International Journal of Future Generation Communication and Networking
Vol. 11, No. 6 (2018), pp.33-48
http://dx.doi.org/10.14257/ijfgcn.2018.11.6.03

A Comprehensive Survey on Seamless Mobility Management in 5G Communications

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Abstract

Mobile wireless communication has become an essential part of life. It has gained huge attraction from researchers due to its significant impact on the communication enhancement in real-time systems where voice, video and data communications can be performed instantly. However, increasing demand of mobile data traffic causes several crucial issues that degrades the QoS (Quality of Service) of the application. Hence, there is an immediate need to develop a promising technique which can enhance the performance of wireless cellular networks. In this field of cellular communication, several techniques have been developed such as 1G, 2G, 3G and 4G. 4G communication standards have shown promising results to improve the communication performance. However, increasing data traffic demand and mobility of mobile users causes several critical issues which may degrade the performance of 4G networks. Hence, recently 5G wireless cellular networks are introduced which can handle huge data traffic demand and seamless mobility by utilizing suitable handover schemes. In this article, we study about the conventional schemes of communication and the advantages and challenges faced during communication. Later, we discuss about the use of 5G communication standard and its advantages in the wireless cellular network communication. Finally, we conclude that 5G cellular networks can improve the performance of communication and improve the QoS.

Keywords: *Seamless Mobility, 5G, QoS, Comparative Study, Handoff Management*

1. Introduction

Demand of mobile devices, services and application has increased drastically across the globe resulting in serious issues on the conventional cellular systems. In a study [1], it is anticipated that nearly 100 billion devices will be connected to the Internet by year 2020. Recently, advanced technologies are growing rapidly and the working process of these techniques require multiple factors to achieve the desired performance such as Internet connectivity and large bandwidth. In the field of communication, wired and wireless networks are adopted widely according to the communication requirement specifications. These days wireless networks are much popular and are adopted in various applications that can support the mobility, connectivity and the performance of the communication. Increasing demand of cellular networks also require better quality of communication. Currently, 3G and 4G technologies are implemented in cellular communication that shows significant performance in communication, but parallelly it increases data traffic, mobility issue, intensive use of huge data processing application and also, requirement of better quality of service has raised the issue of connectivity and performance. Recently, 5G cellular network has been introduced for cellular communication

Received (May 13, 2018), Review Result (July 25, 2018), Accepted (July 28, 2018)

ISSN: 2233-7857 IJFGCN

which helps to obtain the better connectivity, higher performance, improved quality of service and provide a cost-effective solution for the network demand.

During the last two decades, usage of wireless connectivity has increased and it has been adopted in real-time applications which led to the increase in mobile data traffic. The mobile data traffic in terms of multimedia application, data exhaustive social application, video streaming on devices and cloud applications is predicted to grow with an annual growth rate of 61 percent before 2018. Also, it is expected to increase further due to the communication capabilities of 4G and LTE (Long Term Evolution) by 2020 [2].

The dramatic progression of data traffic and lack of spectrum availability raised the issue of communication quality. In order to cater with these issues, researchers have focused on the development of 5G mobile networks that can also provide the better connectivity for seamless mobility in the network. In these networks, several frequency bands are available for communication where narrow usable frequency bands in the range of several hundred megahertz and a few gigahertz are occupied by the various licensed and unlicensed networks comprising 2G,3G, LTE, advanced LTE and Wi-Fi networks. However, dynamic spectrum allotment techniques can be applied to resolve this issue. In the 5G networks, the availability of bandwidth can be explored in the millimeter wave range of 30-300 GHz [3].

The fifth-generation networks (5G) are expected to be implemented by 2020 [3] that may support the communication speed up to 1Gbit/s [4]. Recently, 5G technology has attracted researchers and a fund of approximately 700 million euro has been committed for this research for seven years. Five fundamental elements are considered to formulate the 5G networks *i.e.*, millimeter wave (mmW), massive MIMO (massive multiple input multiple output), smarter devices, device-centric modules and provision for device-to-device interface. In [5], authors discussed about the generic elements to construct the 5G network such as Big Data, Cloud computing, Internet of Things (IoT) and software defined networking (SDN). In [1] authors discussed about the mmW (millimeter wave), massive MIMO, cloud networking, software defined networking, energy efficient communication, spectrum regulation and standard parameters of 5G networks. Figure 1 shows some aspects which are related to the 5G mobile networks.

Figure 1. Aspects Related to the New 5G Mobile Networks

In 5G networks, millimeter-wave based communication are introduced for achieving efficient communication where 30 GHz to 300 GHz frequency bands are available. This higher bandwidth availability increases communication performance of high quality of service applications such as high definition television (HDTV) and ultra-high definition video $(UHDV)$ [6].

Current communication technologies suffer from various issues such as non-uniform data rate, poor end-to-end performance, weak communication coverage, insufficient support to the mobility and high cost for data transmission. On the other hand, network operators also suffer from various issues such as high network capacity provisioning, low latency, higher spectral efficiency, spectrum availability and lower energy consumption. Moreover, mobile devices roam in seamless manner in the provided heterogeneous scenario which ultimately cause connectivity issues. During this movement, mobile nodes need to maintain the uninterrupted connectivity *i.e.*, seamless mobility.

Let us consider a scenario were a mobile node is using TCP and UDP connection protocol for communication. During communication, if that node wants to perform the handover and joins the other network, in that case a new IP-address is provided to the mobile node. In this case, other side of network's TCP/UDP connections are not aware of the mobile node's new IP address. This scenario will result in the connectivity break from the ongoing TCP/UDP connections. This issue need to be resolved during implementing seamless mobility in the networking layer.

If any network supports the seamless mobility, then the mobile node is free to roam and can maintain the connectivity in the heterogeneous network. This network is transparent to the user *i.e.*, entire configuration and information of the network is already known [5]. In handoff process, mobile node receives the packets from the previous connection and meanwhile performs the registration with the new interface and receives the packet from new connection.

Handover process significantly impacts the communication performance during seamless mobility. Soft handover techniques can enable the seamless mobility; however, communication performance also depends on the communication links and different characteristics of the link. Internet data traffic has increased tremendously in mobile wireless networks compared to traditional fixed networks services [1] resulting in immediate need of solution to provide better QoS.

In [3] it was concluded that data used by wireless network will increase up to 500 exabyte by 2020. However, current techniques are unequipped to resolve the aforementioned challenges in communication. in this field, 5G networks can achieve the promising communication performance. These networks can be standardized by 2020. In order to address these issues in 5G, several techniques have been presented and it has attracted researchers due to its significant nature of performance. A comparative study about 5G wireless network is presented in Table 1 [3, 7].

Table 1. 5G Network Requirement

Attributes	Values (Compared to 4G network)
System Capacity	1000 times
Longer battery life time	10 times
Energy efficiency	10 times
Energy and cost reduction per bit	100 times
Mobility support	Up to 500 km/hr
High number of connecting devices	10-100 times
Spectral efficiency	10 times
Reduced Latency	5 times

In this paper, we discussed about recent techniques in 5G communication network and identify the various issues and challenges in 5G. This article presents a comprehensive survey on recent trends and important aspects in 5G networks. First of all, 5G architecture and evolution of cellular networks is discussed. In the next phase, we discussed the issues and identified challenges in 5G networks. Next phase discusses about the related work about the current techniques where QoS aware techniques and mobility management techniques are discussed. Later, a comparative study is presented and finally concluding remarks and future work directions are discussed.

2. 5G Network Architecture and Evolution of Mobile Networks

At the current stage, 5G cellular network development is still in a very initial phase, where research and development teams don't have a clear idea that what can help to achieve the enhanced performance in communication. Several techniques and methods have been introduced to deal with the challenges and issues in 5G in the past.

Here, we present an extensive review on the current techniques in the field of 5G technology. This survey focuses on the pioneer techniques which are based on the different direction of 5G network requirement. We discuss about the techniques in these directions and provide a brief information about these techniques that how these directions can be incorporated along with the varied requirement and constraints of the network to meet the network capacity and demand criteria. This survey helps us to identify the best solution for improving the technology and provides the alternative choices to improve the network capacity performance. A detailed evolution framework of 5G network architecture is presented in Figure 2.

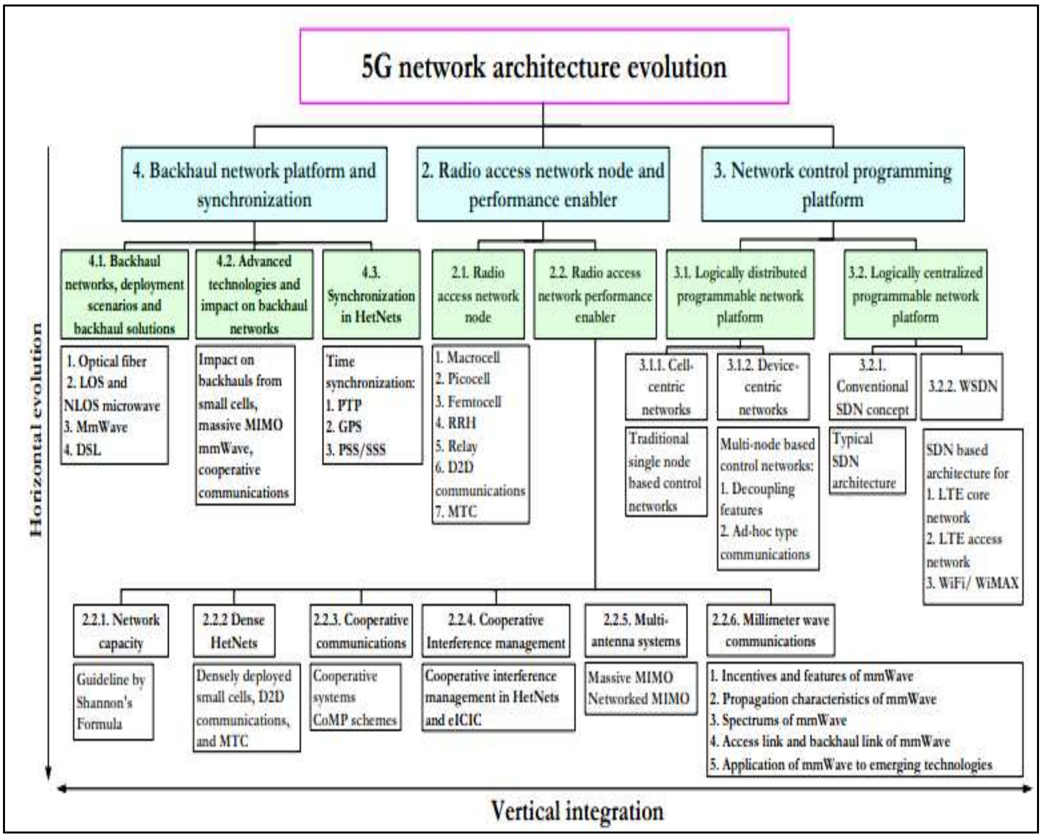

Figure 2. Detailed 5G Network Architectural Evolution Framework

Initially, G. Marconi presented a wireless communication model where initially a letter "S" was transmitted through the wireless communication setup for a 3KM long distance with the aid of electromagnetic waves. Subsequent to this process, wireless communications have become the important part of the daily life. Technical growth in the communication field has advanced the communication system where satellite communication, television, radio transmission models and current mobile telephone communications are included. Figure 3 shows a graphical representation of wireless cellular communication network evolution [2]. In order to represent the evolution of generations of wireless technologies, several parameters are considered such as mobility, data rate, spectral efficiency and coverage *etc*. The growing technology in wireless field leads towards the increment in the coverage, spectral efficiency, mobility and data rate also increases. This study shows that the 1G and 2G technologies make use of circuit switching scheme whereas 2.5G and 3G make use of both packet and circuit switching strategy to perform the communication. Late communication techniques such as 3.5 to now make use of the packet switching scheme.

Moreover, it also helps to identify the licensed or unlicensed spectrum. Currently, evolving generations use the licensed spectrum to establish the communication whereas other wireless communication models such as Wi-Fi, Bluetooth and WiMAX use unlicensed spectrum.

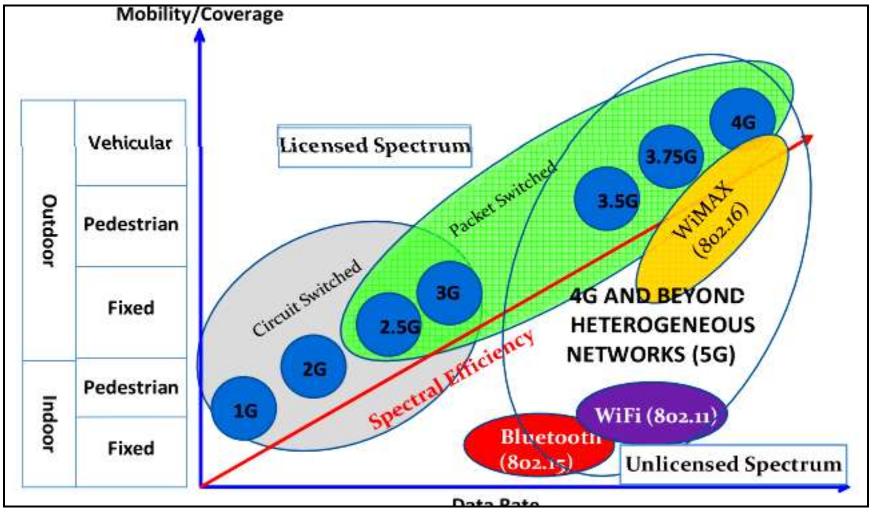

Figure 3. Evolution of Wireless Technologies

Evolution of Mobile Networks

An overview about these evolving techniques is presented below:

1G: This is the first generation used in mobile communications. It was introduced in early 1980's. This technique has a communication data rate up to 2.4 kbps. Main subscribers of this technique are known as Nordic Mobile Telephone (NMT), Advanced Mobile Phone System (AMPS) and Total Access Communication System (TACS). This scheme suffers from the various disadvantages such as low network capacity, insignificant handoff, security *etc.*, [8].

2G: This scheme of mobile network is known as 2nd generation which was introduced in 1990's. In this scheme, digital technologies have been used for 2nd generation mobile telephones.

According to the 2nd generation systems, Global Systems for Mobile communications (GSM) is the most widely adopted technology in 2nd generation communication which can support 64kbps data rate. The main advantages of this technology is that mobile handset's battery lifetime is more because the radio signals have low power. Moreover, this technique supports various other techniques also such as e-mail and Short Message Service (SMS). In this era, GSM, CDMA

(Code Division Multiple Access) and IS-95 are the well-known technologies [3], [8].

2.5G: In order to develop this, 2ng generation cellular systems adopt the General Packet Radio Services (GPRS) and 2.5G is formulated. Generally, 2.5G system follows 2G framework but it also uses packet and circuit switching both strategies. This communication model supports data rate up to 144 kbps. Widely known 2.5G technologies are Enhanced Data Rate for GSM Evolution (EDGE), GPRS and Code Division Multiple Access (CDMA) 2000 [3], [8].

3G: This cellular network scheme is known as 3rd generation which was introduced in late 2000. This technique improvised the cellular networking scheme by supporting the data rate up to 2 Mbps. Other that high speed data rate, it also helps to maintain the QoS. moreover, it also supports the roaming and improves the voice quality which makes it more efficient for implementation. The main drawback of this technique is power consumption and power requirements hence implementation of these networks becomes more expensive [3], [8]. Widely known schemes in 3G are Code Division Multiple Access (CDMA) 2000, Wideband Code Division Multiple Access (WCDMA) and Universal Mobile Telecommunications Systems (UMTS). Further evolution of these technologies has introduced high speed uplink/ downlink packet access schemes which has improved the 3G known as 3.5G which supports 5-30 Mbps data rate.

3.75G: This is the enhanced version of 3G and 3.5G which supports the higher data rates. In this technique, Fixed Worldwide Interoperability for Microwave Access (WIMAX) and Long-Term Evolution technology (LTE) are introduced to improve the communication performance. WIMAX and LTE helps to improve the network capacity hence it can support multiple number of users for varied high speed services such as high definition video streaming, sharing the data over a peer-to-peer network, web services [7].

4G: Recently, 4G cellular networks are widely adopted in the field of cellular communication field. It is the improved stage of the 2G, 3G and 3.5G. To improve the communication performance, advanced LTE are adopted by 3GPP and standardize along with the WIMAX scheme. 4G systems helps to improve the communication by using internet-protocol based solution. Moreover, these networks enhance the communication quality such as voice, data and multimedia by providing high data rate. Several applications are present which uses 4G network scheme such as Digital video broadcasting (DVB), multimedia messaging service (MMS), video chat and high definition mobile TV [2].

5G: Due to the increasing demand of data, high speed data rate and improved QOS, 4G systems need to be replaced with 5G communication strategy. 5G communication strategies are known as Beam Division Multiple Access (BDMA) and Non- and quasi-orthogonal or Filter Bank multi carrier (FBMC) multiple access. According to the BDMA scheme, the base stations establish the communication with the mobile stations. According to the concept of BDMA, an orthogonal beam is formulated initially which helps to partition the antenna beam into different directions based on the locations of mobile stations resulting in the increment in the system capacity. In various cases, 4G networks fail to achieve the desired performance due to several challenges which are not addressed in 4G networks, are as follows: higher data rate, low latency, higher capacity, massive device connectivity, implementation cost and quality of service [9]. Recently, various communication standards have been developed such as IEEE 802.11ac, 802.11ad and 802.11af which are very useful for building the 5G network modules. Here, we present a brief comparative study about these techniques as given in Table 2.

Table 2. Technical Comparison Among Recent 802.11 Standards

Technical Specification	802.11 an	802.11ac	802.11ad	802.11af
Modulation scheme	OFDM	OFDM	OFDM, single carrier, low-power	OFDM
Frequency	2.4, 4.9 and 5 GHz	5 GHz	60 GHz	0.47-0.71GHz
Channel bandwidth	20, 40MHz	20, 40, 80MHz (160 MHz optional)	2 GHz	5,10,20,40 MHz
Nominal data rate (single stream)	Up to 150 Mbps (1x1, 40 MHz)	Up to 433 Mbps (1x1,80 MHz) Up to 867 Mbps (1x1, 160 Mbps)	4.6 Gbps	54 Mbps
Aggregate nominal data rate (multiple streams)	Up to 600 Mbps (4x4,40 MHz)	Up to 1.73Gbps (4x4,80 MHz) Up to 3.47Gbps (4x4, 160 MHz)	7 Gbps	
Range	12-70 m indoor	12-35 m indoor	60 m indoor, 100 m indoor	<100m indoor <5km outdoor
EIRP	22-36 dBm	22-29 dBm	1-10 dBm	16-20 dBm
Spectral efficiency	15 bps/Hz (4x4, 40 MHz)	21.665 bps/Hz (4x4, 80MHz)	1 bps/Hz (2GHz)	NA

3. Issues and Challenges in 5G Networks

Increased demand of data transmission and access has motivated companies to perform the seamless migration for the on-going data flows to achieve the good quality communication for the upcoming next generation networks. However, migration is a tedious task which has several limitations due to the large deployed networks and dynamic behavior of the mobile network environment. These limitations may lead towards various challenges in seamless networking computation. Here, we introduce some challenges which are as follows:

- In real-time communication system, mobile devices are free to roam and can create inter-stem roaming state. This state may cause delay which need to be reduced to support the real-time communication in the integrated environments. This can be obtained by using the current technique known as Mobile IPv6 protocol which can perform the handovers according to the communication requirements. Moreover, it reduces the signaling overhead.
- In this stage of inter-system roaming, several occlusions may occur which can degrade the communication link quality. This can be addressed by adopting different networking scheme. Moreover, during the design phase, these effects need to be considered which can be useful for developing the network model. in addition to this, system designers believe that the data requirement demand can be satisfied by integrating the different networks. However, this integration may cause the complexity issues which can affect the performance.

- The network integration process motivates to develop the handover process which can improve the possibilities of spectrum decision making during the roaming phase.
- According to the cellular systems, mobility can cause the issues of on the network layers such as physical layer and link layers. On other hand, handoff is performed on the third layer in highly coupled IP-based networks which may cause disturbance in upper layer, transport layers which results in the degraded performance.
- The technological improvement in the network devices and services increases the complexities in the resource management. Moreover, seamless mobility demand and continuous network connectivity demand also causes the performance degrading issues.

In order to deal with these issue, handover based policies can be considered, which can improve the network performance by improving the network capacity, utilization cost, security, power consumption and QoS.

3.1. Dense Deployment of Small-Cells

Small cell communication can help to off-load the macro cells resulting in the reduction of signal power. This solution can be implemented for indoor or outdoor solutions and it can provide a cost-effective solution for the massive growth in the data traffic. The limited cell radius can help to improve the spectrum reuse capability which can be used for enhancement in the spectral efficiency and network capacity enhancement. Furthermore, it the mobile node is moving through the multiple base station and passing through various hotspot devices then the possibilities of handover failure and call drop may increase due to frequent link variations. Possible challenges in it are:

3.1.1. Inter-Cell-Interference: As discussed before, small-cell need to be deployed for better and significant communication but dense deployment of the network may lead towards the increased interference among neighboring cells. Moreover, random and uncontrolled deployment of small cells may lead to the uncontrolled shape of the communicating cell.

3.1.2. Handoff Rate: Due to frequent movement of the mobile user from one small cell to other small cells then the handover will take place and the frequent unnecessary handover may lead towards the battery life issue and call drop rates.

3.2. Millimeter-Wave Frequency Band

Now a day, majority of communication system are widely adopting the microwave band communication system which uses frequency of 3GHz. Due to this, microwave communication band becomes uneven in the range of 20-90 GHz due to the wide chunk of unused bandwidth. This step is considered very crucial because mm-wave has different condition for propagation., hardware constraints and atmospheric absorptions. However, these issues can be handled by developing the beamforming and antenna array. According to mm-wave standards, cell radius should be limited *i.e.*, <100m which helps to reduce the path-loss. Hence, path loss can be minimized by deploying small cell communication model [10]. Possible challenges in mm-wave communication systems is high-path loss. It is considered as a challenging task when compared to the microwave bands below 3GHz range. The path loss model can be expressed as [11]:

$$L_{FS} = 32.4 + 20\ \log_{10} f + 20\ \log_{10} R$$

L_{FS} denotes the free space path loss in dB, carrier frequency is denoted by f and distance between transmitter and receiver is denoted by R in meter.

3.3. Massive MIMO/Beamforming

Massive MIMO is the best suitable solution for the scenario where the network is equipped with huge number of antennas at the base station. This deployment of massive MIMO can handle multiple co-channel users in a single time duration. On other hand, beamforming technique helps to concentrate on the power consumption and satisfies the gain requirement. In this field, Beamforming is also considered as a promising task which can help to improve the performance of the MIMO communication systems. Massive MIMO based communication models improve the signal strength which can improve the throughput performance when compared with the conventional 4G systems [1].

3.3.1. Pilot Contamination: Massive MIMO has several advantages but suffers from the issue of pilot contamination [4] which is caused due to increased number of antennas in the neighboring cells.

3.3.2. Channel Estimation: In the massive MIMO communication systems, several antennas are used hence precise estimation of channels becomes a crucial task and Time Division Duplexing (TDD) implementation also becomes a challenging issue due to higher cost and computational complexities. Hence, there is a need to develop a sophisticated technique which can help to achieve the accurate channel estimation in Frequency Division Duplexing (FDD) mode and reduce the communication overhead.

3.3.3. Very Large Physical Architecture: Massive MIMO has significant impact on the communication performance but the size of MIMO architectures is huge and it requires huge space. It can face the issue from the public due to its effects on the human health. Moreover, large size of towers will arise various technical challenges. These issues of massive-MINO can be addressed by dividing the m-MIMO into millimeter-wave band communication [12].

4. Related Works

This section deals with the recent studies in the field of 5G wireless communication. This complete study is categorized as follows: first section provides the studies which are based on the network QoS enhancement, second section deals with the mobility management schemes and handoff management techniques in 5G.

4.1. QoS Aware Studies

In [13], Ding *et al.*, discussed about the NOMA (non-orthogonal multiple access) scheme for LTE communication and their use in the 5th generation wireless communication. Their scheme helps to provide communication service to the multiple users at the same frequency/time/code but differs at the power levels. This strategy obtains the more spectral efficiency gain when compared with the conventional schemes of orthogonal multiple access.

In [12], Bogale *et al.*, studied about 5th generation wireless cellular communication. It was also discussed that current data traffic demand can be handled by the 5G networks. Moreover, these networks are capable to achieve the higher performance in terms of QoS where delay, reliability, and security etc. can be included. These networks can resolve the communication performance issues by developing the small cell dense network deployment using massive MIMO techniques.

Wang *et al.*, [14] discussed about the heterogeneous networks to provide the low-latency communication. Generally, HetNets are composed of macrocells and small cells. Their paper presents the prime characteristics of 5G HetNets and focuses on problems concerned with resource management in 5G HetNets. In HetNets, they also emphasized on cell association issue of multiple classes of users. User in it have option to connect with the cells (small or micro cell) that offers them higher data rates as different class of users need different data rate. Consequently, to maximize overall revenue, for different user classes, even cells too need to allot resources in terms of antennas. On evolutionary game theory, they presented cell association and algorithms for antenna allotment. Their algorithm maintained a good balance to make sure that the cell and the users should not get high data rate and overall revenue, individually, by altering their antenna allotment and cell connection.

Grassi *et al.*, [15] introduced a new approach for resource allocation technique for uplink communication for the 5G air interfaces. Their technique uses MIMO physical-layer based strategy for developing this decentralized, scalable and energy-efficient resource allocations. In order to achieve the desired performance, a game theoretical model is presented which helps to maximize the energy efficiency in mobile terminals. Their model helps to develop the low-complexity, iterative and distributed algorithm which considers channel time selectivity impact on the performance, details of physical layer communication technology.

In [16], Hu *et al.*, presented a cooperative networking system for 5G wireless communication. In their work, spectral efficiency, quality of service and energy-efficiency based state-of-art techniques have been discussed. along with this, multi-layer interference management and power control strategies and dynamic resource allocation schemes are also discussed. In the next phase of their work, a cooperative strategy is presented for optimizing the spectral efficiency, energy efficiency and QoS for the considered heterogeneous wireless network. Their study shows that the energy consumption, QoS management and battery life still remains a challenging task.

In [17], Zhang *et al.*, focused on the next generation mobile communication and discussed about the QoS enhancement strategies and techniques for video transmission in time-varying wireless channels. In this work, authors also discussed about the 5G models where MIMO based full duplex communication and device to device communication modes also can be applicable for performance enhancement of the network. However, integrating these techniques is considered a task which imposes various challenges. Hence, a power adaption scheme is developed in this work where Quadrature- OFDMA technique is used to perform the MIMO based full duplex communication and D2D communication in 5G mobile wires communication.

Hammouti *et al.*, [18] discussed about the advantage of small cell communications. Small-cell based communication model helps to improve the network performance. During communication, as low power nodes grows, the overall energy consumption also grows. At this stage, an efficient algorithm is developed for power control mechanism. In their work, an energy-aware self-organizing network strategy is developed which helped to achieve the desired optimal performance. In order to identify the satisfaction criteria efficient satisfaction equilibrium is defined to maintain the QOS. In order to identify the efficient satisfaction equilibrium stationary channel assumption are taken into the consideration.

In [19], Zhou *et al.*, focused on the energy efficient communication scheme for downlink communication in MIMO systems. Moreover, maximum transmit power constraints and QoS parameters are also considered to maximize the performance of MIMO communication. By satisfying these two constraints, authors introduced resource allocation strategy for maximizing the energy-efficiency performance which is measured by estimating the total number of successfully delivered information bits in per Joule energy consumption. The power consumption is measured by considering both the transmit power and circuit power. In this work, the problem is considered to non-convex in nature which is transformed into the new convex problem. Later, Lagrange multiplier method is implemented to identify the optimal power allocation solution.

Similar to [19], Liu *et al.*, [20] also studied about the small-cell based communication and discussed that the dense deployment of small cell networks can improve the performance. Based on these assumptions, authors presented small-cell based communication strategy for 5G networks to improve the system throughput. Energy efficiency of dense small cell networks is also considered as a crucial parameter in the 5G networks. In huge deployment of 5G wireless network, huge number of cells are deployed hence multiple cells may overlap resulting in the inter-cell interference which becomes most challenging issue. These issues may degrade the quality of service hence needed to be addressed significantly. Hence, in their article, authors addressed these issues and presented clustering based scheme for interference management which can provide the better QoS in densely deployed small cell networks.

Table 3. Comparative Study

Authors	Technique	Energy efficiency	Spectrum efficiency	QoS	Direction
Ding et al. [13]	Non-orthogonal Multiple Access (NOMA)	Low	Moderate	Yes	Downlink
Wang et al. [14]	Evolutionary game theory	Low	Moderate	Yes	Uplink
Grassi et al. [15]	Game theoretic approach	Moderate	Medium	Yes	Uplink
Hu et al. [16]	Cooperative green heterogeneous network	Medium	Medium	Yes	Uplink
Zhang et al. [17]	Quadrature-OFDMA	Moderate	No	Yes	Uplink and Downlink
Hammouti et al. [18]	Tactical power control using efficient satisfaction equilibrium (ESE),	Moderate	No	Yes	Uplink
Singh et al. [21]	biased UA	High	Moderate	High	Downlink
Bao et al. [22]	biased UA + spectrum partitioning	Moderate	High	Moderate	Downlink
Sadr et al. [23]	biased UA + spectrum partitioning	Moderate	High	High	Downlink/Uplink

Based on these studies, we have identified some existing drawbacks and issues which affects the performance. These issues are presented in the Table 5.

Table 4. Comparative Study of Different Generation of Wireless Mobile Networks

Gen.	Access Technology	Data Rate	Bandwidth	Forward Error Correction	Frequency Band	Application
1G	Advanced mobile phone services (AMPS) (Frequency Division Multiple Access (FDMA))	2.4 kbps	30 KHz	NA	800 MHz	Voice
2G	Global Systems for Mobile Communication (GSM) (Time Division Multiple Access (TDMA))	10 kbps	200 KHz	NA	850/900/1800/1900 MHz	Voice +Data
	Code Division Multiple Access	10 kbps	1.25 MHz			
2.5 G	General Packet Radio Service (GPRS)	50 kbps	5 MHz	NA		Voice + Data
	Enhanced data rate for GSM Evolution (EDGE)	200 kbps	1.25 MHz			
3G	Wideband code division multiple access (WCDMA) / Universal mobile Telecommunication System (UMTS)	384 kbps	5 MHz	Turbo codes	800/850/900/1800/1900/2100 MHz	Voice + Data + Video calling
	Code Division Multiple Access (CDMA) 2000	384 kbps	1.25 MHz			
3.5 G	High Speed uplink/Downlink packet Access	5-30 Mbps	5 MHz			
	Evolution-Data Optimized	5-30 Mbps	1.25 MHz			
3.75 G	Long Term Evolution (LTE) (Orthogonal/single carrier Frequency Division Multiple Access) (OFDM-A/SC-FDMA)	100-200 Mbps	1.4 MHz to 20 MHz	Concatenated codes	1.8 GHz 2.6 GHz	Online Gaming + High definition TV

	Worldwide Interoperability for microwave Access (Wi-MAX)	100-200 Mbps	3.5 MHz and 7 MHz in 3.5 GHz band; 10 MHz in 5.8 GHz band		3.5 GHz and 5.8 GHz	
4G	Long Term Evolution Advanced (LTE-A)	DL 3Gbps UL 1.5 Gbps	1.4 MHz to 20 MHz	Turbo codes	1.8 GHz 2.6 GHz	Online Gaming + High definition TV
	Worldwide Interoperability for microwave Access (Wi-MAX) with (Scalable orthogonal frequency division multiplexing)	100-200 Mbps	3.5 MHz 7 MHz 5 MHz 10 MHz and 8.75 MHz		2.3 GHz 2.5 GHz 3.5 GHz	
5G	Beam Division Multiple Access and Non-and-quasi –orthogonal or filter bank multi-carrier multiple access	10-50 Gb (Likely)	60 GHz	Low Density Parity Check (LDPC)	1.8 GHz 2.6 GH and expected 30-300 GHz	Ultra-high definition video + virtual reality applications

Similarly, we presented another comparative study where we study about mobility and handoff management tasks in 5G cellular networks.

4.2. Mobility and Handoff Management

In this section, we discuss about the mobility and handoff management related studies presented by other researchers and finally identify the issues and challenges in the field of 5G communication.

Based on the advantages of handoff, Qiu *et al.*, [24] introduced a novel approach for integrating the network function virtualization and fog computing scenarios. This study shows that the network function virtualization has several advantages which helps to improve the network flexibility and reduces the network overhead. Here, fog-computing based access points are deployed and a direct X2-based handover scheme is also implemented.

In [25] yang *et al.*, discussed about the use of wireless communication for daily life scenario. In the downtown of the city, radio signals received by UE from neighboring eNBs may be covered up by the surrounding buildings. In other conditions, if the user is at the edge of eNBs then also the UE receives the poor radio signals. However, emitted wireless signals can be forwarded by a relay station which can extend the communication range of the B. This relay station helps to bypass the interference signal. Moreover, they presented a handover process between two relay stations.

In [26] Arshad *et al.*, presented a study on the improvement of spectral efficiency and improve the resource allocation process among the multiple users. Spectral efficiency can be enhanced by incorporating the shrinking the base station footprints. In these models, handover process can be implemented to improve the performance of 5G networks. According to this work, handover rate plays important role in the performance of 5G networks and needs to be taken care of properly. In this work, authors discussed about the challenges faced during handover process in

5G networks. Based on these assumption, a topology aware handover skipping algorithm is presented in their work. The proposed approach is validated for single tier and two-tier cellular networks for downlink communication.

Wu *et al.*, [27] studied about the parameter which can affect the performance of 5G communication and studied about the small cell deployments. Their article shows that the current techniques of QoS improvement depends on the prior information and rules of the network. These techniques fail to achieve the desired performance when there is not enough prior knowledge is present. In order to deal with this issue, dynamic fuzzy Q-Learning algorithm is presented to obtain the mobility management in small-cell networks.

Barua *et al.*, [28] *et al.*, discussed a new approach to improve the performance of cellular networks by using device to device communication strategy. This technique of device to device communication doesn't require any base station to establish the communication between two devices. However, mobility management is a crucial task in thee D2D communications. Several methods have been discussed to deal with this issue of mobility in these communication systems but latency, power consumption and complexity remains a challenging in the mobile cellular networks. In their work, authors discussed a new approach where TDD configuration have been used for LTE-A communication systems. Hence, a standard power control scheme can be implemented for TDD.

Zhang *et al.*, [52] discussed the wireless local area network and their significant impact on the communication. In any wireless local area networks, users are surrounded by the multiple access points. In this case, performing the handover between these access points is considered as a tedious task due to latency during handoff process. This latency degrades the network performance by reducing the QoE (Quality of Experience) in multimedia communication. large latency may lead to the unacceptable performance for WLANs, hence a proactive scheme of handoff management is presented in their work. This scheme uses active scan based technique for neighboring access point information analysis and later, RSSI (received signal strength indicator) & variable bitrate video coding (VBR) are applied to improve the latency performance.

Table 5. Challenges in 5G Networks

Issues	Example	Keypoint
Uplink-downlink asymmetry	HetNets presents key asymmetry among the uplink and downlink. The optimal user association for downlink or uplink will be less effective for the opposite direction.	Optimize downlink and uplink performance jointly in the user association design
Backhaul bottleneck	Densely deployed small BSs may bring overwhelming traffic augments for the backhaul link and present small cell backhaul solutions can't deliver sufficiently large data rate	Design backhaul-aware user association for HetNets
Mobility support	User association while avoiding user mobility may outcome in recurrent handovers between the cells in HetNets	Account for the user mobility while creating the user association decision in HetNets to improve the long-term system-level performance and avoid excessive handovers

5. Conclusion

Recently the demand of wireless communication has increased drastically where mobile communication has been considered as a most important part of these communication systems. Current communication scenarios require best performance during communication. However, several promising communication techniques have been presented such as GPRS, GSM, EDGE *etc.*, but these techniques fail to handle higher data traffic and cannot handle the mobility issues. Recently, 4G communication technique has improved the communication performance but several challenges are present in it, such as system capacity, power consumption and handover management, which makes it more complex to handle the higher data traffic. Hence, 5G communication techniques are developed, that shows a notable improved performance for higher data traffic and also can handle the mobility management issues with the help of handover schemes. In this work, we present a comprehensive survey where we discuss about several conventional schemes of communication such as 1G, 2G, 3G and 4G schemes and identified several advantages of 5G communication standards.

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