IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 7.105 ⁘ Vol. 9, Issue 2, February 2022

DOI: 10.17148/IARJSET.2022.9215

Green Cellular System : Technology and Challenges

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Abstract: Abstract Traditionally the aim of telecommunication mainly focuses on achieving easy implementation with large capacity. Environmental degradation emphasis to focus on energy efficient design with aim to achieve green networks [1]. Telecommunication along with its advancements also addressing the significant environment impact, created by themselves as well as cost on power usage. The overall goal of next generation of wireless to provide ubiquitous and unlimited connectivity to a massive number of Internet of Things (IoT) and machine-type devices/users having diversity in quality of service, supporting substantial and heterogeneous traffic demands with great reduction in energy consumption using energy-efficient communication protocols, transceivers and computing technologies[3][4]. In India cellular technology the evolution of 5G proves to fulfil the user demands in present and upcoming years. This will increase the energy consumption by which will result in excess emission of co2. We are discussing some techniques include device-to-device communication (D2D), massive Multiple-Input Multiple-Output (MIMO) systems, heterogeneous networks (HetNets) and Green Internet of Things (IoT) as a part of future cellular system. In this paper, the different techniques for the green communication technology along with the challenges in it are discussed [2].

Keywords: Include at least 4 keywords or phrases.

I. INTRODUCTION

Green technology refers to any technology intended to reduce the impact of humans on the environment. This can include technologies that reduce resource usage as well as incorporate renewable resources. It also includes technology that reverses damage to the environment, though there are few products that fall into this category. Although the market for green technology is relatively young, it has garnered a significant amount of investor interest due to increasing awareness about the impacts of climate change and the depletion of natural resources. The important key issues of Green technologies are related to energy efficiency in computing and promoting environmentally friendly computer technologies and systems. Green networking technologies play a significant role in reducing energy consumption in terms of connecting energy-efficient networked equipments for a variety of applications, computing frameworks, and communication environments[4][5]. The goal of this Special Section is to explore the research and development of green technologies for wireless communications and mobile computing. This special issue intends to provide a collection of the latest researches in the field of green communication for mobile and wireless networks. In order to meet the intense user demands, the 5G networks are evolving, and will be available by 2020. The unfolding cellular technology has raised the energy consumption in mobile networks with the carbon footprint surging to alarming rates. This is causing an adverse effect on the environment and human health[10][11]. Addressing these aspects, this paper presents a survey on techniques for making the next generation cellular networks GREEN. A number of technologies form a part of the 5G networks, in order to support the drastic user demands, and are receiving substantial attention from the perspective of green communication[6][8].

II. DEVICE TO DEVICE COMMUNICATION

With exponential growth of traffic, mobile cellular networks are facing the technology challenges to enable enormous data flows, high data rate, and large system capacity. Despite various application scenarios in mobile communication networks, effective local area communication inside a cell shall be predominant in the future systems. Noticeably, in order to meet diverse need, D2D communication has been proposed as a promising technology which allows users to alleviate traffic from base station inside a cell. Two basic modes for D2D communication have been widely considered: underlay (spectrum shared with cellular users, uplink or downlink) and overlay (orthogonal spectrum with cellular networks). However, the increasing number of D2D transmitters can result in severe interference on same frequency band in hybrid D2D and cellular networks. Consequently, the energy efficiency of the system may be declined since users could consume additional power to achieve the quality of service requirement. Much more efforts have been done in

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early research about such offloading strategy [6][7]. Resource allocation was jointly performed with mode selection in proposed the mode switching algorithm for D2D communications based on the user's energy efficiency optimization. As green communication emerges, the mode selection strategy should not only reinforce the end-user throughput and system capacity, but also guarantee the improved energy efficiency with user's transmission power constraint[8][9]. To evaluate the performance of global network EE on different offloading strategy becomes a critical but overlooking issue to adopt D2D communications, and serves the ultimate goal of this research. In this study, we leverage stochastic geometry to model the position of base stations and users as independent homogeneous Poisson point processes (PPPs) with different density λ, and later interference analysis. Specifically, we consider the density of different network components (cellular user, D2D transmitter and BS), user date rate, system bandwidth and the offloading strategy radius which is the dominant variable through the theoretical model, and we discover delicate relationships between these network parameters. We further derive the more compact closed-form EE and average D2D transmitter power expressions, surprisingly finding that how energy saving gain can be captured with the respect of network parameters changing into different values. The theoretical framework is verified by simulations[7][8].

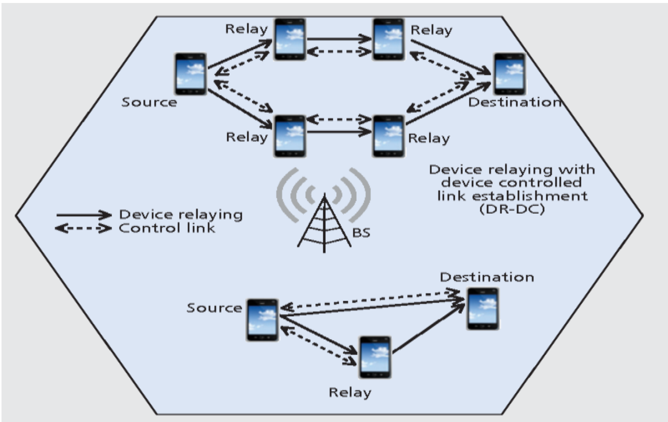

Figure 1: Illustration of device to device communication

One of the benefits derived from D2D is content privacy and strong anonymity. These are provided because the central storage is not responsible for storing the shared information. D2D communications also have the potential to improve energy efficiency, throughput, fairness, and delay. Furthermore, by enhancing the system throughput and spectrum re-usage due to the D2D traffic direct routing, the performance of D2D improves significantly. D2D offloads the cellular traffic by switching the path from infrastructures to direct transmissions. These attributes produce low transmission delay, energy savings, and a high data rate. Standalone D2D is one the drawbacks of D2D because it only uses links that are managed by devices where there is no possibility of channel management and centralized relay, whereas for network-assisted D2D, the BS, together with the help of operator-controlled links, can only partially maintain channel selections and relay. There are many challenges that should be tackled in order to successfully execute D2D communication technology[9][10]. Specifically, D2D communications require complex resource management techniques, efficient device discovery mechanisms, intelligent mode selection algorithms, robust security protocols, and mobility management procedures. There have been many research studies in D2D communications that aimed to improve spectral efficiency and interference management. Nevertheless, extensive reviews of comprehensive studies that examine various aspects of D2D communications, including the requirements and challenges, are largely missing. An overview of the foundational principles in this communication model and its related issues in view of recent advances will need a comprehensive analysis of the existing literature. The motivation of this paper is to equip readers with a primer addressing to some of the problems, solutions, recent advances and challenges in D2D communications. These domains are considered crucial for improving network optimization[10].

III. MASSIVE MULTIPLE INPUT AND MULTIPLE OUTPUT SYSTEM

MIMO, Multiple-Input Multiple Output, technology relies on multiple antennas to simultaneously transmit multiple streams of data in wireless communication systems. When MIMO is used to communicate with several terminals at the same time, we speak of multiuser MIMO. MU-MIMO technology for wireless communications in its conventional form is maturing, and incorporated into recent and evolving wireless broadband standards like 4G LTE and LTE-Advanced (LTE-A). The more antennas the base station (or terminals) are equipped with, the better performance in all the above four respects—at least for operation in time-division duplexing (TDD) mode. However, the number of antennas used today is modest. The most modern standard, LTE-Advanced, allows for up to 8 antenna ports at the base station and equipment being built today has much fewer antennas than that. Massive MIMO is an emerging technology, scales up

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MIMO by possibly orders of magnitude compared to current state-of-the-art. In this paper, we follow up on our earlier exposition, with a focus on the developments in the last three years: most particularly, energy efficiency, exploitation of excess degrees of freedom, TDD calibration, techniques to combat pilot contamination, and entirely new channel measurements[1][3]. With massive MIMO, we think of systems that use antenna arrays with a few hundred antennas, simultaneously serving many tens of terminals in the same time-frequency resource. The basic premise behind massive MIMO is to reap all the benefits of conventional MIMO, but on a much greater scale. Overall, massive MIMO is an enabler for the development of future broadband (fixed and mobile) networks which will be energy-efficient, secure, and robust, and will use the spectrum efficiently[3].

Massive MIMO relies on spatial multiplexing that in turn relies on the base station having good enough channel knowledge, both on the uplink and the downlink. On the uplink, this is easy to accomplish by having the terminals send pilots, based on which the base station estimates the channel responses to each of the terminals. The downlink is more difficult. In conventional MIMO systems, like the LTE standard, the base station sends out pilot waveforms based on which the terminals estimate the channel responses, quantize the so-obtained estimates and feed them back to the base station[10].

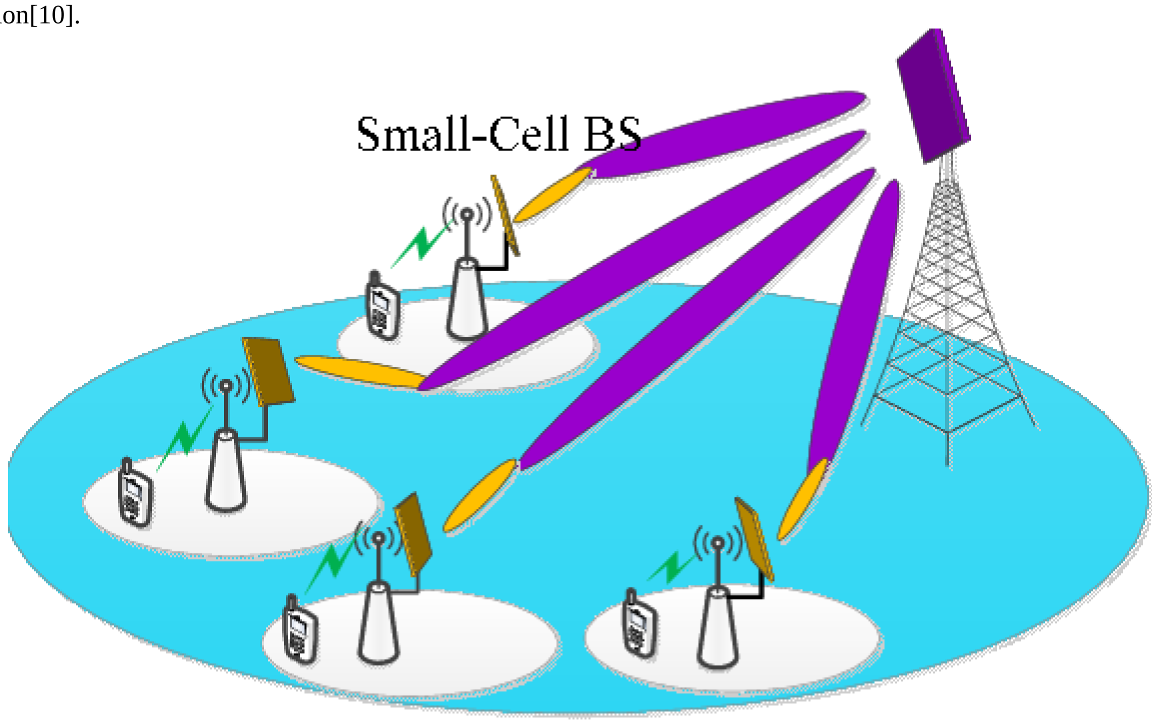

Figure 2: Illustration of massive MIMO.

The amount of time frequency resources needed for downlink pilots scales as the number of antennas, so a massive MIMO system would require up to a hundred times more such resources than a conventional system. Second, the number of channel responses that each terminal must estimate is also proportional to the number of base station antennas. Hence, the uplink resources needed to inform the base station about the channel responses would be up to a hundred times larger than in conventional systems. Generally, the solution is to operate in TDD mode, and rely on reciprocity between the uplink and downlink channels—although FDD operation may be possible in certain cases. Key points are given below:

- Massive MIMO enables a significant reduction of latency on the air interface
- Massive MIMO simplifies the multiple-access layer.
- Massive MIMO increases the robustness both to unintended man-made interference and to intentional jammi

IV. HETEROGENOUS NETWORK SYSTEM

Data traffic demand has been increasing exponentially and this trend will continue over the foreseeable future. This has consumer, i.e., the Base Station (BS) either by using more power-efficient hardware, more advanced software to adapt power consumption to the traffic situation as well as to forced operators to upgrade and densify their mobile networks to enhance their capacity [7]. However network densification requires extensive capital and operational investment which limits operator revenues and raises ecological concerns over greenhouse gas emissions. Although networks are planned to support peak traffic, traffic demand is actually highly variable in both space and time which makes it necessary to adapt network energy consumption to inevitable variations in traffic demand. The concept of heterogeneous networks

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had been proposed as an alternative approach to provide higher capacity and coverage for cellular networks. Along with that, the aspect of "Energy Efficiency" had already received much attention lately due to ecological as well as economic reasons particularly for network operators. Energy efficiency considerations recently gained attention due to environmental aspects; lowering CO2 emissions and reducing energy consumption. Furthermore, it is important to assess network energy efficiency from an operator's point of view, since energy costs are increasing and providing ubiquitous high speed mobile access may scale up the operators' operational expenditure[7][8]. There are basically two ways to improve the energy efficiency in a mobile network. The first consists of reducing the power consumption of the main balance between energy consumption and performance. The second is intelligent network deployment strategies where using high density deployment of Low Power Nodes (LPN) or base stations is believed to decrease the power consumption compared to low density deployment of high power macro base stations[5]. The idea being that a Base Station (BS) closer to mobile users lowers the required transmit power due to advantageous path loss conditions. Network deployment based on smaller cells such as micro, pico or even femtocells is a possible solution to reduce total power consumption of a cellular network. However, as indicated by some of recent researches, network designing needs to be approached with more caution as spreading a high density of small cells will overburden and decrease the power efficiency of the central BS. In addition, the embodied energy consumption may actually dominate and result in an increase in total energy consumption. As such, this paper presented an overview of energy efficiency issues in a heterogeneous cellular network. Heterogeneous network concept was proposed in the framework of LTE-Advanced to increase the spectral efficiency[5][6] Since, radio link performance is approaching the theoretical limits with 3G, network topology is seemed a way to increase system performance. In this strategy, macro base stations are used to provide blanket coverage, on the other hand small, low power base stations are introduced to eliminate the coverage holes and at the same time increase the system capacity in hotspots. Furthermore, heterogeneous networks provide an opportunity for network providers to optimize overall costs, revenues and customer satisfaction. Macrocells are mainly used to provide a widespread coverage area but they can only support low data rate services. One obvious approach to make the cellular networks more power efficient and thereby sustaining high speed data-traffic is by reducing the propagation distance between nodes, hence reducing the transmission power. Therefore, network deployment solutions based on smaller cells such as micro, pico and femtocells are very promising in this context. A typical heterogeneous network deployment is shown in. Smaller micro, pico or femtocell structures can be used for providing high data-rate service to smaller areas with a high density of traffic. Micro/picocells can cater to many devices within the range of a few hundred meters while femtocells are mostly used for indoor or home area.

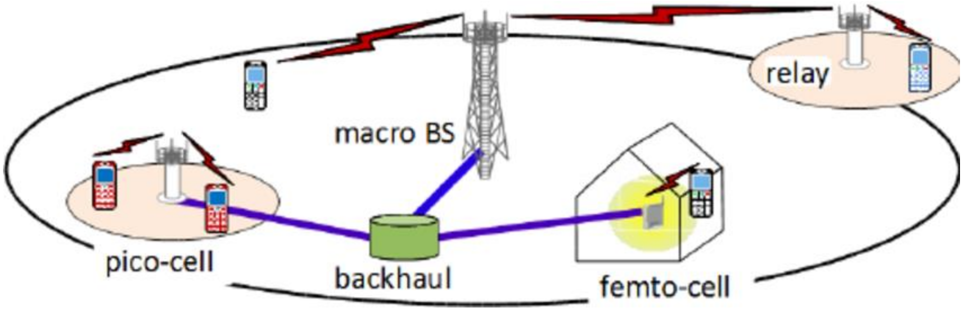

Figure 3. Heterogenous network deployment

V. CONCLUSION

The energy efficiency is critical issue from the viewpoint of cellular network operators in minimizing their operational costs and reducing their energy footprint for environmental reasons. In the context of energy efficiency of cellular networks, this paper outlined the efforts with respect to energy efficiency in cellular networks and the commonly used energy metrics and explored the tradeoffs inherent between energy use and network performance. However, there is a need to define appropriate energy efficiency metrics that capture the overall power budget of the whole network in order to quantify and qualify gains achieved by employing energy aware techniques in network planning. To move towards green cellular network, it is essential to balance between network performance improvement and the required energy consumption in the design of the network. It is anticipated that the heterogeneous network is a significant technique that can improve the energy efficiency of a cellular network. Nevertheless, a careful design for this network is required to avoid reducing the energy efficiency of the macro BS but on the other hand increasing in total

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energy consumption. Besides, optimization techniques are demanded to find the optimal energy efficiency of the whole networks with respect to the number of all types of base stations, their size and locations.

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