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Review

A survey on green communication and security challenges in 5G wireless communication networks

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A R T I C L E I N F O

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A B S T R A C T

The 5G wireless cellular networks are evolving, to meet the drastic subscriber demands in near future. This is accompanied with a rise in the energy consumption in cellular networks. Higher energy consumption result in a rise in the carbon dioxide emissions into the environment, and exposure to greater amount of harmful radiations. To indemnify the ecological and health concerns associated with the rise in CO_2 levels, an important technology is GREEN communication. This paper presents a survey on various energy-efficient scenarios for green communication, involving device-to-device (D2D) communication, spectrum sharing, ultra-dense networks (UDNs), massive MIMO, millimeter wave networks and the Internet of Things (IoT). For improving the battery lifetime of user terminals in a network, a three-layer architecture is proposed, which emphasizes on transmitting information through relays, between a given pair of users. The susceptibility of security attack on relays is also enumerated. As security in the networks cannot be overlooked, secure power optimization is studied, and the possible security attack on users within the small cell access point (SCA) of the 5G networks is proposed. Some of the key research challenges in association to green communication and security have been discussed, and the ongoing projects and standardization activities also stated in the paper.

1. Introduction

The wireless communication networks form the largest share of the Information and Communication technology (ICT), supporting various other industries. These networks have undergone a phenomenal growth, from the first generation (1G) networks, to the fourth generation (4G) networks (4G), transforming the telecom sector. An overview of this transformation is depicted in Fig. 1. The 4G networks can support data rate up to 3 Gbps (Gupta and Jha, 2015), for downlink LTE-A systems. With the dramatic rise in the number of users, more and more users are subscribing for mobile broadband. These users demand quicker access to the Internet, with unconventional multimedia capabilities. The current technologies cannot support the massive data rate demand, resulting in the investigation of 5G networks (Wang et al., 2014). This tremendous progression in technology is accompanied by a prodigious rise in energy consumption.

The rise in the consumption of energy results in increasing carbon dioxide levels in the atmosphere. The global CO_2 share of the ICT is 5% presently (Fehske et al., 2011), and this percentage is rising at a very fast pace, due to increasing number of subscribers. Different sectors of mobile communication contribute to the rising CO_2 levels in the atmosphere. This has been depicted in Fig. 2, where the CO_2 emissions are shown, during 2010, 2015 and 2020. The count of connected devices by 2020 is estimated to be 50 billion (More than 50 billion connected devices, 2011), and further 100 billion by 2030 (Strategy, Accenture, 2015) requiring 1000 times escalated data rates (The data challenge, 1000x) for serving such a huge number of devices. Intensive demand of high data rate and bandwidth demanding applications has resulted in the rise in subscriber demands (5G use cases and requirements, NOKIA whitepapers, 2014). The forecast of mobile traffic on a global platform has been studied in (Index, 2016). To meet these demands, a conforming increase in the count of base stations has been witnessed (Green Power for Mobile, GSMA, Green Power for Mobile Bi-Annual Report, 2014). The base stations (BSs) in a wireless network consume the maximum amount of energy in the networks, contributing to more than 70% of the electricity bill (Han et al., 2011a). The access networks also consume a considerable amount of energy (Auer et al., 2011). As a result, energy-efficient communication becomes a prerequisite for the evolving cellular network architecture.

Energy efficient cellular networks are gaining importance due to the severity of the CO_2 levels in air, harming the environment and global weather. The increasing energy consumption of mobile networks increases the operator costs as well. The ecological concerns, and economic issues have led to the evolution of green communication in

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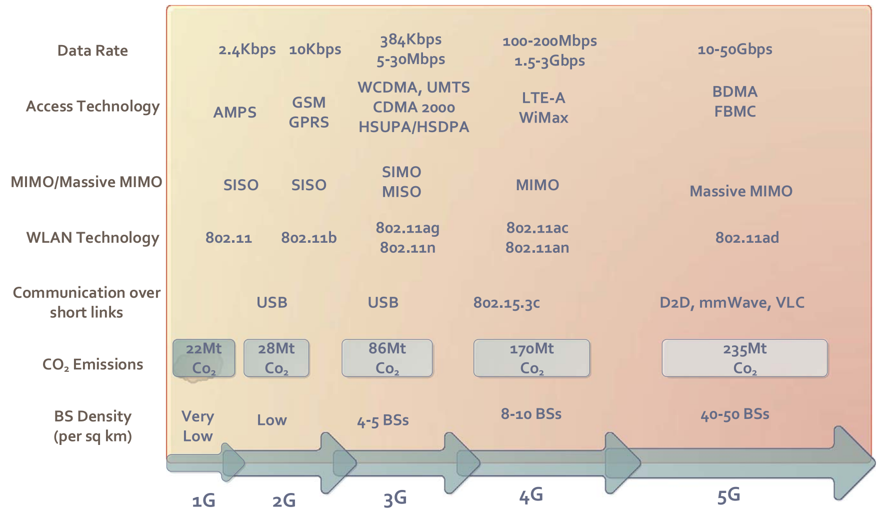

Fig. 1. Comparison of wireless technologies from 1 to 5 G.

cellular networks. Promising research areas for green 5G networks have been addressed in (Chih-Lin et al., 2014).

With the exception of the ecological and economic concerns, the prodigious CO_2 levels result in escalation of the transmission power levels within the cellular networks. These cause a rise in the radiation levels, having a detrimental effect on human health. The radiations are absorbed by human body. These are measured through the metric, specific absorption rate (SAR). A lower value of SAR is desirable.

The advent of 5G cellular networks is expected to increase the energy efficiency up to 1000x (GreenTouch Green Meter Research Study: Reducing the network energy consumption in communications networks by up to 90% by, ", 2020, 2013), with service provisioning to billions of devices. Obtaining energy efficiency in 5G networks through power control is possible by using centralized or decentralized methods. For the same, different approaches have been proposed in 5G networks and can be classified as user centric techniques, like device-to- device (D2D) communication (Boccardi et al., 2014), femto cells (Hoydis et al., 2011), and as network centric techniques, like Cloud-RAN.

5G networks provide the vision of a connected society, providing 1000x capacity in the cellular networks. The present network architectures cannot achieve such high capacities. As a result, 5G networks need new network design. A number of key wireless technologies form a part of the 5G networks, which efficiently utilize the available resources, and improve the efficiency of ever joule of energy, i.e. the energy efficiency. A 5G network scenario, as an aggregation of the various technologies is depicted in Fig. 3. These technologies include device-to-device (D2D) communication, spectrum sharing, millimeter wave (mmWave) communication, Internet of Things (IoT), and ultra-dense networks (UDNs). The state of the art for these energy efficient technologies have been presented in the following sections. These technologies can support green networking in 5G wireless communication network, and also prolong batteries of mobile devices.

Another important aspect introduced to green communication is energy harvesting (EH). This supports powering of user terminals wirelessly (Tabassum et al., 2015). EH supports the use of solar energy, wind energy and other renewable sources of energy for charging the device batteries. This results in clean green communication. The devices must be scrutinized minutely (Lu et al., 2015) for use in energy harvesting networks. Such an approach can significantly abate the CO_2 emissions. The capacity limitations of the cellular networks are being overcome by the evolving 5G networks. This has led to high density topologies and high spatial reuse. Simply escalating power levels will not be an efficient choice, which has led to the introduction of green communication. Apart from energy efficiency, another facet of paramount importance in cellular networks is security. Two fundamental aspects of information exchange are security and secrecy. Absence of a central controlling entity in a network make the users more susceptible to security attacks.

Although most of the work on 5G has been focused on power consumption and data rate demands, nowadays, security concerns have triggered research in this domain. Inclusion of appropriate security measures in cellular networks is preeminent, for 5G networks. Most of the security issues are mitigated by cryptographic solutions. Several vulnerability categories have been identified by 3GPP Security Workgroup (3rd Generation Partnership Project 3GPP, 2007), which are open research problems in this field. More the number of users, greater is the possibility of intrusion (Huang et al., 2011; Shirvanian and Saxena, 2014; Mascetti et al., 2013; Mpitziopoulos et al., 2009).

Several initiatives have been taken up by many organizations towards green and secure 5G networks. The goal of 'Go Green' by ITU-SG 5 (TU-Study Group 5 at a glance) is of paramount importance

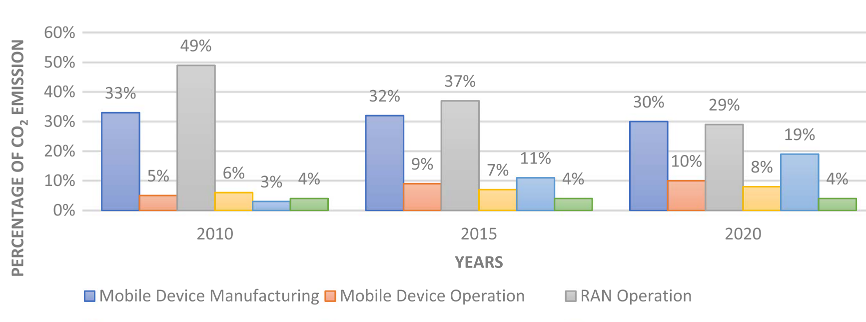

Fig. 2. Carbon Footprint from different sources of mobile communication (from 2010 to 2020).