DESIGN AND DEVELOPMENT OF ENERGY EFFICIENT GREEN IOT MODEL

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Abstract

5G Green IoT is an energy-efficient process connected devices for the purpose of reducing power consumption, the greenhouse effects, and minimizing the emission of CO2. By using green computational units, communication protocols, and network-based architectures with maximum utilization of bandwidth and relatively low energy utilization. The essential element of Green IoT is sustainable design and energy-efficient. Wireless Communication System the previous four generations of cellular technology have each been a major paradigm shift that has broken backward compatibility. So we expect that 5G will be a paradigm shift that includes very high carrier frequencies with massive bandwidths, extreme base station and device densities new 5G air interface and spectrum together with LTE and WiFi to provide universal high-rate coverage and a seamless user experience. To support this, the core network will also have to reach unprecedented levels of flexibility and intelligence, spectrum regulation will need to be rethought and improved, and energy and cost efficiencies will become even more critical considerations. In this thesis we discuss the new thoughts which would improve the efficiency like using mm-waves, small cell, and smart antenna. Then we discuss some of the emerging applications based on 5G Wireless Communication System. In addition, we mentioned some challenges and open issues related to the previous generations and infrastructure boundaries that we have to considerate during designing 5G Device-to-Device Communication System networks. Just a few years ago mm wave was not being put to use because few electronic components could receive millimeter waves. Now, thanks to new technologies, it is on the brink of being an integral part of the next-generation network. Even with the advances of 4G LTEA, the network is running out of bandwidth. The solution, as seen by 5G wireless network developers, is to add more bandwidth by using frequency spectrum in the millimeter-wave frequency range. With hundreds of megahertz of wireless transmission bandwidth available at center frequencies such as 24, 28, and 38 GHz, 5G wireless networks will be capable of almost zero-latency phone calls and extremely high data speeds working on 5G network solutions typically refer to the mmWave frequency range as starting at about 24 GHz. The amount of bandwidth available at mmWave frequencies is enormous compared to the amount of frequency spectrum used by 4G and previous wireless network technologies. The architecture of 5G networks will be much different than earlier wireless-network generations, in part because of the use of mmWave frequencies. Smaller antennas will be used in mobile handsets to transmit and receive

those higher-frequency signals the propagation distances for mmWave frequencies is less than for signals at the lower frequencies traditionally used in cellular networks.

Keywords: 5G Green IoT ,Next Generation, 5G Device-to-Device, mm Wave frequencies LTEA.

Introduction

5G will make the "Internet of Things" a reality. With 5G technology, a device will be able to maintain network connectivity regardless of time and location, and open the possibility to connect all the connected devices without human intervention. The 5G system design is expected to provide support for up to a million simultaneous connections per square kilometer, enabling a variety of machine-to-machine services including wireless metering, mobile payments, smart grid and critical infrastructure monitoring, connected home, smart transportation, and telemedicine. Intelligent devices will communicate with each other autonomously in the background and share information freely. This universal connectivity will truly enable IoT services which in turn is expected to profoundly change human lives by connecting virtually everything as shown in Figure 1 Internet of Things (IoT).

Fig. 1 Green IoT

Fig. 2 Internet of Things (IoT): Connecting "Anything, Anyone, Anytime, Anyplace"

Using 5G wireless assures intelligent and smart vehicular communications through designing a network of interconnected vehicles for traffic management and reducing collisions probabilities. IoV involves exchanging spatio temporal data which have to be proceeded and delivered with safety and security so the most suitable technique here is cloud computing which decrease computing, storage and other function from traditional desktop and portable PCs, all the functions can be realized in cloud computing platform. In other words, we can say IoV is a robust system that cars driving on the road can choose the least crowed road to arrive destination automatically, drivers can acquire real-time traffic information with minimum delay. In addition, transportation administrative management can get real-time monitoring on spot traffic and each vehicle's violation is recorded by IIOVMS' video supervising subsystem so that competent authorities may take effective action on time to prevent concurrency of traffic accident and ensure safety of road traffic. [4] When we mention 5G's features like high data rate, extremely low latency, anywhere anytime coverage, energy savings we expect to face some associated challenges, and we're going to mention some challenges below:

- mm-wave spectrum's propagation characteristics aren't widely studied and analyzed, as compared to current "beach-front spectrum" ,and the huge benefits it offers to satisfy all the overwhelming capacity demands put us in front of big challenge to analyze the physics behind mm-waves, like atmospheric absorption, diffraction, propagation, Doppler, scattering, refraction, reflection, multipath and attenuation. And the fact of mm-waves propagation is dependent on the environmental conditions, receiver and transmitter locations make us know the necessity of investigating in legacy cellular systems and make further research.
- The smart antenna used in 5G changes the entire notion of the cell concept and clarify the importance of refreshing our research for architecture design of both BS and mobile device for processing very high selective directivity.
- Low latency is also crucial for achieving high QoE. Investigation of QoE presents a number of research challenges due to its subjective nature.

Status of LTE-A

LTE has been specified in 3GPP. The LTE standard has been stable and backwards compatible since March 2008, while initial trials and commercial networks have given ample proof of the fact that LTE delivers superior mobile broadband user experience in real deployments. LTE has been a commercial success, going by its adoption rate, that has ex-ceeded any other mobile network technology. By the October 2013, more than 200 operators have launched commercial LTE and TD-LTE networks.

One of the main drivers of the technical enhancements and timetable for LTE-A devel-opment has been IMT-Advanced. ITU initiated the IMT Advanced process to define the re-quirements for the next generation of Radio Interface Technologies (RIT) that were released in a circular letter in early 2008. Meeting the IMT-Advanced requirements has been the goal that 3GPP has to achieve and standardization in 3GPP has progressed well. The first LTE-Advanced specifications have been frozen in the first half of 2011 while evaluations conducted by 3GPP contributors and external parties have demonstrated that LTE-A meets all the IM-Advanced requirements. As a consequence, ITU-R has already approved LTE-Advanced as IMT-Advanced RIT or "true 4G system" in November 2010. The first commercial LTE-A net-works have been

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launched by SK Telecom, LG U+ and KT in Korea during summer 2013. All three operators use carrier aggregation with Nokia Networks as a supplier.

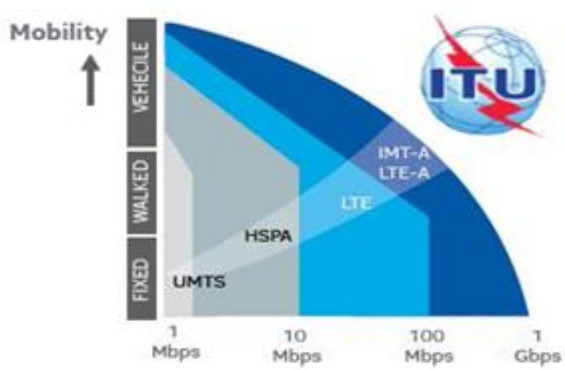

Fig. 3 Evolution of data speeds for stationary and mobile use cases drivers

Looking ahead, the exponential growth in data traffic is expected to continue on the same lines owing to certain key drivers:

(a) Increased adoption of mobile broadband
(b) Enhanced coverage (spreading across more locations)
(c) Increase in usage intensity
(d) Greater availability & choices in terms of devices (smart devices, phones, pads, booklets, notebooks...)
(e) Machine-to-machine communications stepping alongside human users.

A detailed analysis reveals that data traffic is distributed in an uneven way. Eventually mobile broadband networks need to evolve in a manner which goes beyond the conventional approach of applying one standard remedy to the capacity squeeze. Also, the laws of physics imply that conventional mobile broadband networks are approaching the theoretically achievable spectral efficiency, which in turn implies the costs per bit/Hz. Consequently the need for higher bandwidths and higher efficiency can only be answered by combining several tools optimized for specific network scenarios. This is the prime reason for using the term "toolbox" in this paper. LTE-A defines a large set of tools focused on enhancing the mobile broadband user experience, as well as reducing the costs per bit.

The LTE-A toolbox

LTE (as specified in 3GPP Releases 8 and 9) has been optimized for conventional wide area deployment, based on macro base stations and for dual receiver and single transmit antenna single band terminals. Talking specifically about this basic use case, LTE-A does not really provide significant performance improvements since no new technologies have been found to make this feasible. Instead, the focus has shifted to developing new features and technologies to extend the capabilities of LTE, as well as supporting new ways of deploying and operating networks ensuring optimal distribution of services. New technologies of LTE-A include enhancements in uplink and downlink multi-antenna (MIMO) technologies, coordinated multi-cell transmission and reception (CoMP), bandwidth extension with carrier aggregation (CA), relay nodes (RN) and heterogeneous network deployments (Hetnet). The new technology components of LTE-A spell a host of benefits for the CSP community: enabling performance improvements in peak data rates, average spectrum efficiency, cell edge performance, coverage, new ways of cost reduction in the process of deploying and operating networks with small base stations, and with cells without fixed transport connections.

Carrier Aggregation

Carrier Aggregation allows for combining up to five LTE Release 8 compatible carriers with the aim of increasing transmission bandwidth, and for enhancing data rates for end-users. It enables operators to provide high throughput without wide contiguous frequency band allocations, and ensures statistical multiplexing gain by distributing the traffic dynamically over multiple carriers. With Carrier Aggregation, operators can take asymmetrical bands into use with FDD since there can be uplink or downlink only frequency bands. Carrier Aggregation can provide bandwidths with a maximum range of 100 MHz. Even higher bandwidths could easily be supported by the concept, but the need has not been identified yet. Aggregated carriers can be adjacent or non-adjacent even at different frequency bands, so basically all the frequency allocations can be used. There are a lot of permutations and combinations, and some of them are a bit more difficult to implement due to interference problems caused e.g.

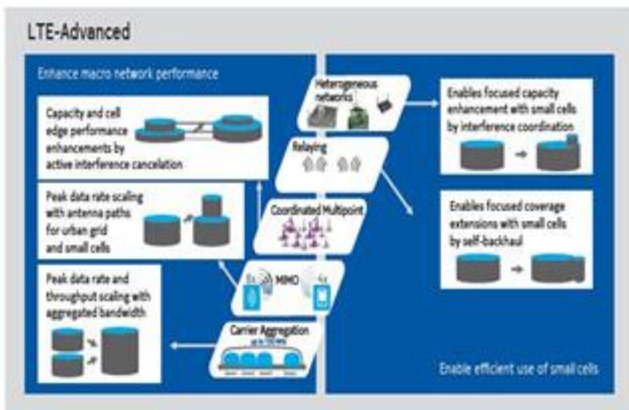

Fig. 4 LTE-A support both: enhancing the LTE macro network and enabling the efficient introduction of small cells

Intermodulation products of transmitted signals on different frequency bands. Therefore, only intra-band carrier aggregation is supported in uplink in LTE Release 10, while a higher range of band combinations will be supported in later releases. Carrier aggregation provides almost as high spectrum efficiency and peak rates as single wideband allocation. In some heterogeneous deployment scenarios, the performance can be even better since flexible frequency reuse can be arranged between local area nodes to provide better inter-cell interference coordination.

Related Work

The Internet of Things (IoT), which links everything in the smart world, is a challenge and an exciting topic for research, according to Mahmoud A. M. Albreem et al. (2017). The idea of a green IoT is driven by the desire to achieve an IoT with minimal power usage. This paper gives a general overview of the green IoT. The life cycle of green IoT, which includes green design, production, usage, and recycling, is also covered. Additionally, green IoT technologies are covered, including green tags, green sensor networks, and green internet technologies. Additionally, research on IoT for smart cities and IoT in 5G are presented. Finally, outstanding issues and future research topics related to green IoT are discussed.

Internet of Things (IoT), green IoT, 5G, wireless sensor networks, cloud computing, smart cities, and energy efficiency are some of the terms used in the index. [1]

The Internet of Things (IoT), according to RushanArshad et al. (2017), is a new idea that aims to link up billions of objects. IoT gadgets perceive, gather, and communicate crucial data from their surroundings. There is a huge need for energy as a result of this tremendous information interchange between billions of devices. Green IoT aims to make the environment safe while lowering the energy consumption of IoT devices. We first provide an overview of green IoT and the issues that are encountered as a result of the excessive use of energy-hungry IoT devices, which is motivated by creating a sustainable environment for IoT. next we discuss and assess the methods that can be utilised to reduce the energy consumption in the Internet of Things, such as developing energy-efficient datacenters, ensuring that sensor data is transmitted in an energy-efficient manner, and creating energy-efficient laws. We also offer concepts that can be used to create green IoT after critically analysing the green IoT initiatives. Finally, we take a look at a case study of an essential IoT component, namely smart phones, and offer a clear and short overview of how to improve present procedures so that the IoT is more environmentally friendly for everyone in the world by 2020 and beyond.[2]

The Internet of Things (IoT) is a concept and theory that aims to connect billions of objects and allow them to communicate a vast amount of data, according to Nitasha Khan et al. (2020). Green IoT uses better energy efficiency to visualise the IoT hypothesis. We begin by providing an overview of the green IoT and the difficulties brought on by the excessive use of energy-hungry IoT devices. Research on IoT energy efficiency is presented in this publication. The authors outlined several difficulties, current projects, chances, and future directions. IoT that is green [3]

According to WaleedEjaz et al. (2017), the dramatic rise in urbanisation over the past several years calls for sustainable, effective, and clever solutions for governance, quality of life, transportation, and other areas. Numerous complex and widespread applications for smart cities are provided by the Internet of Things. IoT applications are using more energy, and IoT devices' numbers and needs are still expanding. Smart city solutions must therefore be able to use energy effectively and deal with the problems that come with it. One important paradigm for the implementation of intricate energy systems in smart cities is energy management. We give a succinct summary of energy management and its difficulties in smart cities in this post. Then, we offer a unified platform for IoT-based smart cities' energy-efficient optimisation and scheduling. We also go over the issues associated with energy harvesting in smart cities, which is a promising way to increase the lifespan of low-power gadgets. Two case studies are described. The first focuses on smart home energy-efficient scheduling, and the second discusses wireless power transfer for Internet of Things (IoT) devices in smart cities. The simulation findings for the case studies show the significant influence of wireless power transfer and energy-efficient scheduling optimisation on the functionality of IoT in smart cities. Before presenting a unified architecture for IoT in smart cities, we first give an overview of energy management in smart cities. Energy-efficient solutions and energy harvesting operations are the two categories under which energy management is categorised. In this article, we discuss numerous angles to look at energy-efficient technologies and energy harvesting for IoT devices in smart cities. Two case studies have also been provided to highlight the importance of energy management. In the first case study, the goal is to lower the cost of power by optimising appliance scheduling in smart home networks. Effective scheduling of specialised energy sources

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for IoT devices in smart cities is covered in the second case study. To demonstrate the benefit of energy management in IoT for smart cities, simulation results are presented.[4]
Green Internet of Things (IoT) is the research and use of environmentally friendly sustainable computing, according to Saurabh Singh et al. (2016). Using dependable and secure connections, green computing aims to minimise the usage of resources and maximise energy efficiency. The paper discusses numerous green IoT technology and problems. It also investigates green information and communication technology (ICT), including green data centres, green cloud computing, and green M2M. This study also discusses the problems with achieving green IoT communication through the use of effective activity scheduling techniques for energy conservation. The green IoT-Home Service (GIHS) paradigm, which offers effective energy management in home automation systems, is the last suggestion we make. [5].

Methodology

In this section, we will model a Green IoT has three concepts, namely, enabling technologies, leverage technologies, and design technologies refer to interconnections, network architectures, communications protocols, and the energy efficiency of devices.
To get a green IoT product, it must go through a closed process including green design, green production, green utilization, and green disposal/recycling cellular network to accommodate unmanned aerial vehicle as flying base stations and cellular UEs and D2D UEs and obtain mathematical expressions for outage, system sum rate will explain network model, channel model, system sum rate, useful results, and performance metrics respectively.
The term IoT to a network of physical devices (i.e., “things”) that can be connected among themselves and with other services that are deployed over the Internet. Such devices are usually composed of sensors, actuators, communications transceivers, and computationally constrained processing units (e.g., microcontrollers). IoT devices have multiple applications in fields such as appliance remote monitoring home automation or precision agriculture The adaptation of the IoT principles to industrial environments is referred to as IIoT and allows for deploying many remotely monitored and controlled sensors, actuators, and smart machinery in industrial scenarios Most current IoT applications are already deployed on cloud computing based systems since they allow for centralizing data storage, processing, and remote monitoring/interaction; however, such centralized solutions have certain limitations.

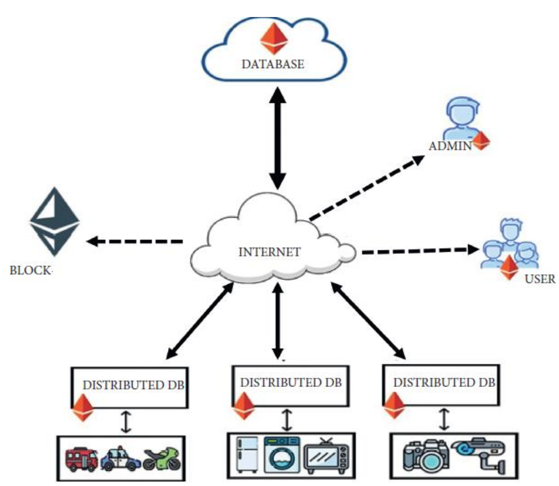

Fig. 5 Proposed model of 5G Green IoT

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Energy Efficiency for IoT: Developing Green IoT Systems

The cloud itself is considered a common point of failure, since attacks, vulnerabilities, or maintenance tasks can block it and, as a consequence, the whole system may stop working . In addition, it is important to note that the number of connected IoT devices is expected to increase in the next years and, consequently, the number of predicted communications with the cloud may overload it if it is not scaled properly.Due to the previous constraints, in recent years, new architectures have been proposed. In the case of edge computing, it is aimed at offloading the cloud from tasks that can be performed by devices placed at the edge of an IoT network, close to the end IoT nodes. Thus, different variants of the edge computing paradigm have been put forward, such as fog computing proposed by to make use of low-power devices on the edge, or cloudlets which consist of high-end computers that perform heavy processing tasks on the edge.

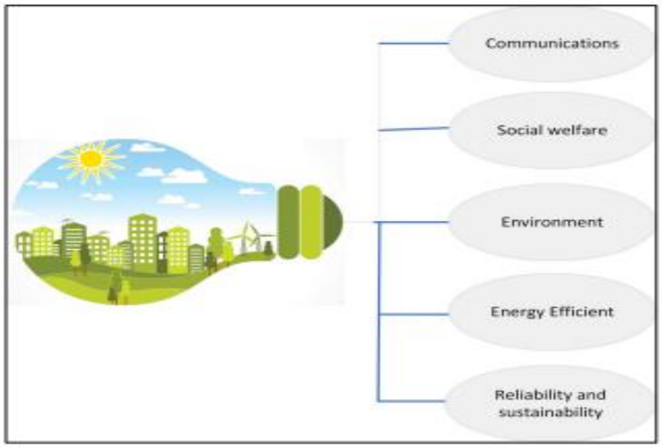

Fig. 6 5G Green IoT Systems Related work

IoT plays a tremendous role in improving smart cities, affecting in different ways with its numerous applications in enhancing public transformation, reducing traffic congestion, creating cost-effective municipal services, keeping citizens safe and healthier, reducing energy consumption, improving monitoring systems, and reducing pollution, However, IoT environmental issues such as, energy consumption, carbon emission, energy saving, trading, carbon labeling and footprint, have attracted researchers' attention. Therefore, carbon emission reduction and energy efficiency technologies based IoT are summarized. The study discusses IoT technologies to facilitate real-time intelligent perception of the environment, and generate and collect energy consumption in manufacturing the entire life cycle.

To fulfill goals of smart cities and sustainability, green IoT is a key technology to decrease carbon emission and power consumption. The increasing number of IoT devices leads to increased energy consumption. Up protocols and sleep schedules of IoT devices are introduced for energy consumption and resource utilization The authors of provided the techniques that can reduce the energy consumption in IoT via efficient energy of data transmission from IoT devices, data center efficient energy, and design energy-efficient policies. Further, authors in introduced Information and Communication Technology (ICT) impacts on carbon emissions and smart cities' energy consumption.

1. Enabling IoT techniques for eco-friendly ICT. Specifically the significant impacts of ICT for reducing energy consumption and CO2 emissions for a sustainable smart city.

2. Different strategies and techniques used for energy efficiency, reduced CO2, reduced traffic, and reduced resource usage in smart cities.
3. Waste management techniques to improve smart cities.
4. Advanced techniques used for smart city sustainability.
5. Surveyed current ongoing research works and possible future techniques for smart cities' sustainability and energy efficiency, based on collaborative IoT.

Designing energy-efficient polities for IoT data transmission and data centers.

1. Exploring the principles of green IoT to enhance quality of life, safety environment and economic growth.
2. The principle of green ICT for smart cities.
3. Applying techniques for enabling green IoT for energy efficiency.
4. IoT concepts and advantages for different applications of smart cities.
5. Enabling techniques for green IoT in smart cities.
6. Fog computing and enabling technologies for sustainable smart cities based on IoT environments.
7. UAV-assisted green IoT applications in smart cities based on 5G networks.

Our work Focuses on techniques and strategies which lead to reduce emissions, reduce traffic, improve waste management, reduce resource usage, reduce energy consumption, and enhance QoS of communication networks for making smart cities more livable, sustainable, and more environmentally friendly.

Results and Analysis

5G Green IoT Inthis segment, we are going to present panoptical numerical results based on our former analysis of outage probability and system sum rate with respect to SINR-threshold, D2D user density and ratio of D2D user density to cellular downlink user density. will include parameter settings, and plots of SINR CDF, outage probability and system sum rate with respect to SINR-threshold , D2D density λ_d, and ratio of D2D user density to cellular downlink user density λ_d/λ_{du}.

Parameter Settings

In the following numerical results, parameter setting for network is selected as per the LTE instructions.

Table 1 Network parameter setting

Carrier freq, f_c	:	2 GHz
UAV transmit power, P_u	:	5 W
D2D transmit power, P_d	:	100 mW
Path loss coefficient, K	:	-30 dB
Path loss exponent for D2D link, α_u	:	3
Path loss exponent for UAV-user link, α_d	:	2
Cellular downlink user density, λ_{du}	:	10^{-4} UE/m^2
D2D user density, λ_d	:	4* 10^{-4} UE/m^2
D2D pair distance, d_0	:	10 m
Outage threshold, β	:	10 dB
Channel bandwidth, W	:	10 MHz
Noise power density, N	:	-120 dBm
Excessive attenuation factor for NLOS,η	:	20 dB

Parameter for dense urban environment, B, C	:	0.136, 11.95

5G Green IOT SINR CDF Versus SINR Threshold

Fig.6 illustrates the variation of Signal-to-interference cumulative density function with respect to SINR threshold value. In our analysis we will range our SINR threshold value from20 dB to 15 dB. Here we have plotted the SINRCDF variation for two different value of D2D user density. Red line represents the SINRCDF when number of D2D users' density are equal to cellular users around a given BS. Blue line represents SINRCDF when D2D users' density is four times that of cellular user in that given BS area. The nature obtained here is monotonically increasing, but this increase is not uniform over the entire range. The lower portion of the curve, i.e. from -20 dB to -10 dB, increases at a lower rate while the middle section ranging from -10 dB to 10 dB increases with considerable rate.

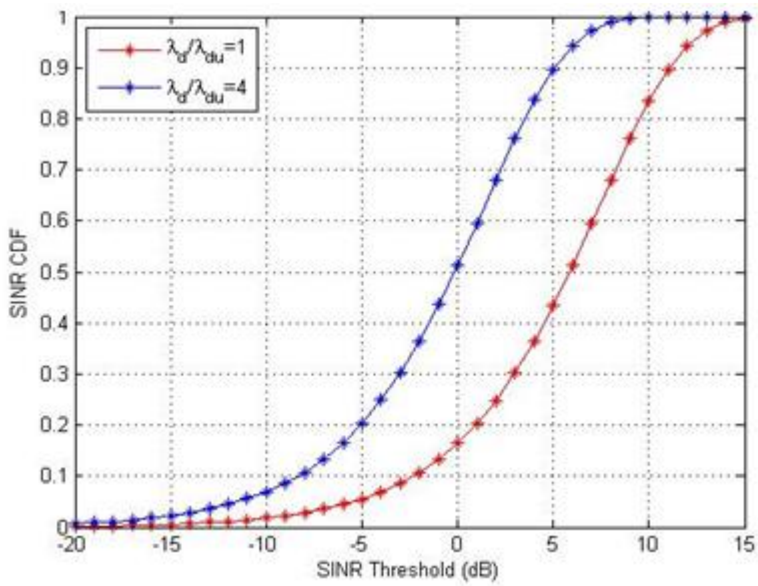

Fig. 7 5G Green IoT SINR CDF Versus SINR Threshold β.

The reason for such behaviour lies in the fact that, when D2D users' density is equal to cellular users' density, distance between corresponding D2D transmitter and receiver is more which results in small amount of received signal strength at D2D receiver. Thus signal strength is less as compared to cumulative interference received at this receiver from all other D2D transmitters. When SINR threshold is increased from -20 dB to -10 dB, the SINR ratio will be very small. This ratio will increase as we increase the SINR threshold, and the SINR-CDF will increase at a greater rate.

The increase in SINR-CDF can be made more is we increase the D2D users' density. With increase in D2D users' density, distance between nearest D2D transmitter and its intendant receiver will decrease, which will eventually increase the strength of the received signal at receiver. The interference term will also increase, but its rate of increase will be less. Increase in SINR threshold will also favour the increase of SINR-CDF.

5G Green IOT Outage Probability of D2D user versus ratio of D2D density and cellular downlink user densirt(Λ_D/Λ_{DU})

Fig. illustrates the variation of outage probability versus the ratio of D2D density and cellular downlink user density (λ_d/λ_{du}). The increase is linear for smaller values of d_0 but is sub-linear for greater values of d_0.

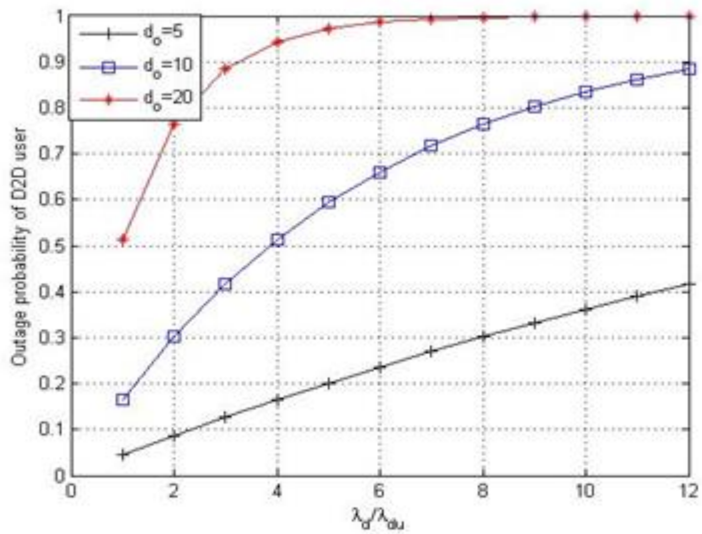

Fig.8 5G Green IoT Outage Probability of D2D user Versus

Ratio of D2D density and cellular downlink user density (λ_d/λ_{du}).

Let us understand the reason behind such variation. When d_0=5m, the D2D transmitter and receiver are close enough, so received signal strength at the receiver is good. This increases SINR value, which means outage probability, will be small. When d_0 is increased at sameλ_d/λ_{du}, D2D pair separation increases, which results in decreased received signal strength at receiver. Due to this, outage probability increases as shown by red and blue lines in the above figure 7.

But when λ_d/λ_{du} increases, it means that number of D2D users are increased. For d_0=5m, interfering D2D users will increase at a greater rate and thus will support the increase of outage probability. When d_0 is increased to 10 meters, signal is received from a transmitter which is located at a distance of 10m but interfering D2D pairs will be available everywhere, hence SINR will decrease and outage will increase at a much greater rate than previous case. Similar will be the case when d_0 is increased to 20m.

Conclusion

Green IoT in the future will make significant changes to lead to a green environment. Every day we will see sensors, machines, drones, etc. communicating with each other to do a task intelligently for the green and sustainable environment. Green IoT not only helps other industries protect the environment and develop sustainably but also directly impacts the IoT industry. In the future, Green IoT will be a sustainable design and technology.

Green IoT not only helps other industries protect the environment and develop sustainably but also directly impacts the IoT industry. In the future, Green IoT will be a sustainable design and technology. Here we looked into the performance of a UAV that acts as a flying base station in an area in which users are capable of D2D communication. We have considered two types of users in the network: the downlink users served by the UAV and D2D users that communicate directly with one another. We have derived coverage probability, outage probability and system sum rate for D2D communication. Analyzing system sum rate was our sole purpose. The results have shown that SINRCDF and outage probability of D2D users increases with increase in SINR threshold. Outage probability increase even with d= du ratio. Finally, we have found that our D2D system sum rate can be increased with SINR-threshold and D2D user density. This increase in D2D users system sum rate decreases if both SINR-threshold and 'd' are in-creased beyond a range. Hence, maximum value is attained over a small range of and d and this is where a tradeoff is made. For the obtained results, it is cleared that we have considered general power law model with Rayleigh fading with mean one.

Reference

1. Mahmoud A. M. Albreem, Ayman A., Muzamir Isa, Wael Salah, M. Jusoh, M.M Azizan, and A Ali (2017) "Green Internet of Things (IoT): An Overview", Proc. of the 4th IEEE International Conference on Smart Instrumentation, Measurement and Applications (ICSIMA), https://www.researchgate.net/publication/322021467, pp-1-7.
2. RushanArshad, SamanZahoor, Munam Ali Shah, Abdul Wahid, and Hongnian Yu, (2017) "Green IoT: An Investigation on Energy Saving Practices for 2020 and Beyond", IEEE, http://www.ieee.org/publications/standards/publications/rights/index.html for more information.,pp- 15667- 15681.
3. Nitasha Khan, Aznida Abu, Muhammad Alam, and M.S Mazliham, (2020) "Analysis of Green IoT", https://www.researchgate.net/publication/344217922, pp-1-15.
4. WaleedEjaz, Muhammad Naeem, Adnan Shahid, AlaganAnpalagan, and Minho Jo, (2017) "Efficient Energy Management for the Internet of Things in Smart Cities", Enabling Mobile and Wireless Technologies for Smart Cities: Part 1, 10.1109/MCOM.2017.1600218CM, pp-84-91.
5. Saurabh Singh, SeoYeon Moon, Gangman Yi and Jong Hyuk Park "Energy Consumption and Reliable Communications for Green IoT", pp- 309-312.
6. Xilong Liu and Nirwan Ansari, (2019) "Toward Green IoT: Energy Solutions and Key Challenges", IEEE Communications Magazine, 10.1109/MCOM.2019.1800175, pp-104-110.
7. Vinita Tahiliani and MayuriDigalwar, (2018) "Green IoT Systems: An Energy Efficient Perspective", Proceedings of 2018 Eleventh International Conference on Contemporary Computing (IC3), pp-1-6.
8. Faris. Almalki, S. H. Alsamhi, RadhyaSahal, Jahan Hassan, AmmarHawbani, N. S. Rajput, Abdu Saif, Jeff Morgan and John Breslin, (2021) "Green IoT for Eco-Friendly and Sustainable Smart Cities: Future Directions and Opportunities" https://doi.org/10.1007/s11036-021-01790-w, pp-1-25.
9. RushanArshad, SamanZahoor, Munam Ali Shah, Abdul Wahid and Hongnian Yu, (2017) "Green IoT: An Investigation on Energy Saving Practices for 2020 and Beyond", IEEE Access, DOI: 10.1109/ACCESS.2017.2686092, pp-1-15.
10. S. H. Alsamhi, Ou Ma, M. Samar Ansari, and QingliangMeng, (2018) "Greening Internet of Things for Smart Everythings with A Green-Environment Life: A Survey and Future Prospects", Electrical Engineering and Systems Science, https://doi.org/10.48550/arXiv.1805.00844 pp-1-14.