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Survey Study on Aspects of Green Communication Systems

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ABSTRACT: As cellular technology develops, energy use in mobile networks has increased, sending carbon dioxide emissions through the roof. The ecology and human health are suffering as a result. This study offers a survey of methods for making the cellular networks of the future green in order to address these issues. In a cognitive and high data rate network, this study discusses recent technological advancements in the area of RF energy harvesting. It has been found that a cognitive platform with an effective RF energy collecting technology unquestionably moves communications toward a greener paradigm. Here, a brand-new security and environmentally friendly communication technique is suggested for networks based on interference-alignment (IA). Full-duplex receivers are used to send fake noise in order to achieve a secure communication (AN). Recently, there has been a lot of interest in green wireless communications in the hopes of discovering new ways to increase energy efficiency for the widespread use of wireless applications. In this paper, we argue and demonstrate that the time-reversal (TR) signal transmission is the ideal paradigm for environmentally friendly wireless communications due to its inherent ability to fully harvest energy from the environment by taking advantage of multi-path propagation to re-collect all the signal energy that would have otherwise been lost in most current communication paradigms. Low energy consumption and less radio pollution for users besides the intended one are requirements for a green wireless system.

KEYWORDS: Challenges, Green Communication, Networks, Techniques

I. INTRODUCTION

The energy consumption of wireless networks and devices has dramatically increased in recent years as a result of the industry's rapid expansion in terms of network infrastructures, network users, and numerous new applications. Due to the widespread use of wireless applications, this rising energy consumption not only places a high burden on wireless communications operators in terms of operational costs and an urgent need for battery/energy capacity, but it also worsens electromagnetic (EM) pollution to the environment at large. In order to identify creative ways to increase energy efficiency, relieve or reduce radio pollution to intended users, and preserve or improve performance metrics, the notion of "Green Communications" has gained a lot of attention. Green communication and increasing power efficiency are becoming more crucial for wireless communication as a result of the rapid expansion of wireless networks and data-intensive applications. With the goal of lowering wireless network power consumption, green wireless communications have attracted a lot of interest in recent years [1]. Particularly, a number of green communications technologies have been put forth, such as cooperative relaying [4], C-RANs [2, 3], and energy harvesting. As a result, over the past two years, government, academia, and business have all given Green Communications a lot of attention [5]. The goal of green communications is to identify suitable network designs and radio technologies that enable the necessary power reduction, as well as to research and develop novel approaches for reducing the overall power required to operate the future mobile communications systems.

S. A. Hassan et. al. (2019) studied in IOT networks; energy-efficient green communication is receiving a lot of attention. The provision of captured energy is a crucial component of green networks. A wireless powering and energy-harvesting-based strategy is suggested for green IoT networks. Radio frequency (RF) transmissions are used in wireless powered communication networks (WPCN) to deliver electricity to Internet of Things (IoT) devices. Backscatter communication is one of the main WPCN enabling methods (BackCom). Backscatter nodes (BNs) and a reader make up a BackCom system. Additionally, employed for a BackCom system were the frequency division multiplexing (FDM) and time division multiplexing (TDM)-based access schemes. In addition to frequency and temporal multiplexing, non-



orthogonal multiple access (NOMA) can be employed effectively to boost the spectrum efficiency of the BackCom system. NOMA is anticipated to be a critical technology for next-generation wireless networks since it enables several users or devices to use the same time-frequency resource block [6].

Bryce R. et. al. [2018] studied the concept of Message Queue Transport Telemetry, sometimes known as MQTT, is a publisher/subscriber open-source standard for M2M (Machine to Machine) communication that has been studied. It is well known for having a small energy and bandwidth footprint, which makes it ideal for Green Internet of Things (IoT) messaging applications or in mobile devices like phones, embedded computers, or microcontrollers where power consumption is limited. It is a fantastic instrument for the green communication age upon us and more precisely Green IoT. Also designed a framework to enhance the MQTT protocol. We call our new protocol MQTTg. It is a well-known and widely used protocol for exchanging data between IoT devices. a MQTT is an incredibly simple and lightweight messaging protocol in its original version, having a publish/subscribe architecture. Prior to the work presented here, we made an effort to address MQTTg using the protocol's Mosquitto implementation [7-8].

II. METHODOLOGY

The ongoing investment in green communications has produced a plethora of engineering knowledge and solutions up to this point, generally falling into two categories. Power amplifier designs that are incredibly efficient are discussed in the first section. For instance, high efficiency class F amplifiers were presented in [9]. The second section, often known as Green Networks, focuses on network architecture, MAC protocol, and routing designs [10-11]. The evaluation of green communication energy in Reference [12] placed a strong emphasis on effectiveness, lowering operating costs, and cutting carbon emissions. The 5G mobile communication R&D project was established as early as 2012. However, some of the main technologies for green communication need to be steadily upgraded to increase the quality of service in order to give people better service. The 5G mobile communication network uses green communication technology, which is based on three principles: self-organizing networks, extremely dense heterogeneous networks, and direct-to-device (D2D) networks [13]. The existing 4G mobile communication network is the first source of demand for self-organizing networks. The technician personally deploys the network and then oversees its operation and maintenance. The idea behind a self-organizing network is that intelligence within the network takes the role of manual tasks. The existing self-organizing network, however, also has several flaws and is unable to fully automate the work. Self-organizing networks have the potential to eliminate manual intervention and increase energy efficiency, but the technology still requires development.

Second, compared to the number of base stations used in a conventional cellular network, the number of access points (APs) installed in an ultra-dense network is referred to as having "super-high density." In the era of 5G networks, it is frequently viewed as a new networking model. Consequently, it is also known as Ultra Dense Networking (UDN). The 5G mobile network's green communication must be able to sustain transmission rates and data rates that are thousands of times higher than those of today. As a result, the cell radius is decreased, the density of the low power node is raised, and the data transmission distance is lowered. Device to Device, or D2D, is a new technology that enables terminals to connect with one another by sharing cell resources while being under the direction of a network system [14]. The frequency efficiency of cellular communication systems may be efficiently increased with the help of D2D technology in 5G technology, which can also lighten the strain on base stations. Networks for communication are naturally green. The only other option, if we are unable to use a telecommunication system, is to physically transport the source to the destination (or vice versa), but this is undoubtedly less energy efficient. In reality, we should consider the environmental advantages of using communications networks because they lessen the need for road transit for information delivery between entities and enable green solutions.

In this context, "Green Communications" is defined as a framework for the design and decommissioning of communication networks that strives at a sustainable growth of telecommunications networks, encompassing wired and wireless networks: in this study, we just focus on the wireless aspect. the lowering of electromagnetic radiation through improved wireless technology's energy efficiency communication systems are crucial for maintaining public health and are thus a step closer to green communication.



What is Green Communication?

A. Types of Environmental Impacts

What exactly is meant by "green" communications is one of the main topics when talking about them. It makes sense to believe that "environmentally friendly" is a synonym for "green."The issue of carbon emissions is currently receiving the greatest attention because it is related to global warming and the resulting climate change. However, with relation to concerns including the ozone layer, usage of natural resources, waste reduction, and the quality of the air, water, and soil must all be taken into account while coming up with an environmentally friendly solution.

Material	Mass (g)	Enrichment Factor	Waste Without Recycling (g)	Recyclability	Waste With Recycling (g)
iron	8090	3.3	26697	0.8	5339.4
copper	2005	110	220550	0.9	22055
Lead	996.5	39	38863.5	0.95	1943.175
aluminum	820	2.9	2378	0.8	475.6
tin	67	2900	194300	0.7	58290
zinc	21	300	6300	0.3	4410
nickel	17.25	39	672.75	0.8	134.55
silver	1.75	2600	4550	0.98	91
gold	0.53	2500	1325	0.99	13.25
platinum	0.066	770	50.82	0.8	10.164
chromium	0.05	2.3	0.115	0	0.115
	12 kg		500 kg		93 kg

Table. 1 Materials and Related Ore Wastes in A PC

Heavy metals and rare minerals are commonly found in significant amounts in telecommunications equipment. Table I contains some of the key information elements that are commonly found in personal computers [15]. The typical ore enrichment variables and their recyclable nature are shown next to it [16–17]. The amount of waste compared to the mass of useable material in a mining ore is represented by the ore enrichment factor. These figures allowed us to calculate the amountof waste generated both with and without recycling of materials.

We can observe that whereas 12 kg of computer-useful material can be recycled, 500 kg of mining waste would otherwise result. This exercise is extremely primitive and excludes other impacts, such as highly acidic effluent water from the extraction chemicals. However, it does show conclusively why it's critical to take material streams into account when analyzing green communications.

The aforementioned activity effectively illustrates the effects of recycling. In truth, recycling is simply the third phase of the waste hierarchy and is thought to be a good technique (Fig. 1). The five phases of a product's life cycle include material extraction, production, use, transportation, and end-of-life. All phases should be taken into account to fully understand how a product will affect the environmenta thing.



B. Direct & Indirect Impacts

The direct and indirect effects of ecologically friendly solutions must both be taken into account. Direct effects are directly connected to how the proposed solution is put into practise. Implementing a solution, for instance, that lowers a service's energy usage has a direct effect. The larger effects of implementing a solution are related to its indirect effects. For instance, the use of email may result in a higher environmental effect of information and communication technology (ICT) but also result in fewer letters being written, which reduces the environmental impact of transportation, paper use, etc. Typically, indirect effect reduction has a greater chance of reducing environmental problems. However, because they depend on political, financial, informational, and behavioural variables, these reductions are more difficult to forecast.

One of the important components of green communication is the use of energy-efficient devices and the management of cellular network power usage. One method for reducing power consumption and improving the energy efficiency of a network is resource allocation, however this method is not without its own set of problems [18-20]. With the ongoing development of information and communication technology, there is a pressing need for green communication, a topic that is gaining more attention. Researchers and businesses are working hard to identify the most practical approaches and methods for green communication.

Techniques

There is a tremendous push toward green communication in the advancement of 5G. Below is a discussion of a few of the green communication methods used in 5G.

1. Device-to-Device Communication

As shown in Figure 2, D2D communication is a radio access method that enables users to connect directly with one another when they are nearby rather than routing their traffic through the network infrastructure.[21] studies device-to-device communication. A promising candidate for 5G cellular networks is D2D communication. Through this, the network's spectral efficiency and energy efficiency can be improved technique. Through direct connection, it also benefits from a solid connectivity and a decrease in latency. Direct user-to-user connection (D2D) results in offloading of data traffic at the basestations base stations can enter a power-saving sleep mode because to this feature. When users are towards the boundaries of the cells in wireless communication, the base stations must send a huge amount of power by using a lot of energy. The system is made to be energy efficient by using D2D communication, which is the best option in this case. In D2D communication, there are three operational modes: cellular, dedicated, and reuse mode. By choosing the most suitable mode, the network's overall efficiency can be boosted. [22] discusses switching mode strategies for more energy-efficient D2D communications and a network as a whole.

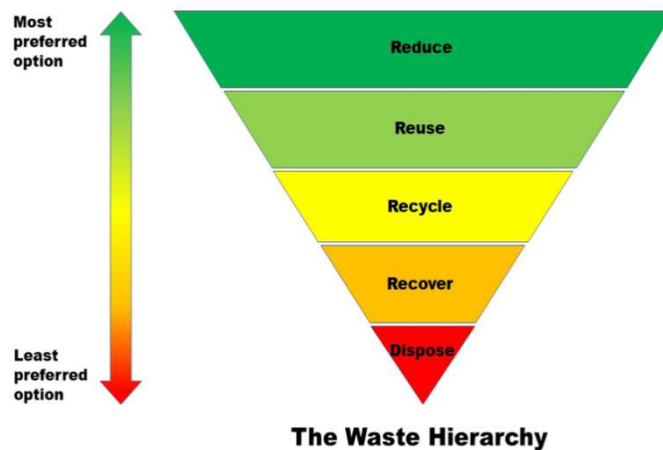


Fig. 1 The Waste Hierarchy

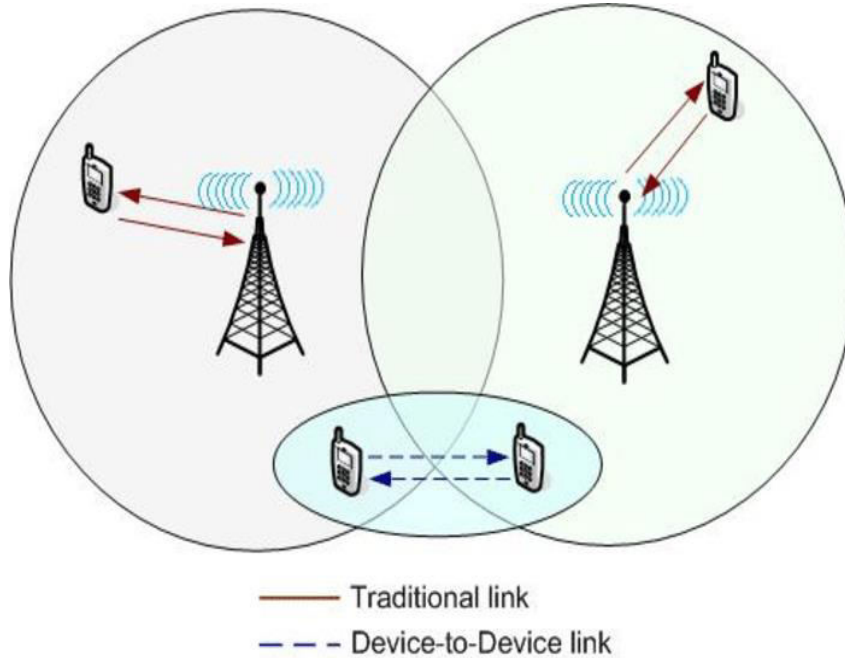


Fig. 2 Device-To-Device Communication

2. Massive MIMO System

MIMO (multiuser multiple input multiple output) systems are becoming more popular. In such systems, a base station with multiple antennas provides service to many users with single-antenna equipment at the same time. In these circumstances, all users can share the multiplexing gain, as shown in Figure 3.[23] studies a huge MIMO method for 5G cellular networks that use less energy. Massive MIMO uses more antennas than MIMO does, making it a strong candidate for energy-efficient devices. Numerous benefits of massive MIMO include large capacity gains, low latency, improved throughput, good energy economy, and robustness [24]. Choosing the right antenna is crucial in huge MIMO. Energy-efficient antennas are necessary to regulate base station power usage. Massive MIMO can also leverage system architectural simplification to cut down on overall power usage. Another answer to this issue is the use of reconfigurable antennas.

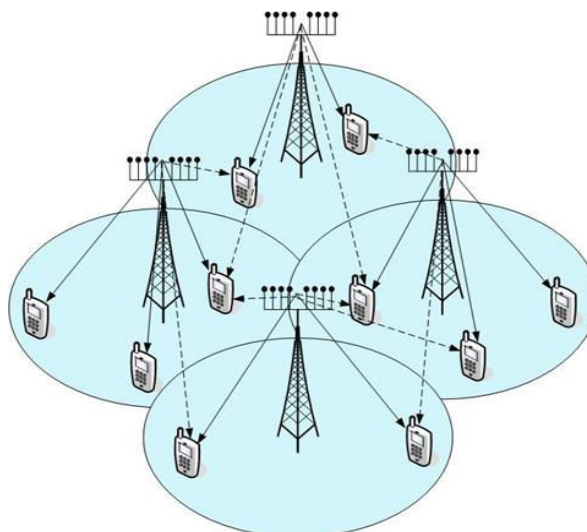


Fig. 3 Massive MIMO System

3. Heterogeneous Network

There are multiple small cells and a macrocell in a heterogeneous access network (e.g., microcells, picocells, and femtocells). As shown in Figure 4, a backhaul network is built by joining the base station to the core network via wired, wireless, or mixed architecture.[25] studies the heterogeneous network technology for green 5G communications. There are many micros, pico, and femto tiny power cells and few large power cells in a heterogeneous network.

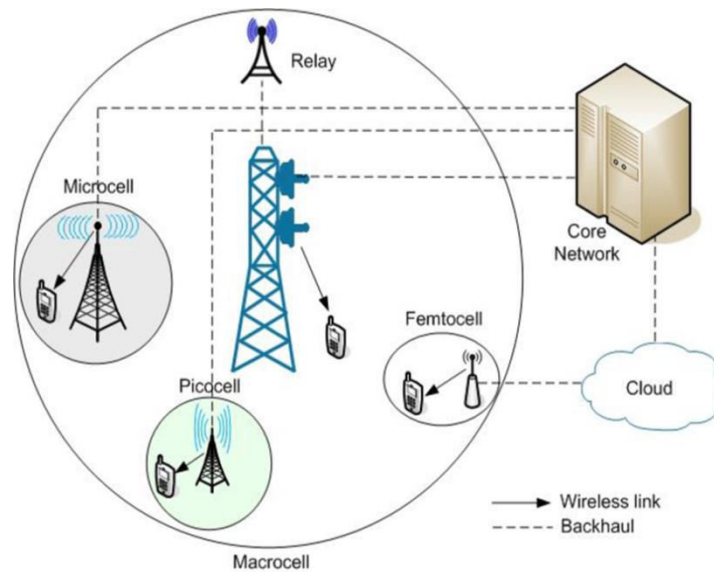


Fig. 4 Network Architecture of a 5G HetNet

4. Green Internet of Things

As shown in Figure 5, the Green Internet of Things is another possible aspect of 5G green communications that aims to provide integration of many industries. In [26], energy efficiency in IoT is researched. The Green IoT plays a significant role in reducing the greenhouse effect by using energy-efficient techniques. The foundational component of the Internet of Things is wireless sensor networks. Each node in wireless sensor networks needs to be operated with controlled power consumption in order to achieve energy efficiency, which is a difficult process [27].By putting the unnecessary and useless nodes in sleep mode, the IoT can increase its energy efficiency [28]. An energy efficiency improvement technique for 5G Internet of Things communication is covered in [29].

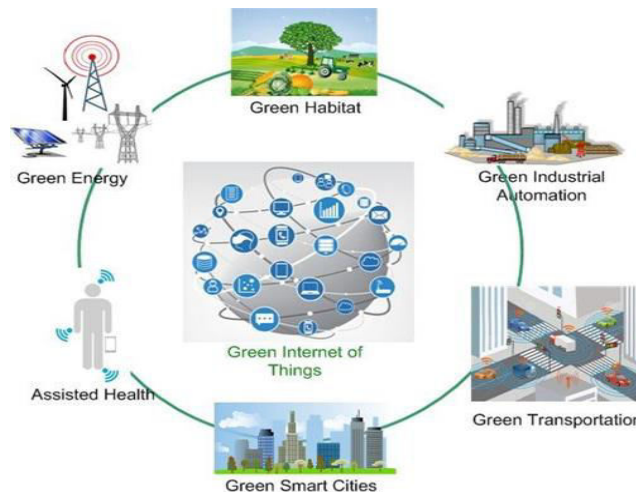


Fig. 5 Green Internet of Things



Challenges

a) Cost

Despite the potential for green communications to consume less energy and save money, the need for additional infrastructure, such as in heterogeneous networks, is sometimes associated with far higher costs than the existing approaches. Similarly, adoption of energy efficient strategies in devices may need additional processing power and result in increasing their price.

b) Spectrum Efficiency

Spectrum efficiency, which is defined as the throughput of the system, is another essential factor that needs careful study. The Shannon's capacity formula states that the transmission rate is inversely proportional to the transmit power and bandwidth available [30]. Data would be affected by changing the transmission power to make the communication green. Therefore, the success of such solutions depends on an effective characterization of this trade-off taking into account real hardware constraints.

c) Bandwidth

Bandwidth requirements are another trade-off 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 lowered by extending the bandwidth for a particular data transmission rate [30]. However, bandwidth expansion does require changes in terms of new schemes and their integration with current networks. Therefore, a thorough investigation of this issue is required for the success of green communications.

III. CONCLUSION

With the advancement of information and communication technologies, the demand for green communications is dramatically rising. Green communication not only uses less energy but also lessens CO₂ emissions, which are harmful to the environment and human health. Different green communication techniques including Device-to-Device communication (D2D), massive MIMO, Heterogeneous Networks (HetNets) and Green Internet of Things (IoT) for 5G cellular networks are studied and discussed in this paper. Despite the fact that the current studies address a variety of issues, difficulties of infrastructure/device cost, spectral efficiency and bandwidth requirements still are the bottlenecks and further research is needed to address these open issues effectively. Network security and secure power optimization is also an aspect that needs to be considered for future green communications due to enhanced level of device connectivity and data sharing.

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