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Green Communication Technologies and Solutions

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Abstract: ***During the past few years, there is a huge increase in connected devices and with the advent of 5G, this will surge. Number of mobile users alone is expected to reach the mark of 5.01 billion by 2019. Higher data rates and fast speed internet will be a basic requirement for these connected devices. A large amount of transmit power would be required to support all these devices resulting in a huge amount of energy consumption. This would result in the emission of greenhouse gases. It is evident that a large amount of carbon dioxide would be produced by these connected devices, which will increase, by millions of tons of fold in future. The energy efficient devices and the control of power consumption in cellular networks are one of the key features of green communication. Resource allocation is one of the techniques to control the power consumption and to make the network energy efficient. Hence, there is an urgent need for the green communication that is a discipline of greater interest with the on-going evolution in the information and communication technologies. The researchers and industries are doing their best to find the most feasible solutions and techniques for the green communication. A lot of work has already been done in this field. This paper presents a review on some techniques employed in the field of 5G communications namely Device-to-Device communication (D2D), massive MIMO (Multiple Input Multiple Output), Heterogeneous Networks (HetNets) and Green Internet of Things (IoT) and some challenges are discussed.***

Keywords: Green Communication, D2D, massive MIMO, HetNets and IoT.

1. Introduction

Green computing is concern with eco-friendly use of computers and their resources. In broader terms, it is also defined as the study of designing, engineering, manufacturing and using the computing devices in a way that reduces their environmental impact. The goal of green computing is to lower down the use of hazardous materials, maximize energy efficiency and popularize biodegradability or recyclability of out-dated products and factory waste. with the growth in population resulting in innovative technologies. Basically, the efficient use of computers and computing is what green computing is all about. A central point of research is testing and applying alternative nonhazardous materials in the products' manufacturing process. The idea is to make computers from beginning to end a green product. Many researches on wireless system have omitted the significance of environmental responsibilities i.e. designing energy inefficient system which causes harm to the planet earth. This kind of activities may leads to rapid growth of greenhouse gases in the atmosphere which was not initially predicted. The overheat occurring in the atmosphere due to Radio Frequency [1]is carried down to the surface by normal convection which further leads to global warming. To address these kinds of issues raised by wireless technologies, the researchers are motivated towards "green wireless communications" which helps reducing environmental impact and even improves energy efficiency. Green communication technique can be adopted in order to degrade the greenhouse gases production due to wireless systems. The regular use of mobile and the growth of internet and wireless technologies increase the emission of CO2 and it could be continued until the networking technologies attain a good energy efficiency system. As IP-based network consumes more energy, the green telecommunication will help in development of energy efficient system with many considerations [2] such as safe telecommunication waste disposal, greening of telecommunication networks and atmosphere friendly design of telecommunication buildings.

2. Green Communication Standard's Terminology

Green handover: When the base station completely switches off its radio communication and associated processing when they are not involved in an active call is known as green handover.

Green codes: The code which attempts to minimize the total energy per-bit required to communicate across a noisy channel is called as green code.

Green electronics: Green electronics analyze compounds of natural agent and endowing economically powerful track for the production of synthetic materials which have relevancy in environmentally safe biocompatible devices and becomes environment friendly electronics and the integration of such electronic circuits with living tissue in particular system [3].

Green antennas: Green antennas were initially proposed with non-planar ground plane and Suspended Plane Antenna (SPA) elements. Each element in SPA has been excited with fundamentals of hail TM mode through L-Probe. For practical experimentation of the research, Ushaped ground plane antennas which also demonstrate the phenomenon of light reflecting surface for solar cell panels. The U-shaped antennas can significantly increase the output voltage of solar cell panels [4]. This kind of Ushaped antennas with solar cell panels demonstrates the behavior of green antenna and these antennas surely enable the future generation wireless technologies.

Green base station standards: It is equipped with the regenerative energy sources like wind power and photo voltaic energy to reduce the power consumption, whenever sunlight or wind is present. During operation times when wind power and solar energy are not sufficient to feed the BTS, additional energy is supplied from the public mains grid.

Downlink and uplink: The communication path established to the ground from a satellite is called as downlink, and the

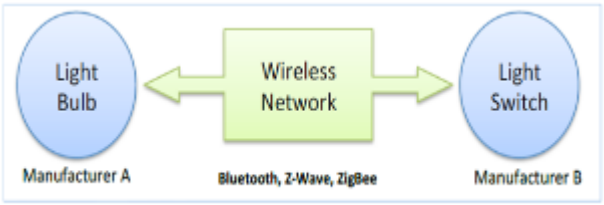
communication established to a satellite from ground is called as Up-link. When spacecraft receives the uplink at the same time Earth receives downlink, the communication is called two-way.

3. Green Computing Techniques

The evolution of 5G has a strong urge for the green communication. Some of the techniques for green communication used in 5G are discussed below.

3.1 Device-to-Device Communication

Device-to-device (D2D) communication that enables direct communication between nearby mobiles is an exciting and innovative feature of next-generation cellular networks. It will facilitate the interoperability between critical public safety networks and ubiquitous commercial networks based on e.g. LTE. The D2D communication is a strong candidate for 5G cellular networks. Spectral efficiency and energy efficiency of the network can be increased through this technique. It also offers advantages of reduction in latency and reliable link through the direct communication. In D2D communication, the users communicate directly, which causes offloading of the data traffic at base stations. It allows the base stations to go in the sleep mode that will save large amount of power. In return, less energy will be consumed resulting in reduced levels of CO2 emission. Energy efficiency comes into play for both wired and wireless networks [5].

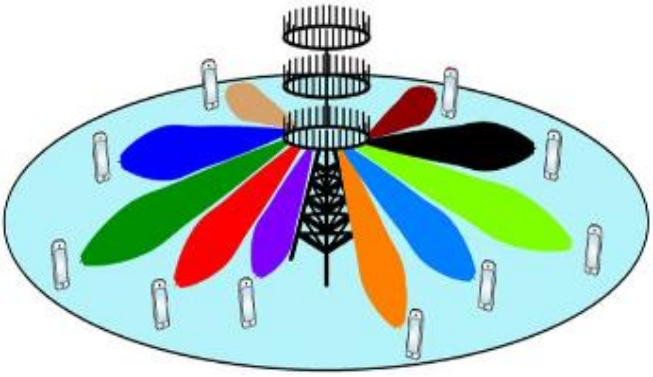


Example of device-to-device Communication model

In wireless communication, the base stations have to transmit a large amount of power by consuming a lot of energy when the users are at the edges of the cells. The D2D communication is the best choice for such a scenario making the system energy efficient. There are three modes of operation in D2D communication, that are cellular, dedicated and reuse mode. The overall efficiency of the network can be increased by selecting the most appropriate mode.

3.2 Massive MIMO

MIMO stands for Multiple-input multiple-output. While it involves multiple technologies, MIMO can essentially be boiled down to this single principle: a wireless network that allows the transmitting and receiving of more than one data signal simultaneously over the same radio channel, typically using a separate antenna for the transmitting and receiving of each data signal. Standard MIMO networks tend to use two or four antennas to transmit data and the same number to receive it. Massive MIMO, on the other hand, is a MIMO system with an especially high number of antennas.The massive MIMO has several advantages like good energy efficiency, robustness, enhanced throughput, latency reduction and high capacity gains . Massive MIMO can be integrated in three different ways: network massive MIMO, single massive MIMO and distributed massive MIMO. The selection of these techniques is based on the network requirement in terms of power control and energy consumption. In a multi-cell massive MIMO, the transmitted power is controlled by taking power constraints at the base station and spectral efficiency constraints at the user end into account .

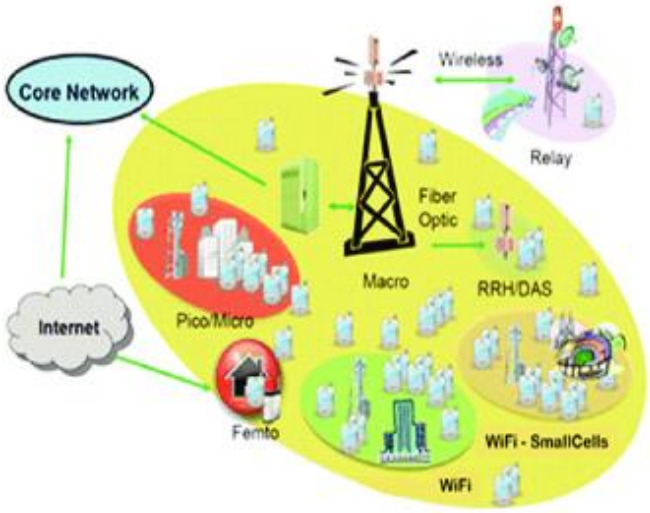


In massive MIMO, the selection of antenna plays an important role. To control the power consumption at the base stations, the antennas should be energy efficient. Overall system architecture simplification in massive MIMO can also be used to reduce the power consumption. Reconfigurable antennas are also a solution for this this problem. Another technique that can be used in massive MIMO for energy efficiency is antenna muting [6]. Muting the antenna in no load or light load conditions can save about 50% of the power. If an antenna has two or more ports, in the condition of light load or no load, only one port could be kept turned on by turning off the rest of the ports. This would not affect the overall system performance and will save a considerable amount of energy.

3.3 Heterogeneous Networks

A heterogeneous network is a network connecting computers and other devices with different operating systems and/or protocols. For example, local area networks (LANs) that connect Microsoft Windows and Linux based personal computers with Apple Macintosh computers are heterogeneous. The word heterogeneous network is also used in wireless networks using different access technologies. For example, a wireless network which provides a service through a wireless LAN and is able to

maintain the service when switching to a cellular network is called a wireless heterogeneous network. [7]



In a heterogeneous network, there is a large number of micro, pico, and femto small power cells and very few large power cells. This kind of mixed wireless system brings the end users closer to the network by increasing signal to interference noise ratio (SINR). This technique gives a robust link and good quality of service. In HetNet, the frequency reuse can reduce the bandwidth issues.

The power consumption in HetNet can be controlled by putting the small cells in sleep mode when there is a low load or no load [8].

3.4 Green Internet of Things

With the rapid development of science and technology, the world is becoming "smart". Living in such a smart world, people will be automatically and collaboratively served by the smart devices (e.g., watches, mobile phones, computers), smart transportation (e.g., cars, buses, trains), smart environments (e.g., homes, offices, factories), etc. For example, using a global positioning system (GPS), a person's location can be continuously uploaded to a server that instantly returns the best route to the person's travel destination, keeping the person from getting stuck in traffic.

The Green Internet of Things is another potential dimension of 5G green communications that is aimed to provide integration of a number of fields. To facilitate the reduction in greenhouse effect, the Green IoT plays an important role by employing energy efficient procedures. Wireless Sensor Networks are the key element for the Internet of Things. To achieve energy efficiency, each node in Wireless Sensor Networks should be operated with controlled power consumption that is not an easy task . In [9], an energy saving technique is introduced in which the data from the near nodes is collected slowly while it is acquired quickly from the far off nodes. This technique results in approximately 19% of energy saving. Sleep modes method is used in this technique. The energy efficiency in the IoT can be enhanced by switching the redundant and irrelevant nodes to sleep mode [10]. This technique has its advantages for both wired and wireless networks. For energy efficient Wireless Sensor Networks, the particle swarm optimization technique is proposed. Through this method, 1 dBm of power can be saved. The Internet of Things can be combined with various other techniques for energy efficiency but in conjunction with D2D, the IoT are more reliable and energy efficient.

4. Challenges

With huge benefits, green communications come at a price. Some of the key issues that might slow the deployment of green solutions are as follows:

4.1 Cost

Although green communications is poised to have less energy consumption and hence, save money, requirement of new infrastructure such as in heterogeneous networks, is often associated with much higher costs than the existing techniques. Similarly, incorporation of energy efficient schemes in devices may require higher computational power and result in increasing their price.

4.2 Spectrum Efficiency

Spectrum efficiency, which is defined as the throughput of the system, is another important issue that needs careful consideration. According to the Shannon's capacity formula, the transmission rate is directly proportional to the amount of available transmit power and bandwidth [32]. Controlling the transmission power to make the communication green would impact the data rate. Therefore, efficient characterization of this trade-off considering practical hardware constraints is key to the success of such solutions.

4.3. Bandwidth

Bandwidth requirements are another tradeoff for the green communications. Shannon's capacity formula puts the bandwidth in direct relationship to the transmission rate for given amounts of transmit power. Energy consumption can be reduced by expanding the bandwidth for a given data transmission rate . However, bandwidth expansion does require changes in terms of new schemes and their integration with existing networks. A detailed analysis of this aspect is therefore, necessary for the success of green communications.

5. Conclusion

Green computing presents a responsible way to address the issue of global warming. Whilst the performance and the breadth of application of computers is increasing, so too is our awareness of the cost and scarcity of the energy required to power them, as well as the materials needed to make them in the first place. However, because computing developments can enable individuals and businesses to adopt greener lifestyles and work styles, in terms of the environmental debate computing is definitely both part of the problem and part of the solution. By adopting green computing practices, business leaders can contribute positively to environmental stewardship— and protect the environment while also reducing energy and paper costs.

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