OVERVIEW OF ENERGY EFFICENCY TECHNIQUES IN 5G NETWORKS

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Abstract: An increase in the number of users and per user bandwidth, wireless networks require advancements byincreasing the cell site density. Suggested advancement includes what is called heterogeneous 5g networks in which small cells are added to the existing macro cell networks. The location of new small cell sites is decided by several locations - dependent factors like congestion measurements, user densities and requests. This paper provides an overview of the technologies and schemes used to make 5g wireless communication between the base station and the mobile subscriber energy efficient and also highlighting the drawbacks of each technology used. By using technologies such as mmWaves providing resistance to noise and very high bandwidth for providing better Quality of Service to customers, having a disadvantage for short range and facing problems in line of sight i.e. could be obstructed by some object. Other technology could be Massive MIMO that can improve the spectrum efficiency and also used to increase the gain of transmitted signals but has high signal processing complexity and costly implementation. Device-to-Device communication provides a method for Dynamic Routing to reduce cost and even provide connectivity in remote areas or dead-zones without proper infrastructure.

***IndexTerms* - Extreme Densification, mmWaves, Massive MIMO, Beamforming, Device-to-device communication.**

I. INTRODUCTION

The growing user request and increase in the number of wireless users has significantly outdone the growth of capacity per cell site over successive generations of mobile radio technology.

4G technology has been actively deployed around the world since 2008, providing data rates of up to 20 mbps and bandwidth of 5-20 MHz but with substantial increase in the number of users around the globe, no matter how fast cellular networks are evolving, they have not been able to cope with the hardware advancements of the mobile handsets or the content that can be delivered through them. Average latency of about 50ms on the current networks has prevented real time transmission of data which is hugely important for IoT, connected devices and sensors making advancements like deployment of self-driving autonomous vehicles on public roads possible [1].

Installing higher density of cell sites has been the primary response by the wireless carriers to the increasing bandwidth request. Most of the carriers globally have started small cell expansions to the current macro-cellular networks. The finances have become more testing now with the increasing cell site densities.

It has been observed that 70% of the energy is consumed on the BTS. If we use certain techniques for making the BTS energy efficient we could save huge amount of Power.

II. LITERATURE REVIEW

Several technologies have been introduced for developing next generation of mobile networks i.e. 5G networks. It is expected to reduce several drawbacks of 4G networks by providing desired characteristics [2] like:

- Data rates of up to 10 Gbps.
- Latency as low as 1-millisecond.
- 100% network coverage
- 100 times the number of connected devices per unit area as compared to 4G.

A. Role of BTS in Power Optimization

A technique to safeguard energy is by using base station sleep mode. There are two types of sleep mode that can be used for obtaining higher energy efficiency.

Light sleep mode –In this technique only the power at the amplifier if off and it is also known as discontinuous transmission.

Deep sleep mode – In this technique only the backhaul is functional and we save a large amount of energy [3].

The approximate power consumed in sleep mode by the BTS is 2.4 Watt. The traffic loads should be studied at each hour and according to load the BTS should be assigned to sleep modes. Also when the BTS wake up instant should be specified whenever an urgent need arises in case increasing traffic load. This technique will provide a method to safeguard a huge amount of energy and also promote Green networks.

B. Extreme densification

This is the approach where the number of network cells in a given geographical area is increased substantially by reducing the size of the cells, called cell shrinking. Femtocells [4] are used here for the implementation of this technology. A typical base station usually has a radius of about 20-30 kilometers whereas a femtocell has a radius of up to 10 meters (Wi-Fi like range).

Major advantages of this technology are as follows:

- Shorter cell range avoids inter-cell interference [5]. Hence, optimal use of spectrum is witnessed by using principle of frequency reuse.
- As less number of users shares a common cell now, competition for the use of base station resources is reduced.
- Closeness to the user and shorter coverage range means better quality and higher throughput.

Major disadvantages include:

- As more number of cells lead to the creation of more cell boundaries [6], the number of intercellular handoffs also increase substantially when the mobile device moves.
- Increase in the need for careful network management.

C. Millimeter Wave

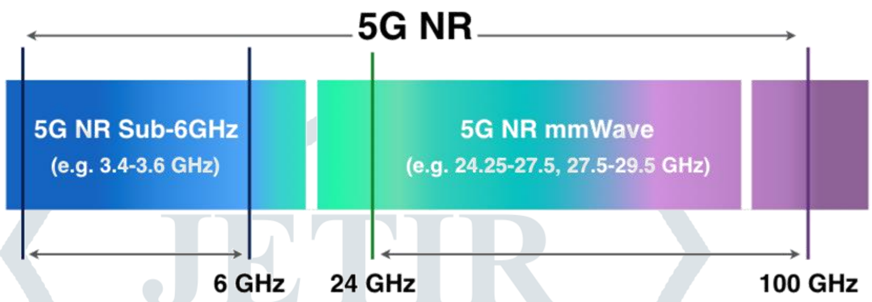

Fig. 1: 5G New Radio unified design across diverse spectrum bands and types including Millimeter Wave spectrum [7].

Currently, the spectrum bands allocated for wireless communications range from hundreds of MHz to a few GHz. But the spectrum that's currently in use is insufficient to deal with the bandwidth demand. This is due to the ever-increasing number of users and development of IoT (Internet of Things). Hence, to supply the demand, idle higher frequency spectrum is required. This is done using the millimeter wave spectrum. Millimeter wave [8] [9] spectrum also known as "beachfront spectrum" is the wave of spectrum between 30GHz and 300GHz [10]. The 5G new radio (NR) spectrum has been shown in fig 1.

Major advantages of this technology are as follows:

- High bandwidth availability.
- As available bandwidth is directly proportional to data transfer rates, it is capable of providing high data transfer rates of up to 10Gbps.
- Use of smaller circuitry and equipment as components and antennas used for millimeter waves are very small compared to lower frequencies.
- Low interference due to short range of millimeter waves.

However, there are a few challenges associated with this spectrum, like:

- It has a very limited range of about 10 meters due to the short wavelength.
- Millimeter waves are susceptible to high attenuation by fog, rain and moisture.
- As millimeter waves are highly directional and very narrow, link acquisition i.e. establishing connections between users and base stations becomes difficult.

D. Massive MIMO

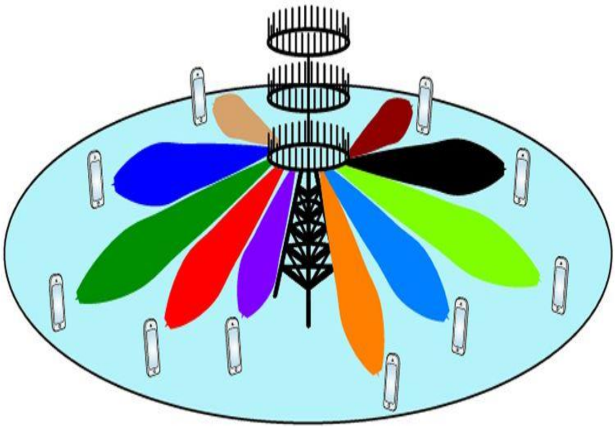

Fig. 2: Working of Massive MIMO [11].

Massive MIMO [12] [13] stands for massive multiple input, multiple output which is an extension to the MIMO technology. It is technology used for improving the spectrum efficiency and betters the throughput by grouping together a number of antennas at both transmitter and receiver as shown in fig 2. Massive MIMO uses around 100 of antennas at the transceiver per base station up from around 5-20 used in MIMO.

Major advantages of this technology are as follows:

- High spectrum efficiency due to a very large antenna array at each base station.
- High number of antennas at the transceivers leads to better performance in terms of data rate and link reliability.
- Massive MIMO antennas can be used to increase the gain of transmitted signals. It means this system is energy efficient as they radiate less power while transmitting data.
- It allows tracking individual user with a narrow signal beam giving the users a better and a reliable connection.

Challenges associated are:

- Architecture of Massive MIMO requires thoroughly different base station structures. Each of the antennas in use has to be powered by its own amplifier.
- High signal processing complexity due to high number of antennas and users.
- Implementation is costly.

E. Beamforming

Fig. 3: Working of Beamforming [14].

In a system that contains many antennas, beamforming [15] controls the directionality of the transmission or reception of a signal on an array of antenna by altering the phase and amplitude of the signals applied to the individual antenna elements in the array as shown in Fig 3.

Beamforming can be used at both transmitting and receiving ends. It has 3 subtypes [16]:-

- Analog Beamforming- Amplitude and phase of analog signal is varied at transmission end. Signals from all antennas are consolidated and is then ADC converted in analog beamforming at receive end.
- Digital Beamforming- Amplitude and phase of digital signal is varied and then DAC converted at transmission end. After ADC and DDC operations are performed, the reverse process is done.

- Hybrid Beamforming- Hybrid beamforming combines the analog and digital beamforming. Precoding is applied in both analog domain and digital domain at radio frequencies and baseband frequencies respectively.

Advantages of Beamforming:

- As beams are concentrated in the desired direction, it has a very high power and can reach subscribers that are far away.
- Interference near to the cell towers is avoided.
- It increases Signal to Noise ratio of the signal and hence the signal can withstand against noisy and attenuating channel which leads to better coverage capacity of the base station.

Disadvantages of Beamforming:

- Use of multiple antennas makes hardware complexity higher.
- Cost of beamforming system is higher in comparison to traditional systems.
- Power requirement in beamforming system is higher due to use of more resources.

F. Device-to-Device (D2D) communication

D2D allows communication between two devices without participation of base station. It allows routing of the data through proximity devices without needing network architecture. The main purpose of D2D communication is to reduce offload traffic. To develop efficient D2D communication, operation of D2D links and cellular communications within the same shared cellular spectrum is controlled and assisted by the network architecture.

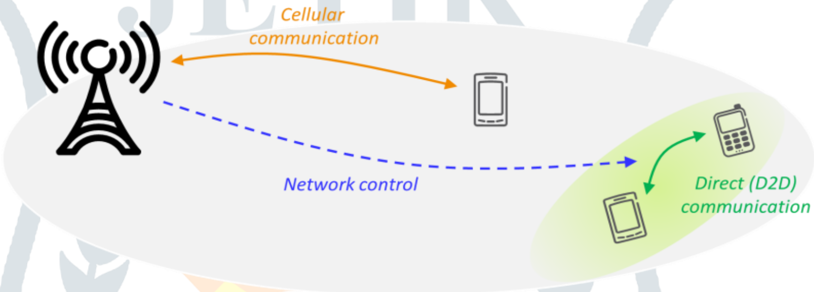

Fig. 4: Shows Device to Device communication [17].

Advantages of D2D communication are:

- Reduced latency.
- Spectrum reuse.
- Increased coverage area.

Disadvantages of D2D communication are:

- Less feasible as distance increases.
- Increased power consumption for detection of nearby devices.

Technologies	**Comparison Parameters**				
	Interference	***Range***	***Overhead***	***Spectral Efficiency***	***Bandwidth***
Extreme Densification	Low	Low	High	High	-
Millimeter Waves	Moderate	Low	High	Moderate	Very High
Beamforming	Low	High	Very High	Moderate	-
Massive MIMO	Low	Moderate	Very High	High	High
D2D	Low	Low	High	High	-

**QOS is high for all the techniques.*

Table 1: Represents Comparison between all the techniques

III. Hybrid Model

It has been established that the technologies if implemented independently is sufficient for meeting the subscriber demands. Hence we propose the use of hybrid models which shall combine two or more technologies. Hybrid models are aimed to remove the drawbacks of the technologies and to combine the advantages of the technologies.

Millimeter Waves have short range and are not able to travel around obstacles in line of sight such as trees and building. We propose to use D2D communication in combination with mmWave technology. The D2D communication shall allow user devices to relay the signal around obstacles. Adding beamforming to the system will ensure better signal transmission to devices in the line of sight further increasing performance and reliability of the system.

IV. Conclusion

With rapid increase in the number of users, the current generation demands the evolution of 5G to meet needs of the user's requirements. Techniques like Extreme densification are optimal in providing high QOS to the users and it also utilizes the spectrum in an optimal manner by using principle of frequency reuse. Millimeter Waves providing not only a very large Bandwidth but also high data transfer rates of up to 10Gbps.Though mmWaves have a very short range and face certain issues in line of sight with objects hindering the connection with device but still this technology can be used very efficiently to provide a very high speed connection to the users. Massive MIMO a technique that can be used to improve throughput and having a low interference can be useful for creating a better form of network connection by increasing the gain of transmitted signals and making system energy efficient by avoiding signal retransmission. Beam Forming can provide connection to subscribers who are far away by using powerful directional signal beams for connection. Being an effective technique it compensates for its high cost and complexity. Other energy efficiency techniques like Device–to-Device communication can be used to provide connections to users in remote areas by connected with devices without direct connection to the BTS.

Overall it is certain that combining these technologies to work together as a whole networking system, keeping in mind certain preventive measures for their drawbacks, a networking system can be created that would provide the users with higher data rates, better speed, larger range and high Quality of Service. The system will also be able to accommodate the rapid growth in number of subscribers will maintaining the required service quality standards.

V. Acknowledgment

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