5G: Survey of Technologies and Challenges

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Abstract-With the advancement in technologies and each upcoming generation, all the services like audio, video, multimedia and broadband data services have been integrated into identicalnetwork. Evolution started from 1980's 1G to 2010's 4G by solving the issues faced by previous generation both technically and economically with time. High downlink speed,less latency and scalability of users are the main issues, which this generation is facing currently.Many issues like spectrum crisis and high-energy consumption are there which has to beaddressed. Objective of this paper is to analyze the issues faced by generations till now and the upcoming generation 5G and how they can be resolved technology and economically wise in efficient manner. Survey have been done in details of the latest available literature and research work of authors around the globe associated to 5G challenges and their proposals to resolve them. Massive MIMO(Multi Input Multi Output), VLC (Visible Light Communication),Cognitive Radio Network, SDN (Software defined network), Millimeter (mm) Wave, Femtocell, Hetro Nets etc. are some key promising technologies to handle the challenges of upcoming generation 5G.

Keywords- LTE (Long Term Evolution), WIMAX (Worldwide Interoperability for Microwave Access), SDN, HetNets, MIMO, Interference.

I. INTRODUCTION

From analogue to 4G, each evolved generation of cellular technology has set objectives to achieve in the following new generation. With time new requirements appeared like increasing numbers of users day by day, decreasing radio spectrum and high data rates.Mobile broadband has brought vast benefits like email, social media, music, video streaming and online gaming to controlling your home appliances from anywhere in the world, which are the daily needs of a common man now days. These all innovations have fundamentally changed the lives of many people.

From the second generation (2G) mobile communication system in 1991 to 3G system first launched in 2001, the wireless mobile network has been mutated from a pure telephony system to a network that can transport a wide variety of multimedia contents in addition to voice. The 4G wireless systems were designed to fulfill the requirements of International Mobile Telecommunications-Advanced (IMT-A) using IP for all services [1]

1Gwireless mobile telecommunication introduced in 1980's.It was analogue and first generation of analogue phones was introduced, achieving data rate upto 2.4kbps. 2G Came in 90's.Digital technology was used. Mainly used for voice communication and data rate upto 64kbps achieved.3G introduced in late 2000. Carried speech and data together with data rate upto 2Mbps.4G decedent of 2G, 3G standards.3GPP standardized LTE-A as 4G standard along with WiMAX.MMS, DVB (digital video broadcast) and video chat,HDTV (High Definition TV) supported by 4G at quite higher data rate as compared to previous generations, achieving data rate upto 1Gbps.

5G,increasing users, high speed and less latency like are the factors, which demanded for a new generation. Many of researches, projects that have been working on 5G projects 8 requirements [4]:

- 10Gbpsconnectivity.
- Latency <1ms.
- 99 % availability, coverage.
- 1000 times bandwidth.
- 100 times of connections as having today.
- Reduction in network energy usage.

Typical task to develop a new different technology capable of addressing all these issues same time.It is more likely that various combinations of a subset of the overall list of requirements will be supported 'when and where it matters'.

As 100% coverage and 99.99% availability can also be achieved with previous generations by spending more on devices and infrastructure.To achieve the capability of 10-100 times the number of connections relies upon technologies working together, including 2G, 3G, 4G, Wi-Fi, Bluetooth etc. 5G singly cannot be considered as a final end solution, but just an additional enhancement to the already existingtechnologies, evolution to enable connectivity of machines. Similarly1,000 times bandwidth per unit area is not solely dependent upon new generation, but will be the cumulative effect of more devices connecting with higher bandwidths for longer durations.

New advancements or functionalities like Virtual reality/autonomous driving/connected cars/multiperson videoconferencing/wireless cloud office/machine to machine connectivity etc. need support of 5G like technology improvement meeting<1ms latency and downlink speed >1Gbps target.

Table 1 lists the year wise growth in standards and various enhancements in generations [2][3].

Table 1.EVOLUTION

Generation	Year	Services	Weaknesses	Access Technology	Data Rate
1G	Initial 80's	Analogue phone calls,no data service	Poor spectral efficiency,security issues	Analogue,FDMA,AMPS	Upto 2.4kbps
2G	Late 90's	Digital phone calling and messaging	Limited data rates, difficult to support internet/email	CDMA,TDMA	64kbps
3G	late 2000's	Phone calls, messaging,data	Real performance failed to match hype	WCDMA,services based upon IP	Upto 2Mbps
3.5G	late 2000's	Phone calls, messaging,broadband data	Following oldmobile specific architecture, protocols	HSUPA/HSDPA	5-30Mbps
4G	2010	Voice,data,multimediaeverytime,anywhere	Highdata rates and capacity for users,spectral deficiency	OFDM,LTEadvanced, WIMAX	1Gbps

II. LITERATURE REVIEW

A lot of research is going on this future generation of cellular communication. Many proposals in terms of architecture and technology have been given by different authors and research communities around the world along with addressing the issues, problems that may occur in implementing these proposals [2,12,17]. Brief overview of all these research work related to this next generation have been presented here contributing towards 5G,with respect to the technologies which are definitely the key promising technologies associated to this new generation 5G.

A) MASSIVE MIMO

Multiple-Input Multiple-Output (MIMO)[2,6,10,19,21] technology is a wireless technology that uses multiple transmit and multiple receive antennas for a single user, which contributes the capability of transferring more data at the same time. Aspiration behind using this technique is high transmission rate of 1Gbps and high-speed links offering good quality of service. MIMO takes advantage of a natural radio-wave phenomenon called multipath.Each multipath route can be considered as a different unique channel creating multiple "virtual wires" over which signals will be transmitted. MIMO employs multiple, spatially separated antennas, which takes advantage of these "virtual wires” to transfer more data.

And at the receiving end MIMO antenna combines data streams arriving from different virtual wires/paths, at different times to effectively increase receiving power of the receiver end.A cellular architecture comprising this massive MIMO technique have been proposed in[2] conjunction with other techniques. Challenges associated with this technique have been discussed in [2,5,6,7,11,18,19]. Employment of this technique in order to enhance performance also been proposed[7] by combining this in dense cell deployment concept [7,15]. MIMO dealing with multi cell interference by way of beam forming applied at each base station is also presented [22].

B) COGNITIVE RADIO NETWORKS

The CR network is software defined radio technique exploited to increase the utilization of the congested Radio Frequency spectrum [6,8,9,10]. Reason behind usingthis technique is that maximum portion of the radio spectrum stays idle most for long durations, and by exploiting this region; spectrum can be utilized in more efficient way.

In CR networks, a secondary system are made such that they can sense the radio environments and by itself can find the white,grey and black space in theenvironment and adjust its transceiver parameters to exploit the idle resources along with the licensed primary system[10]. In interference-free CR networks [8,14], when authentic or licensed users are not using the spectrum, CR users are allowed to borrow spectrum resources till the licensed ones comes to work. Key to enabling interference free CR networks is finding out how to detect the spectrum holes (white space) in wideband frequency spectrum. A coordinating mechanism is explained in multiple CR networks that try to address the challenge of accessing the same spectrum to prevent users colliding when accessing the matching spectrum holes[6,7,8].

C)MOBILE FEMTOCELL

The MFemtocell is a new concept evolving as a candidate technology in next generation intelligent systems [2][3][6]. It is explicitly known that cellular coverage; especially for data transmission, which demands for better signal strength, is not so good inside buildings. By using a small base station - femtocell (femto cell), which can be established in trains, buses and vehicles and thus performance can be improved by using this station for other services too.Concept is same as bifurcating the indoor and outdoors devices in moving vehicles.MFemtocells can improve the spectral efficiency of the entire network.

D)VISIBLE LIGHT COMMUNICATION

Visible light is very small portion of electromagnetic spectrum. Mainly it is used for vehicle-to-vehicle communication and in networking in indoor environments. VLC has bandwidth of 400-700 nm. The technology uses fluorescent lamps to transmit signals at 10 Kbit/s, Light Emitting Diode's for up to 500 Mbit/s. Main issues which needs to be addressed in this are connectivity, multiuser support and shadowing. A lot of improvement can be gained by using this technique in femtocells [6]. Main limiting factor is detecting and avoiding the interferences [2,6,10].

E)MILLIMETER WAVES

Millimeter Wave also known as extremely high frequency by the international telecommunication unit can be used for high speed wireless broadband communications.Millimeter Wave is used for variety of services in mobile and wireless networks, as it permits data rates up to 10Gbps. Millimeter waves has large wavelengths than infrared waves or X-rays, but shorter than radio waves or microwaves. As having shorter wavelength mm wave signal strength can be effected by atmosphere conditions, thus it has a short range of line of sight up to 1km. One of the important uses of millimeter waves is in transmitting large amounts of data [2,8,20]. Millimeter wave mobile broadband is presented as a next generation mobile communication system [26].

F)DEVICE TO DEVICE COMMUNICATION

Device-to-device (D2D) communication provides high data rate services between the nearby users and devices.It is an exciting and innovative feature of next-generation cellular networks [2,5,9,19], offering a wide variety of advantages over the traditional cellular networks, e.g. higher throughput, efficient spectral usage, improved energy efficiency, delay etc. many others.

In highly busy network, the total throughput benefits from offloading local traffic to D2D mode, as D2D communication requires 1 hop while relaying compare to via a Base Station requires 2 hops. Ways to tackle issues like security, which is prominent in this communication, as data has to be forwarded from other mobile device, have been explained in [24,25].

G) INTERFERENCE CANCELLATION

To mitigate the internetwork, Intra network interferences in any scenario like D2D, CR, MIMO etc. is a challenging issue, because large amount of bandwidth, throughput and capacity gets wasted which we would have converted into the useful utilization. Number of methods, techniques have been proposed to deal with cancellation or minimizing the effect of interference in D2D,MIMO etc. architectures [2,23].IC(interference cancellation) technique for CR network have been proposed in [8].

TABLE 2. Technologies discussed in survey of literature.

Authors	MIMO	VLC	D2D	CR	mm Wave Communication	IC
[2]	✓	✓	✓		✓	
[5]	✓		✓			
[6]	✓	✓		✓		
[7]	✓			✓		
[8]				✓		✓
[9]			✓	✓		
[11]	✓					
[14]			✓	✓		✓
[18]	✓					
[19]	✓		✓			
[21]	✓					✓
[22]	✓					✓
[23]						✓
[26]					✓	
[24]			✓			
[25]			✓			

III. CONCLUSION

Literatures available on the performance requirements of 5G wireless cellular communication systems have been defined in terms of capacity, data rate, spectral efficiency, latency, energy efficiency, Quality of service and the respective challenges associated with each one of them and how they can be tackled with promising technologies in the future have been studied. Technologies like massive MIMO and Device to Device communication in particular and interference management, Cognitive Radio, ultra dense networks, millimeter wave communication,HetNets,Femtocell and Cloud Technologies etc. with radio access networks and software defined networks(SDN) are the promising techniques for resolving and meeting the challenges of 5G in the future.

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