An overview of 5G Technology and Challenges

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Abstract-Main objective of this paper is to make a comprehensive study of 5G technology.5G Networks will provide many benefits over the currently available 4G LTE networks. Main goal of 5G technology is to meet the demands of high user data rates. 5G wireless technology is supposed to provide more capabilities than the previous wireless technology. It will provide high data rates, high reliability and low latency. Main components of 5G networks will be high frequency bands, device to device communication and multiple antennas for transmission. This paper highlights all these components. It also highlights various different challenges which are faced by 5G technology. Some of these components are already used in the previous high speed networks and some of them are still under development phase.

Keywords-Small Cell; MIMO; Beamforming;

1. INTRODUCTION

5G means fifth generation. 5G network are currently under development and they are expected to hit the market in 2020. It is the next step to replace the currently available 4G LTE technology. 5G technology is the next mobile internet technology. Main features of 5G network are faster speed and reliable connections. It will provide higher data rates and much network efficiency. 5G network will help in boosting the IoT technology. Average download speed of 5G is expected to be around 1Gbps. It uses radio waves to transmit and receive user's data [1].

2. MAIN FEATURES OF 5G NETWORK

Main features of 5G technologies are:
According to IMT-2020 specifications 5G network is expected to have the following features.

2.1. Very high speed

5G network is expected to deliver more speed as compared to 4G networks. User data rate is expected to 1Gbit/s. Peak download capacity for 5G network is expected to 20Gbits/s. Now a high definition movie can be downloaded within few second [2][11].

2.2. More capacity

5G network will have increased bandwidth. It is supposed to provide 1,000 times more capacity as compared to currently available 4G network.

2.3. Reduced Latency

It will stop the transmission delay between the two communicating devices. Latency means time taken by the sender to send a message to a receiver. In case of

5G network it is expected to 1ms. It will help in handling multiplayer mobile game, self driving cars, and robots [2][11].

2.4. Provide larger bandwidth

For supporting increased throughput new spectrum frequency bands are allocated. It will utilize the existing LTE spectrum (600 MHz to 6 GHz) as well as millimeter wave bands (24–86 GHz)[1].

2.5. Lower battery consumption devices

Earlier high speed network stress the devices and result is poor battery life. But 5G network promise to offer better battery life. 5G networks offer best possible connection to the connecting devices, increasing battery life [3].

2.6. Uninterrupted and consistent connectivity

5G signals are more reliable than the previous mobile network radio signals. 5G technology is a combination of various advanced technology which will be very helpful for providing users uninterrupted and consistent connectivity.

2.7. Allow access to parallel multiple services

One of the disadvantages of the earlier high speed networks is due to the less bandwidth multiple applications are not supported simultaneously. But 5G network will support multiple applications simultaneously [3][4].

2.8. Remote place access

Currently wireless network development in the remote area is still very poor. In these areas transmission

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speed of the data is very less [12]. 5G will use massive MIMO technology to improve the speed [5].

All these features of 5G technology are shown in the table 1 given below.

Table 1. 5G Features and Benefits

Main Features of 5G and their benefits		
S.N.	Features	Benefits to Users
1	High Speed	It will handle many users within same area, many devices and their traffic demands.
2	Low Latency	Handle Time bound Traffic more easily and in accurate way.
3	High Speed Mobility	Supporting users which are moving with a very high speed.
4	New Radio Spectrum	It will utilize the millimeter waves and radio carrier aggregation
5	Massive MIMO	Increased throughput within a sector
6	Small Cells	Increase in data capacity, longer battery life, low latency rates

3. 5G Techniques

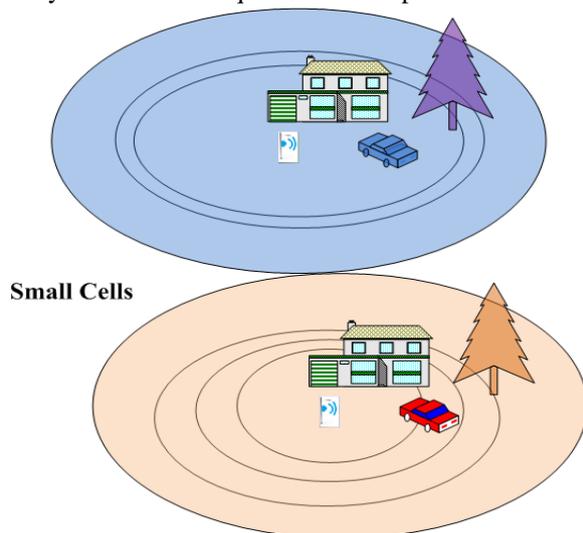Many new 5G techniques are developed for inclusion

Small Cells

Figure 1 Small Cells

in the 5G Network. All these new techniques will help 5G networks for achieving high efficiency. These new techniques will also help 5G networks for providing flexible and dynamic services. Main techniques which are included in 5G are given below:

3.1. *Small Cell*

As the number of users in the network increase, demand for the higher data rates also increase. One solution for this problem is to decrease the size of the cell and deploying many small cells. These are the low power transmission systems which cover the small geographical area. They can be placed on the wall or on the lamp post for supporting indoor or outdoor applications. These cells are further divided into three major categories i) pico ii) micro and iii) femato [10][17].
Figure 1 shows the small cells are used for covering small areas.

3.2. *Massive MIMO*

MIMO technology is the core component of 5G Network. This technology allows transmission and receiving of multiple signals simultaneously. MIMO technology use two or four antenna but massive MIMO uses a high number of antenna arrays. Main benefits of using massive MIMO are capacity of the wireless connection will be multiplied without requiring the more spectrum. It will help users to provide better data rates and reliability of the link [11].
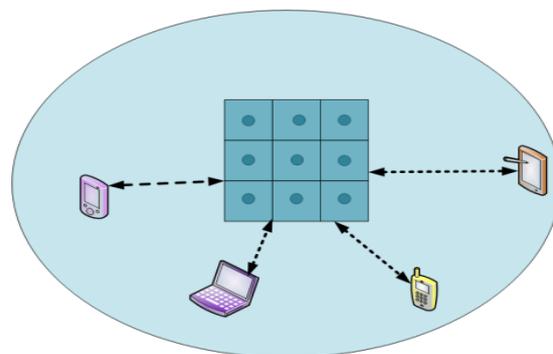

Figure 2 Multiple Antennas used in MIMO

3.3. *Carrier Aggregation*

Users nowadays demanding more mobile data from the network providers, therefore mobile carriers and manufacturers must increase the capacity and should offer this data with faster speed. But they have already utilized the existing Radio Frequency Spectrum. One solution for this problem is Carrier Aggregation. With the help of Carrier aggregation multiple channels are combined together to increase the performance of the network. This technique also allows the user faster

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downloading and uploading. Carrier Aggregation is already used in 4G LTE advance networks [13].

3.4. *Device to device communication*

It is a technology that allows user's device to communicate with the other device without the need of base station or access point. These can be cell phones or vehicle. One main application of D2D
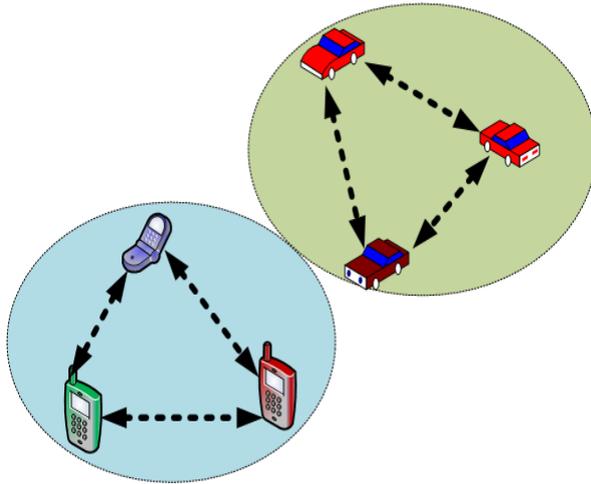

Figure 3 D2D Communication

communication technology is to provide the users local connectivity for safety purposes in case of damage to radio infrastructure [6][7].

3.5. *Radio Network Access*

5GNR technology will be used by 5G mobile network. It will utilize sub-6GHz frequency and mmWave frequency bands [8].

4. 5G technology depending factors

Many new technologies are being developed to be included in 5G standard. These new technologies will help the 5G networks to achieve the desired requirements [5]. Some main technologies are discussed below:

4.1. *Millimeter waves*

Spectrum range for 4G is from 2 GHz to 6 GHz. But nowadays users which are using 4G technologies are increasing data by day. Therefore all these users are using the same spectrum. So congestion in the network is also increasing. Transmission speed is also reducing between the two communicating devices. To overcome these problems there is need to use the higher spectrum. Millimeter waves uses spectrum within the range of 30 - 300 GHz, which can be used

to increase the speed between the two communicating devices.

4.2. *Small Cells:*

Main drawbacks of millimeter waves are that these waves cannot pass through buildings, trees, and mountains. These waves have very less wavelength. Therefore instead of using a single antenna many smaller base stations are used.

4.3. *Massive MIMO*

MIMO means multiple input and multiple output. This technology is used in 4G. But in case of 5G this technology is increased 4 more times.

4.4. *Beamforming*

Since 5G technology is using Massive MIMO so there is interference between the transmitted signals. In order to decrease the Interference a method beam forming is used. Beamforming means shaping of the radio signals and confining in such a way that these are focused on a particular area. Confining the radio signals avoids the unnecessary noise interference and the target area receives the maximum signal quality [9].

5. 5G Technological Challenges

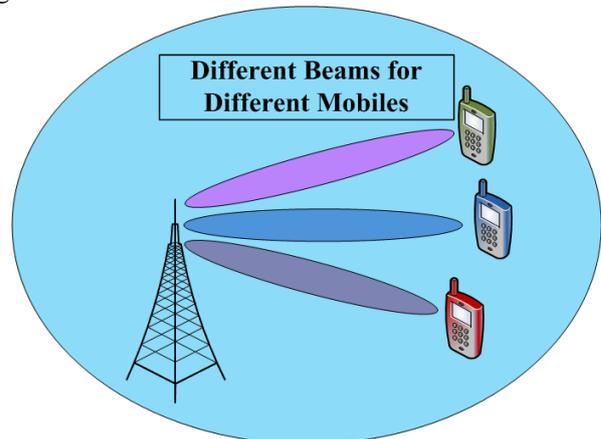Main Challenges for 5G with respect to technology are given below:

Figure 4 Beamforming

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5.1. *Interference*

It is the major issue that needs to be solved.
Due to the difference between the size of small cell and macro cell there will be interference problem [14].

5.2. *Device to device communication*

It is the new concept where one mobile device is communicating with the other device, without using the base station signal. This concept is very important in case of various emergency situations where there is poor signal or network is absent. Therefore there is need of complex transmission protocols to implement D2D communication. If the number of communicating devices increases within the same cell then there will be congestion problem [15].

5.3. *Hardware for handling the new frequency bands*

Current LTE devices operate below 3.5 GHz range. But in case of 5G unlicensed spectrum below 6Hz will be utilized. But the design of the hardware for handling millimeter waves is very complex. It will increase the device complexity [15].

5.4. *Massive MIMO Technology:*

Massive MIMO technology will be used in 5G. MIMO means multiple inputs and multiple outputs. So complex algorithm will be needed to implement this technology. Moreover this will also increase the complexity of user device and base stations [15].

5.5. *Security and Privacy*

Security and privacy is the major factor for any wireless transmission system. 5G network must ensure security and privacy of end users data and applications [15].

5.6. *IOT*

4G is already deployed in many countries but it will not support many new applications which will come in the next 5 or 10 years. Many applications related to IOT will not be supported by 4G. 5G technology will increase the data rates, and will reduce the end to end latency. These features are important for applications related to IOT. Another issue related to 4G is that in case of 4G there are different types of short range networks. e.g. RIFD, Bluetooth, UWB. But these existing small network technologies will not support IOT applications. So there is a need of unified network and 5G can provide solution for this [16].

5.7. *Small Cells*

5G technology has to deal with the issues such as higher band width, low latency, high data rates and reliability. To address these problems 5G technology has to use small cell concept. Small cell cover small geographical area. Small cell use short range and low power transmission systems. These small cells support all the features of the basic conventional base station. These systems can handle high data rates for the individual users. These small systems can be fixed on the wall for managing indoor applications or on the small tower or on the lamp post for handling outdoor applications. Backhaul connections can be made by using microwave or wired or using fiber connections. Problems with the small cell are that these signals will have lower penetration power. So coverage area will be very small. High power transmitter will be needed to cover the area [17].

6. CONCLUSION

In this paper new techniques and technologies which will be used by 5G Network are explained. One main objective of 5G is to help building smart cities. It will support high speed interactive multimedia, voice and other services over 5G networks. It will provide high capacity without decreasing the transmission speed. Now many users can be added to the network without decreasing the transmission speed. This paper also highlights research problem related to these technologies.

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