [4,5].

In this paper the focus is given on the comparative study of design methodology and the outcomes to provide the solution to accommodate the spectrum demand. Moreover, use of various techniques such as deployment of multi-antenna, multi-carrier schemes are defined. With all these aspects to handle these demands, still better utilization of spectrum and recourse allocation techniques is the key concern for the next generation wireless network designs. The power optimization to design energy efficient network and improvement in coverage area are the challenges that 5G networks expecting to resolve is addressed in this paper. The paper is organized in three different sections. The first section deals with the details of 5G architecture, second section deals with the important aspects of 5G protocol and the last section gives the literature review, followed by the features of 5G and key challenges while designing the 5G network.

Table 1 shows the detailed literature review of design of energy efficient and improvement in performance of 5G networks [6-31].

Table 1 The detailed literature review of design of energy efficient and improvement in performance of 5G networks

Outcomes	Ref.
The detail discussion on how 3GPP and LTE promise the requirement of high-speed data rates and related applications.	[6]
This paper gives a review of versatile communication technologies grew up until this point and furthermore illuminates what would we be able to anticipate from the eventual fate of portable world.	[7]
The importance of understanding receiver characteristics when constructing resource distribution schemes for next-generation mobile networks discussed in this paper.	[8]
Requirement of the ICT industry while	[9]

considering use in future generation network.	
The different multiplexing schemes GFDM, UFMC and FBMC are presented. The comprehensive taxonomy of HetNets AI-based techniques is shown by examining the pros and cons of various AI-based techniques for different HetNets problems.	[10]
The paper gives basic ideas of supervised, unsupervised and reinforcement learning with their comparative study.	[11]
5G associated handovers problems is discussed.	[12]
A comprehensive investigation and a survey of the 5G network and its vision with respect to the smart grid is exhibited,.	[13]
Background information on new licensing models as well as summary of a recently completed DSA standard. Network management systems and the various architectures that have been proposed for providing legacy user security.	[14]
Effective radio resources management, mobility management and required services provisioning management are presented in this paper.	[15]
Spectrum management issues discussed in this paper and these issues will need to be addressed by equipment and network designers in consultation with policy makers, for guarantee success.	[16]
The paper presents an energy-efficient model for 5G heterogeneous networks and proposed considerations for both the access and backhaul network element.	[17]
Different design issues for CRAN in 5G	[18]

and beyond networks discussed in this paper also this paper gives future directions to solve these issues discussed.	
In this paper, a receiver system for a cooperative multi-relay system with NOMA in cellular networks is presented. The results compared with proposed and existing algorithms with SR and outage probability.	[19]
An implementation and significant use of massive MIMO is carried in this papers.	[20]
Different channel losses and hardware implementation issues case studies elaborated for designing of efficient 5G network	[21]
NOMA structure power optimization problems discussed and handled in this paper	[22]
Small cell architecture defines in this paper is having the issue at high frequency signals having low magnitude level hence drop in call occurs.	[23]
How the beamforming is the most suitable solution to avoid channel interference is defined in this paper.	[24]
Important of cloud services and their efficient use to improve the routing strategy explained in this paper.	[25]
Comparison of different cloud parameters with different cloud methods is deliberately done in this paper.	[26]
In this paper, the novel algorithm based on integrated machine learning and coordinated beamforming strategy which enables highly mobile applications. It focuses on the deep learning model an, Omni-received uplink pilots and the beam training result.	[27]

Different ML approaches to wireless communication and traditional approaches together with their performance comparison with ML based approaches discussed. Afterwards the focus is given on ML based paradigms, open data sets and platforms for researchers and theoretical guidance for ML implementations.	[28]
This paper proposes the combined implementation of massive MIMO beamforming and low band up-link to allow similar coverage to be provided for the 5G downlink at 3.5 GHz as for the existing LTE at 1.8 GHz.	[29]
This paper elaborates that the DSS provides full benefits when combined with SA architecture for maximum coverage and new 5G services and with CA for maximum 5G data rates.	[30]
This paper focuses on the potential solutions for 5G from an ML-perspective. It elaborates the fundamental concepts of supervised, unsupervised, and reinforcement learning.	[31]

From table 1, it is seen that to understand the receiver characteristics while designing the network is very important and the handover issues need to address properly [10]. The use of Massive Multiple Input Multiple Output (MIMO) and Non-Orthogonal Multiplexing (NOMA) with machine learning approaches for deciding the routing strategy will definitely improve the performance of 5G Network [19].

5G Architecture

The 5G technology compatible mobile phones are available in the market still the 5G structure is in investigational state [13]. The spectrum range is defined from 30 GHz to 300 GHz which is considered as millimeter waves, the millimeter (MM) waves less used and new band available for next generation mobile communication [14]. The high frequency wave carries the maximum data at higher speed. This structure distinguishes the performance of MM waves than the others type of frequencies [14]. It is possible to design massive MIMO structure using

the MM waves, the massive-MIMO concept uses the large number of antennas at the base stations to serve the different user interface nodes/terminals, which improves the overall coverage area capability of the next generation mobile communication network. A survey on massive MIMO deals with the presence of different channel losses [20] where as hardware implementation issues case studies elaborated in [21]. To resume the spectrum for increasing the network capacity the small cell network is utilized [13]. The implementation of small cell network is easy and less complicated process; the small cell architecture has issues of fluctuations in the signal strength due to obstacles as the high frequency signal have low magnitude. So, it is difficult to pass these hurdles and hence loss of connection takes place [23]. Beamforming is the key enhancement used in the 5G as in 4th Generation (4G) the transmitted signal is not Omni-directional. Thus, the signal tends to lose its energy more quickly, to make thing worse different, users might get interface with each other if they are standing close to each other which the transmission between user and base or cell station more directional and it can be visualized as laser beam communication between the cell station and user terminal [24]. The higher density of beamforming tends to less interference and less energy consumptions and thus faster data rates can be achieved [29].

The traditional multiple access techniques fail to get the good results for next generation mobile commutation. Hence the novel solution NOMA will used to get the good spectral efficiency low latency with high coverage area as discussed in [18]. NOMA allows to share the frequency, time and code within the multiple nodes for individual operations it also allows to use orthogonality in the power levels of nodes which precisely solve the power optimization problems as discussed in [19,22]. Most of the applications hosted through cloud computing by dealing with mobile edge computing. To share different frameworks and data, cloud computing is used, various services applications for the end users and the hardware along with system software can be shared with cloud so, ultimately cloud providers give better control over the different shared resources [25]. The different cloud methods and their parameter perspective applications briefly discussed [26]. In comparison to radio technologies, 5G has advancement such that practically possible to avail the super speed from 1 to 10 Gbps, Latency of 1 millisecond (end-to-end round trip), 1000x bandwidth per unit area, feasibility to connect 10 to 100 numbers of devices, worldwide coverage and bout 90% reductions in network energy usage with much longer battery life of node [1].

Novel ideas to address challenges of 5G:

- Minimization of power under Signal to Interference Noise Ratio (SINR) by adopting the use of multiple antennas at transmitter end. Massive MIMO used to enhance the connectivity of network while designing the M-MIMO one has to take care regarding the mapping of antennas installed and requirement of network. Extensive use of beamforming enables the faster connectivity and reduce the inter channel interferences. In beamforming, the light wave directed between the node and antenna.

- Effective traffic shaping is another concern to enhance the capability of 5G network. Routing optimization like advanced JAYA, PSWA and Hybrid algorithms in association with effective machine learning approach leads to enhance the routing performance.
- NOMA architecture to improve the throughput and compensate with the desired power levels.
- Optimum power and spectral efficiency improvement can be done using M-MIMO with sharing circuit power adoption strategy and suppressing the interference within the channels along with use of small cell architecture.

Conclusion

In this paper, 5G technology protocol architecture, the key challenges and novel methods to solve problems associated while designing the 5G networks were discussed. The deployment of effective utilization of radio recourses, traffic offloading strategy using systematic approach is proposed to solve the issues related to the quality of services and energy efficiency, traffic load for next generation heterogeneous networks by improving inter-tier interference and power consumption. The approach discussed in this paper will be open a key feature for the evaluation of 5G network.

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