A Framework for Enhancing the Energy Efficiency of IoT Devices in 5G Network

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Abstract: -A wide range of services, such as improved mobile broadband, extensive machine-type communication, ultra-reliability, and low latency, are anticipated to be delivered via the 5G network. The 5G network has developed as a multi-layer network that uses numerous technological advancements to provide a wide array of wireless services to fulfil such a diversified set of requirements. Several technologies, including software-defined networking, network function virtualization, edge computing, cloud computing, and tiny cells, are being integrated into the 5G networks to meet the needs of various requirements. Due to the higher power consumption that will arise from such a complicated network design, energy efficiency becomes crucial. The network machine learning technique has attracted a lot of interest from the scientific community because it has the potential to play a crucial role in helping to achieve energy efficiency. Utilization factor, access latency, arrival rate, and other metrics are used to study the proposed scheme. It is determined that our system outperforms the present scheme after comparing the suggested scheme to these parameters.

Keywords: Security, Privacy, IoT, 5G network

1. Introduction

The Internet of Things (IoT) systems has been a recent trend in recent decades. Internet-of-Things (IoT) provides a strong backbone of intelligent sensor technology. In the current scenario, many IoT devices are available in different areas, especially for the Intelligence system. The vast amount of data and information spread on the market in all different areas. The IoT system also releases vast amounts of data from sensor networks and devices. Object and cloud network topologies currently support IoT-based sensors and their release date. The IoT healthcare system is proving rapidly and changing personal lifestyles, but security and privacy are important issues responsible for network data [1]. The IoT healthcare security system uses many concepts and applications to run such an environment. The internet of things has been deployed in every area, such as banking, railways, healthcare, vehicle management, the automobile sector, and intelligent transportation. The Internet of Things defines that network as consisting of interconnected smart sensors. These intelligent sensors can sense their environment and exchange the process and information of different domains [2]. The Internet of Things can make available an enormous quantity of applications which are likely to persuade our existence and get better quality. Most are at present obtainable on the market. The recent trend of intelligent IoT-based sensors involves different domains, especially in innovative healthcare systems. The security reason architecture of IoT infrastructure cooperates a vital role in a logical vision. The architecture of the IoT system would be responsible for Technical, Scientific and industrial reasons, among this privacy and security.

5G network

5G will improve our smartphones' throughput and introduce fresh, immersive experiences like virtual and augmented reality with quicker, more consistent information rates, reduced latency and low cost-per-bit. The initial roll-out of 5G mm-Wave NR is focused on enhanced Mobile Broadband (eMBB) to increase the data bandwidth and efficiency of connections using a different set of radio frequency bands, enabling better download and upload speeds compared to a 4G/LTE network. Ultra-reliable Low Latency Communication (URLLC) focuses on highly latency-sensitive or mission-critical use, such as factory automation, remote robotic surgery and driverless autonomous cars. The URLLC requirements area is still standardized and will be a part of the 3GPP Release [1]. Massive Machine-type Communication (mMTC) focuses on low-power and high-density use cases, which includes requirements for technology like Narrow Band Internet of Things (NB-IoT), focusing on the internet of things and smart devices. Fig 1. shows the current view of the 5G ecosystem and a few targeted use cases defined in 3GPP Release 15. 5G is poised to tackle insatiable mobile broadband demand of more than 60x increase in mobile information traffic, generating over ~136B Gigabytes of monthly data traffic by 2024, and 25% of mobile data traffic will be carried by 5G networks which are 1.3x more than 4G traffic today [3].

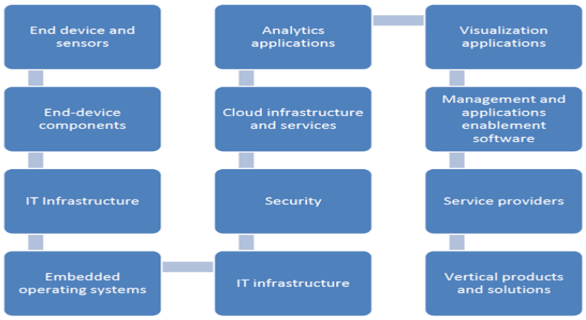

Figure 1 Internet of Things (IoT) new business model

2. Energy-Efficient Techniques

Various techniques can be adopted to make the upcoming 5G networks energy efficient. These techniques can be classified under three categories which are using energy-efficient architectures or energy-efficient resource allocation, or using radio technologies which are energy efficient [4]. The following techniques are available: -

1. Energy-Efficient Architectures
    - Optimisation of cell size: large vs small cell deployment
    - Overlay source: microcell, picocell or femtocell
    - Relay and cooperative communications
2. Energy-Efficient Resource Management:
    - Joint power and resource allocation
    - SISO vs MIMO with packet scheduling
3. Energy-Efficient Radio Technologies:
    - Heterogeneous network deployment (multi-RAT)
    - SWIPT

These techniques have been discussed further for power optimisation and their integration with the 5G network.

A. Simultaneous Wireless Information and Power Transfer (SWIPT)

Due to the greater demand for energy efficiency in wireless communication, there is a lot of interest in integrating energy harvesting technologies in wireless communication systems. The most upcoming technology is WPT (wireless power transfer), where nodes charge their batteries from electromagnetic radiation. Strong signals increase power transfer, but at the same time, they also increase the amount of interference. This technique can be most helpful in the case of a sensor node or for the upcoming Internet of Things technology in which the control signals will be used to charge the access point. The future networks will overcome the problems of path loss with the use of MIMO, small cells and mm waves [5]. The element used for this purpose is a Rectenna which converts microwave energy to direct current. It is achieved by splitting the received signal into two orthogonal signals. SWIPT involves modification in the existing communication system. There can be three scenarios where we use SWIPT:

- Near field scenario: Power is transferred using inductor or capacitor coupling, and up to tenths of a watt can be transferred with a range of 1 m.
- Far-field Scenario: Power is transferred using directive power beaming with directive antennas up to mW and a range of several meters.
- Far-field low power scenario: Power is transferred with RF power scavenging up to micro-Watts with a range of several km.

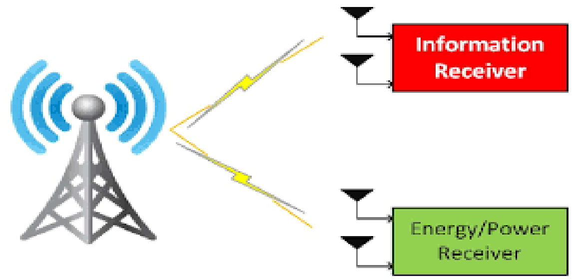

Figure 2 Simultaneous information and power transfer

Now we concentrate on the far-field scenario. For this, the power signal received is split into two signals: one for energy harvesting and another for information decoding [5]. Several methods are used to achieve this, which are as follows: -

1. Time Switching: This is not a simultaneous processing technique, as an RF signal is used either for information or power transfer in a one-time slot. It requires time synchronisation.
2. Power Splitting: A power splitter separates an RF signal into two streams of different power levels. It is more complex and is used for critical information transfer.
3. Antenna Switching: In this technique, an antenna element is switched for decoding and rectifying. It can be used in MIMO systems. It uses some antennas with the most robust channel paths for energy and the rest for information.
4. Spatial Switching: This technique exploits the interference channel's multiple degrees of freedom (DoF). The MIMO channel is transformed into parallel Eigen value channels that can be used for either power or information transfer.

It is an up-and-coming technique for the following generation networks and has attracted the attention of many researchers. However, there are still issues to be addressed for its practical implementation and integration with the existing networks, as the present receivers need to be modified.

B. Small Cells

Small cells are an umbrella term for operator-controlled, low-powered, low-cost base stations (BS) operating in a licensed spectrum. Small cells can be of different sizes depending on which they are classified: -

- Femto cells
- Pico cells
- Micro cells

They can have a centralised base station (BS) or remote radio heads, wired or wireless, with a core network. They reduce the distance between the user and BS, reducing the transmit power required to overcome the path loss and improving the EE of both uplink and downlink. Three basic access policies can be used in each cell [6]. These are listed below-

- Closed Access: In this scheme, only the users in a closed subscriber group can connect.
- Open access: In this scheme, all users can connect.
- Hybrid access: In this scheme, all users can connect, and priority is given to specific users.

A Small Cell Access (SCA) point will be installed on buildings and communicate with Base Station. The Mobile Stations inside the building will only need to communicate to the SCA and not to the far-located base station, hence decreasing the load and power requirement. Deployment of Small cells requires minimum changes in the current standard and can save many users' battery consumption. The BS sleeping strategy can balance traffic offloading and energy consumption.

C. Massive MIMO

Energy saving is a global trend, and the design philosophy must change accordingly. Facing this challenge, energy efficiency (EE) becomes increasingly essential for mobile communications to prolong batteries' life cycle. Power-control optimisation for single antenna systems operating on uplink code division multiple access (CDMA) Gaussian channels is tackled in the game theory framework to maximise each user's energy efficiency. Its counterpart for multicarrier systems with orthogonal frequency-division multiplexing (OFDM) transmission, taking into account the circuit power consumption, link adaptation, and resource allocation. Massive MIMO is an evolving technology that has been upgraded from the current MIMO technology. The Massive MIMO system uses arrays of antennae containing a few hundred antennas simultaneously, a frequency slot serving many tens of user terminals. In general, massive MIMO is an evolving technology of Next generation networks, which is energy efficient, robust, secure and spectrum efficient [6]. Massive MIMO depends on spatial multiplexing, which further depends on the base station to have channel state information, both on the uplink and the downlink. In the case of downlink, it is not easy, but in the uplink, it is easy, as the terminals send pilots. Based on pilots, the channel response of each terminal is estimated. The base station sends the pilot waveforms to the terminals in conventional MIMO systems. Based on these, the terminal estimates the channel quantises it and feedbacks them to the base station. This process is not viable for massive MIMO systems, especially in high mobility conditions, for two reasons. Firstly, the downlink pilots from the base station must be orthogonal among the antennas, due to which the time requirement and frequency slots for the downlink pilots increase with the number of antennas. So Massive MIMO systems would now require many similar slots compared to the conventional MIMO system. Secondly, as the number of base station antennas increases, the channel estimates also increase for each terminal, which needs a hundred times more uplink slots to provide feedback on the channel responses to the base station. A general solution to this problem is to work in Time Division Duplexing (TDD) mode and depend on the interchange amid the uplink and downlink channels. Massive MIMO systems can not only provide high SE but also may improve EE. A power scaling law in massive MIMO systems was revealed in [8].

When the number of antennas at the BS is much larger than that of users, channel vectors for different users are asymptotically orthogonal. In this case, simple linear pre-coders, such as matched-filter and zero-forcing, can achieve the capacity asymptotically. The transmit power is scaled down by the number of antennas at the BS to achieve the same data rate as single-antenna systems when perfect CSIT is known at the BS. The EE decreases with the increase of the SE with perfect CSIT. With imperfect CSIT, the EE increases with the SE at the low-power region and decreases with the SE at the high. When circuit power is considered, massive MIMO equipped with more RF chains will consume considerable circuit power, which may lead to severe EE reduction. In order to improve the EE of the system, some antennas at the BS can be turned off, which is very similar to traditional MIMO [9]. Also, by adding more hardware, power consumption in Massive MIMO systems can be considerably decreased as the dynamic part is decreased, which results in fewer propagation losses and improved energy efficiency. Energy efficiency can be improved by implementing a network topology combining massive MIMO and installing a few single antenna small cell access points in areas with active users with little additional hardware. Many other techniques can also be used to improve energy efficiency, which is the scope for future research.

D. D2D Communication

With the growing trend of proximity-based applications, such as peer-to-peer file sharing and local multicasting and advertising, D2D communications have been proposed to improve local service flexibility and network throughput and to support public safety service in case of lack of network coverage in 3GPP LTE-Advanced. In D2D communications, proximity users in cellular networks can transmit data directly to each other without going through the BS. Due to physical proximity, D2D communications can provide proximity gain, reuse gain, and hop gain. Thus, D2D communications can significantly improve network SE and device EE. Furthermore, D2D communications can provide more freedom for D2D users, as they can transmit data in three modes:

- Dedicated mode: D2D users directly transmit data using the orthogonal resource of regular cellular users.
- Reusing mode: D2D users directly transmit data by reusing the resource of cellular users.
- Cellular mode: D2D users are treated as regular cellular users and communicate with each other through the BS in the standard way. Proper mode selection allows the EE of both devices and the network to be significantly improved.

E. Relays

Relays in a wireless system can be considered an “agent” of the base station outside its cell coverage area. These wireless relays allow the mobile terminals to help forward information when they are neither the source nor the destination of the information involved. Relays were introduced to increase the coverage area of transmission only. Still, later it was realised that relaying can be applied in a wireless communication system to increase the coverage area, network throughput, system capacity, and transmission power. The basic principle in relaying is that in a relay-assisted network, the mobile stations can receive the signal from both a base station (BS) and a Relay Node (RN), depending on which provides better signal strength, mainly depending on the distance between them. It differentiates it from a standard wireless network in which each mobile station (MS) directly communicates with a base station [7]. Relaying splits longer paths into shorter ones by providing LOS communication and thus reducing the resulting total path loss. It consequently reduces the power required for transmission. There exist three primary relaying schemes: Decode-and-Forward, Compress-and-Forward and Amplify-and-Forward. The first two schemes were proposed in Cover and El-Gamal’s pioneer article.

- Decode-and-Forward (DF): In this relaying scheme, the relay decodes the source message in one block and transmits the re-encoded message in the following block.
- Compress-and-Forward (CF): In this relaying scheme, the relay quantises the received signal in one block and transmits the encoded version of the quantised received signal in the following block.
- Amplify-and-Forward (AF): In this relaying scheme, the relay sends an amplified version of the received signal in the last time slot. Compared with DF and CF, AF requires much less delay as the relay node operates timeslot by timeslot. In addition, AF requires much less computing power as no decoding or quantising operation is performed on the relay side.

So, we can use Amplify and Forward relay in power-constrained scenarios. Various relay selection policies are possible for different types of applications [8]. A reduced channel estimation overhead policy is provided for high mobility scenarios. A delay minimisation policy is given for delay critical applications. A low power consumption policy for power-efficient communications is established. So, to meet the objective of improving energy efficiency, the policy for low power consumption for both the base station and the relay node needs to be adopted.

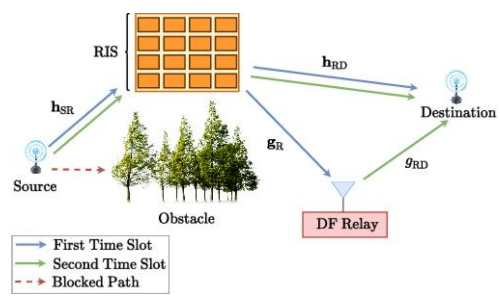

Figure 3 Decode and forward relay

3. Methodology

The downlink transmission of wireless communication system antennas transmits independent information to a subset of users, each equipped with a single antenna. The Shannon capacity of this MIMO broadcast channel (MIMO-BC) can be challenging to implement in practice. Motivated to study more straightforward transmission techniques, we focus on a linear precoding technique based on the zero-forcing (ZF) algorithm.

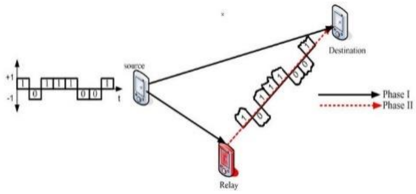

Figure 4 Amplify and forward relay

In contrast to the typical sum power constraint (SPC), we consider a per-antenna power constraint (PAPC) motivated both by current antenna array designs where each antenna is powered by a separate amplifier and by future wireless networks where spatially separated antennas transmit cooperatively to users. We show that the power allocation problem for maximizing the weighted sum rate under ZF is a constrained convex optimization problem that can be solved using conventional numerical optimization techniques. We find an analytic solution based on water-filling techniques for the particular case of two users. For the case where the number of users increases without bounds, ZF with PAPC is asymptotically optimal. The ratio of the expected sum-rate capacities between ZF with PAPC and DPC with SPC approaches one. How the results can be generalized for multiple frequency bands and a hybrid power constraint Finally, we provide numerical results that show ZF with PAPC achieves a significant fraction of the optimum DPC sum-rate capacity in practical design for the multiple-input single-output (MISO) multiuser broadcast channel is an important problem in modern wireless communication systems. The main difficulty in this channel is that coordinated receive processing is impossible, and all the signal processing must be employed at the transmitter side. From a signal processing point of view, there are still many open questions, and there is an ongoing search to find an efficient yet straightforward transmitter design. The most common linear preceding scheme is zero-forcing (ZF) beamforming. It is a suboptimal approach that attracted considerable attention since there are computational difficulties even within linear precoding strategies. For example, we lack efficient techniques for maximizing throughput using linear beam forming. Instead, ZF is a simple method which decouples the multiuser channel into multiple independent sub-channels and reduces the design to a power allocation problem.

MMSE Detection of Multicarrier CDMA

Minimum mean squared error (MMSE) detection of multicarrier code-division multiple-access (CDMA) signals is observed. The theoretical performance of two different design strategies for MMSE detection is compared. In one case, MMSE filters are designed separately for each carrier, while in another, the filters are optimized jointly. Naturally, joint optimization produces a better receiver, but the differences in performance are substantial. The multicarrier CDMA performance is then compared with the single-carrier CDMA system on a frequency-selective fading channel. A mechanism is then developed to track the channel fading parameters for all the users' signals so that joint optimization of the receiver filters is possible in a time-varying channel. The minimum mean square error combining (MMSEC) scheme performs best among various equalization and combining schemes for downlink MC-CDMA. However, it is also the most computationally complex to realize as it involves coefficient for MMSEC based on reduced-size Multicarrier code division multiple access (MC-CDMA) is a technique that combines direct sequence (DS) CDMA with orthogonal frequency division multiplexing (OFDM) modulation. It is a candidate technology for the 4th generation of wireless communication systems. MC-CDMA transmits every data symbol on multiple narrow-band sub-carriers and utilizes cyclic prefixes to absorb and remove inter-symbol interference (ISI) from frequency selective fading. As it is unlikely for all sub-carriers to experience deep fade simultaneously, frequency diversity is achieved when the sub-carriers are appropriately combined at the receiver. It is shown that MC-CDMA outperforms the conventional DS-CDMA and two other forms of CDMA with OFDM modulation, namely MC-DS-CDMA and multi-tone CDMA. Several combining techniques have been proposed for MC-CDMA systems MMSEC performs best compared to all other schemes mentioned above; however, it is also most computationally complicated to realize because it involves the matrix inversion operation of a large complex matrix and the way to reduce the matrix inversion dimension for calculating the MMSE equalizer coefficient for downlink MC-CDMA MMSE channel estimator and DS-CDMA detector. For downlink transmission, all user signals are synchronously combined before transmission.

4. Result

Energy Efficiency Techniques 5G networks outage ratio for HPUEs performance of the MC-CDMA system, the theoretical performance and computer simulation results are presented. TPC, TPC-GR, Prioritized TPC, and GR QAM modulation are employed for all investigated systems. For MC- CDMA and PSK 16 systems, MMSE for MC-CDMA based systems, the parameters of TPC, TPC-GR, Prioritized TPC, Prioritized TPC, GR performance versus signal-to-noise ratio (SNR) dB/N0, where dB is the energy transmitted per information bit and N0 is the one-sided noise power spectral density. For comparison purposes, both theoretical performance and simulation results of the linear receivers for MC-CDMA in impulsive noise are plotted. It can be seen that the computer simulation results match the theoretical analysis perfectly evolution Towards 5G Multi-tier Cellular Wireless Networks with Higher Data Rates Transmission in MIMO Systems. In addition to setting, they transmit power for tracking their objectives, and the LPUEs limit their transmit power to keep interference caused to HPUEs below a given threshold. HPUEs can notify the nearby LPUEs when the interference exceeds the given threshold.

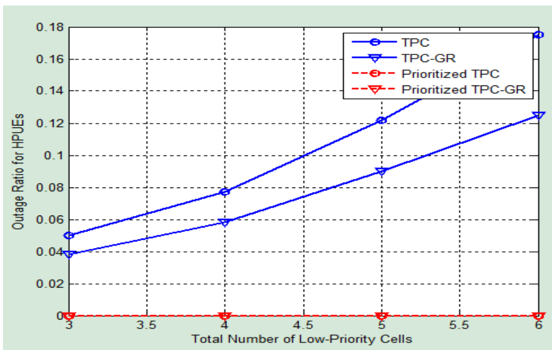

Figure 5 Performance of TPC, TPC-GR, Prioritized TPC, Prioritized TPC, GR and the total number of low Priority Cell

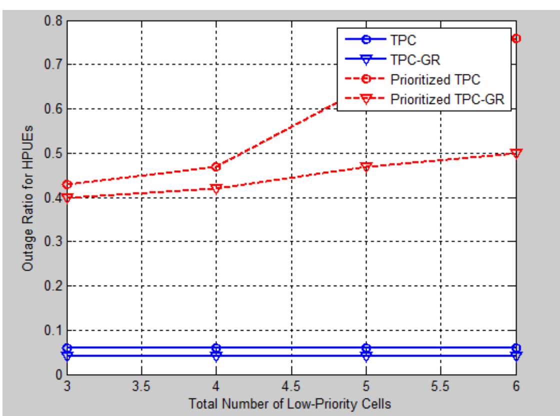

Figure 6 Energy Efficiency Techniques in Ultra-Dense Wireless Heterogeneous 5G networks

5. Conclusion

Energy Efficiency of IOT-5G networks We considered the effect of Performance gain due to cognitive spectrum access Outage probability (of small cell users) vs spectrum sensing threshold for cognitive techniques and different values pc (=percentage of SBSs operating in the closed access mode)Outage due to SINR violation and outage due to unavailability of channel for opportunistic spectrum access for small cell users vs spectrum sensing threshold for different cognitive techniques and different values prefect of channel allocation at the macro tier Two channel assignment techniques for the MBSs in a two-tier network with cognitive SBSs: random channel assignment (RCA) and sequential channel assignment (SCA)RCA: each MBS randomly and uniformly chooses one channel for each of its associated users the available channels have a specific order. Each MBS assigns the channels to its associated users in a sequential manner. RCA deteriorates the opportunistic spectrum access performance for cognitive SBSs. SCA minimizes the number of unique channels used by the coexisting MBSs (hence maximizes the opportunistic spectrum access performance for cognitive SBSs).

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