Green Ultra Dense Networks

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ABSTRACT
Tremendous Evolution has been done from the day telephone was invented over the last few decades. The number of consumers has reached over a billion with the advent of new features and the basic need of communicating with a distant relative who stays miles apart in all possible ways. Technology has improved from only voice calls to video conferencing and may pave the way for High Definition video conferencing in near future, and Fifth Generation is the starting point for this. The packet transfer data communication service begun and consequently the data rates began increasing in the third and fourth generations. The microwave spectrum has become saturated due to increase in the number of mobile devices and now new spectrum needs to be legalized to improve the data rates to Gigabits. This paper studies the various technologies that are seen as the components for fifth Generation Networks like the Air interface, Spectrum and Antennas. This paper studies the basic layout for its architecture. However increasing carbon emissions and hazardous environmental impact of generating electronic waste in excess needs to be understood and efforts should be made to reduce it. This paper studies the various technologies used in Fifth Generation and how Cloud Radio Access Network can help advanced future generation networks transform to Clean and Green **Networks.**

Keywords
Fifth Generation, Air Interface, Antennas, Radio Access Networks.

1. INTRODUCTION
There is a huge demand for broadband like wireless communication by the consumers. This huge demand has put a lot of pressure on network operators to increase the speed of data transmission as well provide a large number of services in a cost effective manner. The number of consumers globally has already crossed a billionth mark and is still growing. This huge demand has led to spectrum shortage and the network operators are falling short of meeting these huge capacity requirements. Also though Long Term Evolution has been deployed but exact specified data rates by the Third Generation Partnership Project haven't been met yet. Research and Innovation in technology have led to the invention of various technologies such as Driverless Cars, Home Automation, Automatic traffic control systems, Automatic Accident Avoidance, Deep Machine, Artificial Intelligence, Delivery Drones and Smart watch to name a few. Constant reliable connection is highly important for these systems to work efficiently. These system networks need to be Ultra reliable. Device to Device communication will demand many new IP addresses as a new individual radio connection will be assigned to each and every small working device. This has created the need to think beyond Microwave Band.

The conventional microwave band is ubiquitous and hence has become saturated throughout these years. Research needs to be done beyond the conventional Microwave Band. The Millimeter Wave band is perfect candidate for the growing consumer needs. It ranges from 30 GHz to 300 GHz. Millimeter wave or Extremely High Frequency Range is studied widely to understand its attenuation and absorption problems. Therefore it can form the basis for fifth generation wireless communication and also for the future generations. Every generation has evolved with some new services provided to the consumers. Macro cells can be combined with small cells and Pico cells to provide point to point communication. However care should be taken that instead of increasing the number of devices the functionalities of different devices are incorporated into a single device.

However as the population increases, in order to meet basic needs such as food, shelter and clothing; trees are cut and green areas are transformed into concrete buildings. Over the past years this has taken a huge toll on our climate and nature. It has increased the carbon emissions in the atmosphere as well as has given invitation to Global Warming. A huge part of laying the hardware for fifth generation will force network providers to acquire new areas and create new and more complex Base Stations. Hence newer and Greener ways are studied in order to curb electronic waste on a large scale.

This paper studies the various wireless technologies such as millimeter wave communication, Pico cells, Air interface, Decoupling of uplink and downlink, Massive Multiple Input Multiple Output antennas and various other applications. These advancements are studied with C-Ran or the cloud Radio Access Network for a greener and softer implementation of fifth generation.

2. LITERATURE SURVEY
The 1G Phone or the Advanced Mobile Phone system is the first Cellular Wireless Phone system. It used Frequency Division Multiple Access as the modulation technique and transferred analog signals. It could be used only for calling and also had very poor voice quality. It was deployed during 1980s.It could support only one user per channel and required a large gap between the spectrum. AMPS used the concept of frequency reuse and provided interconnection between the PSTN and Cellular mobile phones. Maximum data rate was about 2.4kbps.Due to analog signals phone signals were not encrypted and hence the communication was not secure. It was the least secure communication ever.

FDMA did not prove much useful as it could not cater to the needs of new users and also occupied a large bandwidth for a single user. Better multiplexing was provided by Time Division Multiple access (TDMA) and Code Division Multiple Access (CDMA).GSM was first deployed in 1991 as a FDMA plus TDMA system [1].It allowed 3 users per channel. The maximum data rate achieved was 22.8kbps. The digital signals were encrypted and hence phone communication became secure over this period. The second generation introduced Short Messaging Service, Picture messages and Multimedia messages. 2.5G or General Packet Radio Service worked over Packet switched domain. The EDGE (Enhanced data rates for GSM evolution) further improved the data transmission rates with the introduction of 8PSK encoding.2G systems had few limitations such as it could not be efficiently used on tablets and few more features needed to be included in the services provided to the consumers.

The Third Generation was introduced in 1998 based on Wideband-Code Division Multiple Access scheme. 3G allowed many users to use the same frequency with a different unique code for each user. At the receiver end the user equipment could decode the code belonging to the particular user and the rest of the code seemed to be noise. Thus the entire spectrum could be utilized to its peak. It promised a wide range of data speeds depending on the position or status of the user such as a minimum data rate of 2 Mbps for stationary or walking users and 384 kbps in a moving vehicle. New features such as Global Positioning System (GPS), Location-based services, Mobile TV, Telemedicine, Video Conferencing and Video on demand were introduced in 3G which could not be implemented in 2G [2].

The High Speed Packet Access Technology known as 3.5G led to the evolution of LTE and LTE-A. Here the GERAN domain evolved from the integration of GSM and EDGE technologies. This works as the circuit switched domain for carrying the voice traffic. The UTRAN (Universal Terrestrial Radio Access Network) belongs to UMTS architecture which carries the data transmission.LTE has directly evolved into Evolved Packet Core where even voice traffic will be carried over a packet switched domain.

LTE delivers a data rate of 300Mbps downlink and 75 Mbps in the uplink. LTE-A requires to deliver a peak data rate of 1000Mbps in the downlink and 500Mbps in the uplink [3]. The major difference between LTE from the other technologies is that it allocates an IP address to a device as soon as the device is switched on and releases the IP address when the device is switched off. LTE uses OFDMA scheme for downlink, SC-FDMA (single Carrier Frequency Division Multiple Access) for uplink and 64QAM modulation. It works on 4x4 spatial multiplexing for downlink. LTE-A uses another scheme called carrier aggregation for achieving higher data rates [4], [5].

The data rates proposed for Fifth Generation is in GHz range, approximately 10Gbps for downlink and 1000Mbps for uplink. In order to achieve such high data rates point to point and point to multipoint communication is required. LTE uses the concept of Macro cells. The range of macro cells is several kilometers. The transmitted wave travels through obstacles and fades by the time it has reached the receiving antenna. Hence small or Pico cells will be used for Fifth Generation along with different modulation schemes to increase the accuracy and provide high data rates in point to point communication[6].This will be used with massive multiuser multiple input multiple output antennas with the backhaul network communicating on millimeter wave. The decoupling of Uplink and Downlink will increase the capacity of systems and thus reduce the power consumption by user equipments [7], [8].However this abundance of advanced technologies is going to generate a lot of electronic waste and much further harm the environment. A balance needs to be created between the advanced technologies and nature. Hence an alternative to this problem is Green IT or adopting green technologies. An example of green technology is the CRAN.CRAN and software defined networking will help to curb the harm caused to environment and can help us creating a perfect balance between technology and nature [9], [10].

3. WIRELESS TECHNOLOGIES FOR FIFTH GENERATION

Since the inception of newer technologies mobile traffic has increased 10 fold. The mobile traffic may become very dense by 2020 with most of it generated indoors or hotspot generated traffic. Hence the capacity of the network needs to be improved by 1000 fold. The downlink data will immensely be more as compared to the uplink data. The data connectivitywill increase. All the machines will be connected to the user's mobile phones and to each other. The energy consumption by the devices needs to be reduced by 100 fold. Also reliability needs to be increased by reducing latency. Below are the features and Technologies that will define 5G.

3.1 Evolution for 2020 and Beyond

Considering the current Scenario in LTE-A the number of users is restricted by the amount of bandwidth utilized and available. Hence it is necessary to increase the bandwidth which will increase the system capacity. Thecurrent concept of frequency reuse can be used with the number of increased Cells. 4G systems are implemented on the concept of Macro cells which limits the system capacity. If the number of cells is increased the system capacity will automatically increase.

3.2 Increasing the System Capacity

A basic scenario for increasing the capacity of system is by developing Ultra dense Networks or the Heterogeneous Networks. An ultra dense Networks as its name suggests will include many small cells or more specific many Pico cells and Femto cells deployed in today's Microcells. The cells can be Micro cells, Pico cells, Femto Cells, Consumer Femto cells, Enterprise Femto cells et al. The Pico cells have a range of about 15 to 200 meters outdoors and 10 to 25 meters indoors. They will be used to cover locations such has Malls, Business Parks, Hospitals, Schools, Colleges et al. Each Pico cell will be controlled by its Corresponding Macro cell. This type of architecture is known as the ultra dense Architecture. However it will increase the cost of installation and maintenance of all these small base stations. It will reduce the power transmitted by the user equipment as the range for transmission will be greatly reduced. Heterogeneous networks will work on the integration of Wi-Fi, LTE cells and different Access Points provided by different Network providers both in the licensed and unlicensed band. Thus small cells will increase the overall capacity of the system.

In order to increase the range of the Macro cell Base stations we will have to increase the no of antennas at the macro cell base station. This concept is called as Massive MIMO.

3.3 Massive MIMO with Millimeter Wave Communication

MIMO stands for Multiple Inputs Multiple Outputs. MMO can be of four types Single Input Single Output, Single Input Multiple Output, Multiple Input Multiple Output and Multiple Input Multiple Output. Hence the number of transmit and number of Receive antennas can be increased to about 128.

Long Term Evolution uses 4x4 MIMO. Massive Multiple inputs and Multiple outputs is suitable for 5G as there will be many no of Pico cells that will send data to the macro cell base station. The number of connected devices will be huge and hence we need a base station which can handle a huge number of transmissions at the same time. This is possible by using the same Massive MIMO base station instead of a single input single output antenna. There are many factors which need to be studied before such a concept is implemented such as spatial Multiplexing, beam forming and diversity. Spatial Multiplexing uses multiple paths to send same data thus using them as additional channels to send data. Beam forming techniques are used to further send accurate data. Phased arrays and adaptive phased array systems carry out channel estimation for multiple channels. The basic difference between diversity and spatial multiplexing is that in spatial diversity same information or data is transmitted on different channels whereas in spatial multiplexing data is divided or modulated and transmitted over different channels. In Phased Arrays the switched beams are predefined and in adaptive Phased arrays the receivers adapt to the strongest beams in real time. Hence Adaptive Beam forming is more costly and complex.

3.4 Decoupling of Uplink and Downlink

In conventional Architecture same Base station was used for both uplink and downlink. Communication was carried out with the same Base station for Sending Control Information such as Power Control, Signaling information and sending of User data was done on the same plane or same Base station using either FDD or TDD. This technique had few disadvantages. Since the main Base station controls the Macro Cell, the user equipment has to use more power to transmit data to and from the base station. In small cells the user equipment can detect the small cell base station nearest to it and then transmit the data hence the power required by the UE will be less here. Hence the user data can be transmitted over small cells or Femto cells and the controlling information can be transmitted by macro cells. This technique is called as decoupling of User plane and Control Plane.

The decoupling of user plane and control plane will automatically reduce SNR. This technique will also reduce the uplink transmit power.

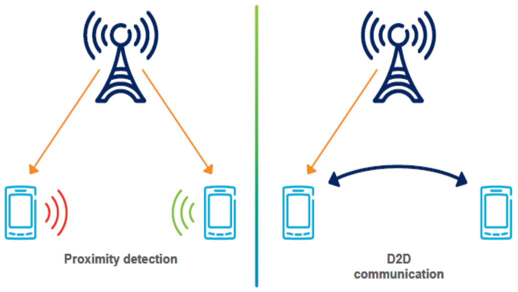

Fig. 2 Distribution of Electromagnetic Spectrum

Higher-frequency bands in 5G will provide capacity with smaller cells, and lower bands will provide coverage with larger cells.

Until now Orthogonal Frequency Division Multiplexing had been used for LTE and LTE-A. Also the different Modulation techniques for 5G that can be used are Filter-Bank Multi-Carrier transmission, Universal Filtered Multi-Carrier transmission, and Generalized Frequency-Division

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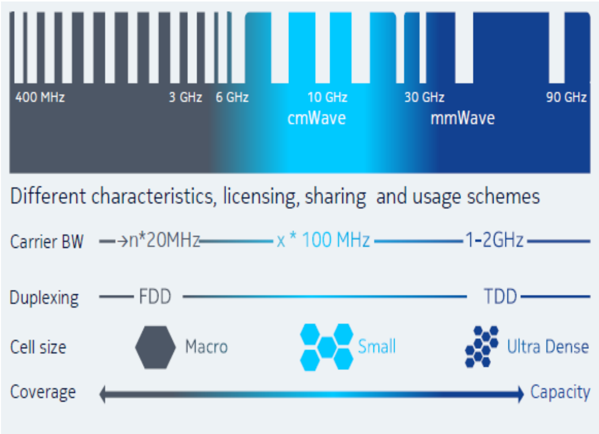
In Device to Device Communication small antennas can be mounted on the roof of the car and hence decoupling of data and user plane open numerous opportunities for small distance communication as it will help in device D2D communication. Proximity detection is mainly to detect nearby user and D2D communication is the actual transfer link between the two devices. This allows communication between two devices without actually involving the core network.

3.5 Air Interface

LTE uses both Frequency Division Duplex and Time Division Duplex. Major work has already been done on FDD however TDD still needs to be explored. Till now Static Time Division Duplex has been used. Static TDD is not flexible and is rigid. Hence it cannot be used where there are many fluctuations in the uplink and the downlink. This might cross mutual interference problems in Massive MIMO Networks as Millions of devices may be connected to Macro-cells. In order to avoid these problems Time Division Duplex will be used for 5G architecture. Different users can be given different free slots in TDD and the problem of interference can be reduced to a greater extent.



3) Ultra-Reliable Critical Services: Examples are as follows

- Industrial Automation
- Robotics
- Artificial Intelligence
- Medical Automation
- Aviation Industry
- Vehicle to Vehicle Communication

Multiplexing. Orthogonality in OFDM avoids interference and creates high capacity but requires extensive signaling and increases delay. Non-Orthogonal Multiple Access and Sparse Coded Multiple Access could complement orthogonal access by taking advantage of advanced interference-cancellation techniques.

4. FIFTH GENERATION VISION AND APPLICATIONS

Fifth Generation has the capability to transform the world into a truly connected and highly reliable smart society of human beings. The Vision of Fifth Generation can be considered as follows

1) *Evolved Mobile Broadband*: Examples are as follows
- 3D and Ultra High Definition Teleconferencing
- Virtual Reality
- Augmented Reality
- Live Feed through Venues
- Software Defined Networking

2) *Internet of Things*:
 Examples are as follows
- Smart Cities
- Smart Homes
- Inventory Management
- Wearable Device

Device to device communication would be possible on a real time basis. Hence Low latency and Ultra Reliability becomes an important part in the real time communications. Accidents can be avoided with the help of V2V communication. The Vehicles will operate as Vehicle to Pedestrian, Vehicle to Network, Vehicle to Traffic Signal and Vehicle to another Vehicle. Hence the backbone of this network needs to be really strong and secure. One small bug or virus can damage the entire system network.

5. GREEN ULTRA DENSE NETWORKS

This paper gives a brief over view of all the changes and all the technological challenges that will be undertaken for the implementation of fifth generation mobile communication.

As seen the number of base stations and antennas is going to be increased ten folds. This means there will be a small base station every few kilometers. This will increase the capacity and speed of network and also will provide better coverage however this comes with additional costs.

5.1High Maintenance Costs

Each Base station is deployed taking into consideration the maximum traffic that it will be able to be sustained. In case of Fifth generation the number of Base stations is going to be very high due to the implementation of Pico cells hence it will increase the cost many folds. Each new base station that will be deployed will require space, additional hardware requirement and also air conditioning. The site support power equipment also increases much of the network providers overall cost.

5.2 Dynamic Traffic

While implementing a network user mobility also needs to be considered. The traffic data rate is much lesser in a residential area as compared to a corporate area during the day time or the peak hours. Hence the base station is powered with much extra capacity in order to operate efficiently during the peak hours too. However the Bases station lies idle when the traffic is less and hence its resources are underutilized.

5.3 Heterogeneous Networks

Fifth Generation will coexist with the existing 2G, 3G, and LTE/LTE-A networks for a long time in order to meet consumer demands. Therefore interconnectivity between different networks and different service providers will have to be maintained. Multi-mode Base stations will be required further making the Radio Access Networks more complex.

5.4 Environmental Effect

In order to create more space for larger Base Stations the green cover has been greatly reduced or damaged. The amount of electronic waste which still hasn’t been recycled is huge. Electronic waste is one of the largest wastes to be generated in the last decade. Also a large part of it isn’t recycled properly. It cannot be buried or burnt as burning electronic waste produces dangerous and hazardous fumes that can cause air pollution and lead to air borne diseases. Hence the only solution to this problem will be to reduce the number of extra hardware equipments either by virtualization or making them more compact.

5.5 Software Defined Networking

Hence all the technologies studied so far needs to be implemented in a greener and softer way with the help of another concept called C-RAN. C-RAN stands for Centralized, Cooperative, Cloud and Clean Radio Access Network. C-Ran paves the way for Network Function Virtualization and Software Defined Networking. All the different functionalities of Air Interface will be included into a two small units called the Baseband Unit and the Remote Radio Unit.

6. CONCLUSION

Thus this report describes how the foundation for Fifth Generation Ultra Dense Networks can be laid by studying the various candidates for its deployment. It gives a brief overview of all the changes that might be required in the current scenario by putting forth different technologies that can be used to achieve the give 1000 fold data rates, massive communications, ultra reliability, extremely low latency and less energy consumption. It also puts forward that along with advancements in technology a clean and green way should be adopted to meet the high consumer demands. This can save the environment and thus pave the way for green communications.

7. ACKNOWLEDGEMENT

I express my gratitude to respected Principal Dr. Manjusha Deshmukh and Prof. Sheetal Bukkawar, H.O.D of Electronics and Telecommunication Department, Saraswati College of Engineering for providing me an opportunity to present a seminar on “Green Ultra Dense Networks”.

My sincere thanks to my project guide Dr. Manjusha Deshmukh for her invaluable support, encouragement, supervision and useful suggestions. Her moral support and continuous guidance enabled me to complete my work successfully.

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