Survey of Various Techniques to bolster Energy Efficiency in 5G IoT

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***Abstract*— Wireless networks are the modern infrastructure on which global connectivity is built. 5G is the next generation of wireless technology. It is a faster, more efficient and a more reliable network. 5G network is used in various fields like national defence, industrial production, developing smart cities, transportation and even in healthcare. The main feature of 5G wireless technology is that it operates in a wider bandwidth and in turn carries more data faster. Compared to previous generations, 5G increases coverage, so massive number of IoT devices can be connected and it improves the efficiency of low power communication. Boosting energy efficiency (EE) and hence lifetime of 5G Internet of Things (IoT) by employing various methods and algorithms in both wireless and wired components is discussed in this paper. Improved Cellular Partition zooming (CPZ) for wireless IoT network, refined variation of precaching mechanism for the wired portion of IoT, Ds2Ds, clustering techniques of wireless IoT and split architecture based CRAN approach for backhaul network are introduced. Further, an integrated model which caters to efficiency requirements for both wired and wireless is proposed and emerging EE is investigated. All the mechanisms discussed are found to be more energy efficient as compared to standard systems. One of the major sources of energy consumption in IoT networks is due to the transmission of information and reception of information which indeed is dependent on the routing protocol in place. So, if routing protocols which are energy efficient are employed, it can greatly help to reduce the amount of energy spend in one successful trip of information from the sender to the receiver. The routing protocols discussed are Lightweight On-demand Ad hoc Distance-vector Routing Protocol-Next Generation (LOADng) and Routing Protocol for Low Power and Lossy Networks (RPL). The simulator used while analysing the routing protocols is Cooja and the operating system is Contiki. In this survey project, we are focusing on emerging technologies in 5G IoT like Clustering, Ds2Ds, etc that improves the overall energy efficiency, use case, challenges, prospects and various security threats and the preventive measures. In order to have a deep understanding of 5G in IoT, the general architecture and it's enabling technologies are analysed. Also, the two most widely used and followed clustering techniques in wireless sensor networks – LEECH and HEED are discussed in this paper. Clustering not only improves the lifetime of the nodes connected in a network but also leads to network scalability and robust performance. Another factor that greatly affects the energy of the nodes in IoT network is backhaul communication. To manage the increasing number of devices and data transfer requests without leading to interference at the base stations, an improved CRAN technique is used in the backhaul network architecture.**

***Keywords*—5G IoT, CRAN, CPZ, Ds2Ds, CH, LEECH, HEED, backhaul network, BS, LOADng, LPWANs, URLLC,**

I. Introduction

According to recent survey, by the year 2030 nearly 80 billion devices will be connected with IoT. All these devices would require a huge amount of energy to operate 24x7 without human intervention. The existing wireless technologies like LTE 4G cannot be used to connect massive number of devices, long distance communication or used in low power wide area networks (LPWANs) like Wi-Fi, Sigfox, Zigbee, LoRa and NB-IoT, hence we move to fifth generation wireless networks. The major areas covered in this paper are listed below:

1. Architecture of 5G IoT.
2. Analysis of the issues and challenges with respect to IoT.
3. Improving techniques of communication using wireless and wired components of 5G IoT.
4. Analysis of Clustering technique and Ds2Ds technology to improve energy efficiency.
5. Improved backhaul network for 5G IoT.
6. Security threats and challenges faced in 5G IoT.
7. Future prospects in this field.

Energy efficiency forms an integral part of IoT as the devices involved face challenges in respect of limited power and storage capabilities, among others. Select and Sleep methodology via Improved Cellular Partition zooming (CPZ) where resources are more efficiently allocated utilizing pie shaped cellular coverage areas depending upon the both the angle and distance of the user device from the base station (BS). Further massive MIMO (e massive multi-input multioutput) in place of existing single antenna remote radio head (RRH) is discussed for economic viability. Now we know that in this digital world there is lot of identical information in terms of videos, songs etc. that is required multiple number of times. So, in order to shorten the transmission lines between the user equipment and the servers, copy servers are created and loaded with most frequent information sought after via precaching mechanism which helps to conserve energy and bolster the lifetime of 5G IoT systems. Efficient routing protocols enable us to save energy while securing successful information transfer between the operating components of IoT network. This paper also evaluates RPL (Routing Protocol for Low Power and Lossy Networks) and LOADng (Lightweight On-demand Ad hoc Distance-vector Routing Protocol-Next Generation). RPl is used for cognitive network designed to make use of machine learning, knowledge representation etc. whereas LOADng is a demand routing protocol. In LOADng route is constructed by using control messages and stored information by nodes. RPL uses less number of hopes by finding a reliable path using ETX combined with ranking of the IoT network than LOADng while transferring message from source to destination hence is more energy efficient. The paper simulates and compares finer details of energy consumption mechanism between the two. Internet of Things (IoT) revolves around large scale of devices that are connected to the network. Hence device centric communication has become an integral part of 5G networks. Devices to Devices communication (Ds2Ds) is a new method of device centric communication in which multiple source IoT devices (SID) can send data to multiple destination IoT devices (DID) using multiple interfaces. The key algorithm employed in this technology is the Tree-search algorithm to choose the efficient resource allocation for the source-destination IoT devices and interfaces. The neighborhood criteria for each source and destination IoT device are defined as follows:

1. Source IoT Device (SID) is within acceptable range of distance.
2. Source IoT Device (SID) contains packets or data that is requested by destination IoT device (DID).
3. SID is also willing to take part in the devices to devices (Ds2Ds) communication.

The typical behavior of a Ds2Ds communication technology is that a destination IoT device (DID) requests some data from the network and indicates its willingness to engage in Ds2Ds communication. The network broadcasts this information to the network. If a source IoT device (SID) contains few or all the data packets, it responds to the network. Based on this indication the network employs tree search algorithm to locate the optimal SID. This optimal selection is SIDs and DIDs results in maximizing the energy efficiency of the IoT system.

Clustering involves grouping of nodes into groups called clusters. Various clustering algorithms have different parameters to select a node from each cluster as the head of the cluster and is known as cluster head (CH). The main role of the cluster head is to aggregate the data from all the nodes in its cluster and transmit the aggregated data to the base station or the sink. The CHs consume more energy than the other nodes in the cluster. This is because of two reasons. First, all the other nodes of the cluster communicate only with the CH to send data or information to the sink or base station. Second, the CH often has to send data over long distances which consumes more energy (as more distance needs more energy). The node which is the cluster head does not remain the cluster head of that cluster for entire time else its power would die out soon and the node would be dead. To avoid this, the role of cluster head is rotated among the nodes in the cluster to balance the power consumption of every node. LEACH and HEED are the two classic clustering protocols that are used as benchmarks and a lot of research has been done on these to further improve clustering techniques.

With the increase in the number of devices in the communication network today, along with the increase in data transferred per device and the variety of data transmitted (such as video, voice, text, images etc) it has become necessary to provide an efficient mechanism to communicate or transfer data from one device to other, or to the entire network. 4G is at the verge of reaching its saturation point. With the development of 5G, backhaul will be an important factor to take care of and at the same time reduce or limit the energy consumed for backhaul and the entire network as well.

The rest of the paper is organized as follows. Related work are described in Section II. Section III gives a detailed description of the architecture of 5G model. Section IV has the algorithms of CPZ, precaching, different clustering techniques and routing protocols. The new split functionality architecture of 5G backhaul network is discussed in section V. Finally, section VI concludes the energy efficiency methods provided in this paper.

II. Related Work

In this paper [5], the authors have discussed about a novel method of device centric communication using tree-search algorithm where multiple source IoT devices can transmit information to various destination IoT devices by making use of numerous interfaces. They have carried out several stimulation tests in order to compare the energy efficiency of per source device. The results indicate that Ds2Ds has a better throughput over Ds2D communication. Moreover, Ds2Ds is superior in terms of energy efficiency of per source device when compared to MH-D2D (Multi-Homing). Whereas Ds2Ds and MH-D2D produce similar energy efficiency when the number of source devices are increased.

Lalit Chettri and Rabindranthan Bera [2] has thrown light on emerging technologies related to 5G systems that enable IoT such as low-power wide area networks (LPWANs) Narrow Band-IoT, 5G New Radio, HetNets, AR, multiple-input-multiple-output antennas that work on beamforming technology etc. This paper focuses on security challenges like Cyber security, eavesdropping and interference and their control measures. This paper provides a detailed illustration on the architecture of 5G IoT and challenges faced in each layer. 5G is a much faster network that would transform the internet. There is a huge shift in the evolution of 5G from 4G in terms of the technology and the user experience of cellular communication. The use cases provided by 5G that are discussed in this paper are enhanced mobile broadband (eMBB), ultra-reliable low latency communication (URLLC) and massive machine-type communication (mMTC). Moreover, various industry applications like smart homes, smart cities, smart factories, E-Health care and Smart transportation are briefed upon.

Di Zhang et al., 2016 gives an integrated proposal of energy efficient system for 5G-IoT [3]. The author combines the energy efficiency in both wireless and wired part of the 5G IoT network. The paper talks about single antenna control and MMIMO (massive multi input multioutput) which are superior to remote radio head (RRH) while using same C-RAN (cloud radio access network) in terms of coverage area and hence offer economic viability while accessing the already laid transmission lines (Base Station). The paper provides Improved Cellular Partition zooming (CPZ) and precaching mechanism as solution to improve the life of 5G-IoT system. Improved Cellular Partition zooming (CPZ) overcomes energy efficiency issues by dividing the coverage areas into pie shaped sections which result in better utilization of energy resources as it takes into account distance as well as angle of the user device from the base station (BS). The precaching mechanism serves as boon for saving energy resources as it involves deployment of copy servers which contain the most sought information whether it be a video or song and hence result in shortening of transmission lines thereby saving energy and increasing life time of 5G-IoT system. Channel state information is another aspect which when shared between the base station can result in efficient transfer of information among various base stations and between the user equipment and the base station as it provides the vital frequency and power needed for transmission of information from sender to receiver.

Zibuyisile Magubane et al., 2020 proposed efficient routing protocols to operate in 5G IoT networks [4] Since maximum energy is spent either in sending the information or receiving it, so routing intelligently and ensuring successful and safe transmission can result in saving energy resources and increase life time of 5G IoT system. The paper evaluates various improved adapted routing algorithms and presents a correlated study between the RPL (Routing Protocol for Low Power and Lossy Networks) and LOADng (Lightweight On demand Ad hoc Distance vector Routing Protocol Next Gen.). RPL while being a distance vector protocol adapts quickly to challenging network conditions including low power and signal loss and provides us with efficient routes rather than just the default ones. RPl grants control messages for constructing topology of the network which is identical to trees like structure. The paper discusses RPl for cognitive network while making use of machine learning, knowledge representation etc. The author further presents LOADng (next generation) as a demand routing protocol which enables generation of control messages and facilitates storing of information by the nodes. It is found that RPL is more energy efficient then LOADng as it employs a smaller number of hopes while transferring information between sender and receiver. It finds a dependable path using ETX and then ranks the IoT network, so that it could use low latency path which make the transmission efficient. The paper also talks about Congestion Avoidance Multipath Routing Protocol (CA RPL) which takes in account routing cost for quick generation of Directed Acyclic Graph resulting in improved packet loss scenario but is less energy efficient then standard RPL.

Xu, Collier and O'Hare in 2017 presented a survey on Clustering Techniques in WSNs [1]. They described the need for clustering algorithms and also provided an overview of well-known clustering algorithms that exist, followed by the difficulties in realizing the same with 5G IoT network. Clustering, as they described, benefits WSNs as it involves the two main tasks which ensure the increase in lifetime of network nodes, which are sleep scheduling and density control. The paper also categorizes clustering in WSN networks into Voronoi-based and Non-Voronoi-based algorithms and discusses the benchmark algorithms for both approaches. LEECH and HEED are standard protocols widely accepted for Voronoi-based network structures. Whereas PEGASIS and CSS are well known clustering methods for Non-Voronoi structured networks such as chain and spectrum. The algorithms for clustering are described in detail in section #. Another point of concern focused in this paper is the need of clustering algorithms to consider other QoS requirements along with the need to work on energy efficiency. Such QoS include network latency and transmission reliability. Making a clustering algorithm that not only ensures energy saving but also other QoS factors will make the upcoming networking generations a lot more advanced than they already are.

Another paper, proposed by N. A. Nawawy, N. Mohamed, R. Dziyauddin and S. Mohd Sam [6] gives detailed analysis on the 5G backhaul energy efficiency. In mobile networks, backhaul is the sub-network that connects the nodes and base stations to core or the backbone of the network. The known CRAN approach for backhaul network of 5G IoT separates the base stations into two - Baseband Unit (BU) and Remote Radio head (RRH) and at the same time centralizing the operations of the two by a Master base Station. This method allows to handle the increasing nodes in the network. A new method of optimizing the energy and efficiency of 5G backhaul network, presented in the paper [6] is based on split architecture using CRAN approach. The idea behind this approach is to either rely on time switching or split the received signals into energy harvesting and information reception. This is done at three layers of the 5G network - CRAN, MAC and PHY layers.

III. 5G Architecture

The IoT devices are classified into two components – the general devices like home appliances and the sensing devices. The general devices are connected either by wired or wireless interface. The sensing devices collects information from the surroundings. These IoT devices are connected to network with the help of IoT gateways. The gateways process the information collected from the sensors and transfer it to the cloud (backend storage unit). The cloud acts as both as the storage and processing unit for the data collected. The wired and wireless interferences such as Wi-Fi, Bluetooth, ZigBee, GSM, Sigfox etc are used to provide connectivity. Let's look at the detailed functioning of each layers.

A. Sensor Layer

The first layer in the IoT 5G framework is the sensor layer, also known widely as the perception layer. This layer consists of the physical devices such as smart sensors, RFIDs (Radio Frequency Identification), actuators, and various other devices that communicate with the network layer. These smart sensors are used in different IoT applications like smart homes, smart cities, smart transportation, E-Healthcare, smart factories, security and for public safety. These sensors are tiny, low cost and importantly consumes less energy. The main responsibility of these sensors is to sense and gather information about the surrounding and transmit the collected data to the network layer for the next stage of processing.

B. Network Layer

The main responsibility of the network layer is to provide longer range connectivity at a low power. LPWANs – Low power wide area networks, is not a single technology but a group of technologies. As the name suggests it offers cost effective, low power and wide area coverage needed for robust IoT sensor networks. LPWANs can receive data from extremely far distances more than 45kms. The LPWAN technologies are categorized into Licensed and Unlicensed spectrum and include proprietary or open standard options.
Sigfox and Lora falls under the proprietary unlicensed spectrum and NB-IoT falls under the licensed spectrum. For short distances Wi-Fi, ZigBee, Bluetooth etc are used.

SIGFOX: Sigfox is a proprietary unlicensed spectrum. It is a new independent network operator originated in France. Sigfox uses a ultra-narrow band modulation technology to offer strong connectivity, low power consumption and hence it is significantly cheaper compared to other technologies. It allows very small data packets to be sent to the network. These features make Sigfox ideal to connect massive number of devices to the network. Sigfox has a bandwidth of 100 MHz and operates in a frequency band of 915-928 MHz [1].

LORA: LORA is also a French-based unlicensed spectrum band and can provide a long-range coverage up to 10km. LORA can operate in various ISM bands i.e. Industry, Scientific and Medical radio bands. The most widely used band is 868 MHz which is available in European Union and 915 MHz widely used in USA.

NB-IoT: Narrow-Band IoT (NB-IoT) is a low power wide area (LPWAN) wireless technology standard developed by 3GPP under release 13 in 2016. It operates under the licensed spectrum. The bit rate of NB-IoT is around 150-200Kbps. The unique feature about NB-IoT is that it does not require any gateways and the sensors can directly communicate with the primary servers. NB-IoT is suitable for IoT systems that has high device density. It operates in the frequency band of 180 Khz. Furthermore, NB-IoT operates in three modes. The choice of deployment plays a vital role in impacting the network dimension, quality of service and total cost of ownership (TCO)

- In-band mode: This method is more cost-effective. Here NB-IoT channel goes within a standard LTE carries and utilizes its resources which are otherwise used for mobile broadband.
- Guard band mode: NB-IoT makes use of the unused 180 KHz frequency band (resource blocks) within the carrier guard-band of LTE.
- Standalone mode: Here a dedicated spectrum is provided. NB-IoT occupies the 200 KHz bandwidth by reframing the GSM spectrum.

Wi-Fi: Wi-Fi is a wireless technology for short range communication of about 100m. It is widely used at home, buildings, society etc. It operated on the unlicensed spectrum ISM band. The two popular bands used by Wi-Fi are 2.4 Ghz and 5 Ghz for 802.11.

ZigBee: ZigBee is IEEE 802.15.4 based specification. It is used for low bandwidth communication applications like home automation, medical device data collection and other low power low bandwidth applications. Due to its low power consumption limits it transmission capacity to 10-100m depending upon the line of sight and various other environmental characteristics. It operates world-wide in a frequency band of 2.45 Ghz, 868 MHz in Europe and 915 MHz in the US & Australia.

C. Communication Layer

The technology used in 5G for communication is the New Radio technology (NR). 5G NR is the new radio access technology (RAT) developed by 3GPP. It is believed to be the foundation for 5G. New radio is a air unified interface that supports diverse spectrum, services and deployment models. 5G NR uses two frequency ranges – sub6-6 GHz frequency bands and the mm-Wave frequency band in the range 24-100GHz. 5G NR is a combination of existing LTE and 5G NR. Some additional features are present in 5G NR like multiple numerology, massive MIMO, mmWave, beam management etc.

The radio frequencies that are being used in 5G are between the range of 600Mhz to 6Ghz. 5G also uses a higher band of frequencies in the range 24Ghz to 86Ghz (unused) which is more suitable for higher data rates. Thus, there is a greater bandwidth to accommodate numerous data.

Waveform, Numerology and Frame structure:
5G NR delivers optimized waveforms and multiple access techniques based on the OFDM technology. Scalable numerology will address different spectrum type and spectrum bands. Numerology means subcarrier spacing. Carrier spacing is given by,

$$\Delta f = 2\mu \times 15 \text{ kHz, where “}\mu\text{=0,1,2,3,4” is numerology.}$$

In LTE there is only one subcarrier spacing of 15Khz. Whereas 5G NR supports scalable numerology to manage different spectrum bands, services, and bandwidth. There are five different subcarriers spacing like 15, 30, 60 kHz for less frequencies within 6 GHz band and 120, 240, 480 kHz are used for frequencies greater than 6 GHz band. It is important to note that low carrier spacing are used for IoT applications and high subcarrier spacing are used for eMBB and other major communications. The subcarrier spacing μ=4 i.e. 240 kHz is used only for synchronization and broadcast channels and not for data transmission.

NOMA is Non-Orthogonal Multiple Access, where the key idea is to use power level of a user device to access the base station. The new multiple access method would allow different signals to share the same channel simultaneously. NOMA provides a higher sum rate when compared to the usual orthogonal method.

MIMO and mmWave technology:
Multiple-Input Multiple-Output (MIMO) is a wireless technology for sending and receiving multiple data signals simultaneously over the same radio channel. Massive MIMO offers much greater coverage and capacity. MIMO technology incorporates the use of an array of smart antennas. These smart antennas have the capability of hybrid beamforming, spatial multiplexing, beam tracking and tracing. Due to the interference cancellation property of the smart antennas, better spectral efficiency and reduction in delay spread is observed when data is transmitted from one MIMO antenna to other. MIMO antennas possess two unique properties like switched beam pattern and switched adaptive array. In switched beam pattern based on the requirements of the user it is peaked and the interference is traced by switching the antenna beam. In switched adaptive array, the signal is steered towards the direction of the user along with nullification of interference signals.

Beamforming is the method used to create the radiation pattern of the antenna. In 4G the wireless signals are widespread over a large area as they travel. Hence the signals lose energy more quickly. In addition, different users interfere with each other's signals. Whereas in beamforming, the transmission between the users and base station more directional. It can be envisioned as a ray of laser beam directed straight to the user. The higher density of beamforming leads to less interference, reduced energy consumption and a faster data rate.

The biggest problem faced by the mmWaves is the distance. They are very short range but of high speed. It travels well within line-of-sight, so factors like buildings, trees etc block and disrupt the high frequency signal. These high frequencies face more collisions with the obstacles in the air and thus they tend to lose more energy sooner. Hence these waves cover shorter distance. To overcome this, small cell stations are needs to fill the coverage gaps between the BS (base station) and the users. The mmWaves have three advantages – it is a less used band; the higher frequencies carry more data than lower frequency wave and the makes it possible to have massive MIMO antennas.

D. Architecture Layer

Cloud plays a big role when it comes to scalability, cost saving infrastructure, energy saving etc. The benefit of cloud in IoT is prevalent in many ways. IoT generates massive number of data each second and cloud paves the way for this enormous data. It is an integration for storage and also to access data remotely. The two major reasons of cloud computing are undeniable combination of networking and mobility of IoT. Cloud acts as a remote processing unit with high processing speed. It provides a massive storage space for the huge amount of big data generated by the IoT devices. Most importantly Cloud enhances the security and privacy of IoT data. Cloud IoT can be deployed in three modes such as public cloud, private cloud, and hybrid cloud. Some of the challenges faced by integrating IoT and cloud are:

- Handling a large amount of data can affect the performance of the application.
- Processing massive amount of sensor data on time is a huge challenge.
- Migrating the application to cloud.

E. Application Layer

As a service driven network 5G deploys an end-to-end network slicing architecture which aims to provide flexibility and efficiency. 5G IoT offers a wide range of application where human interventions are minimized to the maximum. Some of the important factors to be considered in all the 5G IoT applications are high data rates, low latency, energy efficiency, low power consumption, faster response time, multiple device connectivity etc. Major 5G Machine type communication applications are:

- Smart Homes: 5G IoT facilitates monitoring temperature, water usage and electricity. Multiple devices at home can communicate with each other depending on your mood. One can control the home appliances from his office or anywhere. It increases the security and safety by having a remote control on the locks of the doors.

- Smart Cities: Smart cities are entirely interconnected that will regulate traffic, save energy, prevent accidents etc. It is expected that the future generation cellular technology would provide higher data rates up to 2GB/s which is ten time more than the existing technologies. With the help of these increased data rates, more devices will be connected to the internet enabling a seamless smart communication. Smart city is a combination of smart transportation like autonomous vehicles that prevent accidents, smart parking lots, smart robots etc.

- E-Healthcare: 5G IoT will revolutionize the healthcare field. It takes a new step forward in helping the patients to be more connected and the health care service to be more effective. The ability to take an expert and place them where the patient is, even if they are not in the same place. The ability to take rich dense medical information like scans and make them available in an augmented reality while treating the patient or surgery. IoT is transforming healthcare. Doctors can remotely treat patients which would be more and more common through telemedicine. However, connectivity is the major issue in healthcare as a minute delay can even cost a life. Latency is crucial.

IV. Algorithms and Models

Energy efficient model of 5G-IoT systems is proposed by Di Zhang et al,2020 [3]. Firstly, massive MIMO along with improved CPZ mechanism when used in place of single antenna RRH covers a larger coverage area while using the already deployed BS thereby lowering the load of the operator. Secondly the precaching mechanism used shortens the transmission lines when encountered with most frequent demanded media and other resources by making use of copy servers instead of remote servers thereby resulting in efficient 5G- IoT system. Select sleep and wake up uses only required nodes and leads to enhanced life of the required network. Further channel state information gained from BS allows for uniform distribution of energy resources [3]. CPZ algorithm is given by:

Algorithm 1 CPZ Execution Algorithm [26]

Initialization: divide the coverage area into several pies with respect to the distance and angle.
When new user joins, execute the cell search and initialization, report its location.
if $A_{new}^{user} \subseteq \sum\{A_{exist}^{user}\}$ **then**
  if $d_{new}^{user} \leq \max d_{exist}^{user}$ **then**
    $A = A_{new}^{user}$, $d = \max d_{exist}^{user}$
  else $\{d_{new}^{user} > \max\{d_{exist}^{user}\}\}$
    $d = d_{new}^{user}$; Allocate power with the new elements of A and d, and BS goes to sleep mode in other areas.
  end if
else $\{A_{new}^{user} \subsetneq \sum\{A_{exist}^{user}\}\}$
  $A = A_{new}^{user}$, update $\{A_{exist}^{user}\}$ with new element A_{new}^{user}. Allocate power with the new elements of A and d, BS goes to sleep in other areas.
end if

[3]

Here A,d correspond to required angle and distance. The underline concept of algorithm is:

1. First user connects to the network for transmitting information.
2. BS is notified of the locations involved.
3. The control node will determine the angle and distance of the required pie coverage area section.
4. BS will then allocate the required energy resources for successful transfer of the information and process then repeats.

For the wired part energy efficiency as mentioned in paper takes into account the medium of transfer, distance between the routers, energy drop with respect to the distance and number of routers in the system which collectively when included with the factors surrounding for the wireless part allow us to have a robust and energy efficient 5G -IoT system.

Efficient routing protocols for low consumption of power by 5G-IoT network is given by Zibuyisile Magubane et al., 2020. RPl is defined as protocol which is distance vector based and adjusts the path as according to the availability of transmission lines. It constructs an DODAG (Destination Oriented Directed Acyclic Graph) which is tree like and uses control messages for transfer of packets among nodes. Each node communicates the availability and capability (destination advertisement object) up to the root node which then decides accordingly [4]. New joining nodes have to send DODAG information solicitation (DIS) to control root node which then allows permission by transferring a DAO acknowledgment (DAO-ACK). (MRHOF) Minimum Rank with Hysteresis Objective Function helps to find an energy efficient path which is also cost efficient [4]. Control messages are constructed using ETX (Expected transmission count) and Hop count [4] which discovers a path which has the relatively lowest latency and is energy efficient. The paper also mentions Low power and lossy networks Lightweight On-demand Ad hoc Distance-vector Routing Protocol constructs control messages for successful transfer of packets by making use of route reply and route reply acknowledgement as constructed by LOADng router which indeed makes use of hop counts to select energy efficient short transmission lines [4].

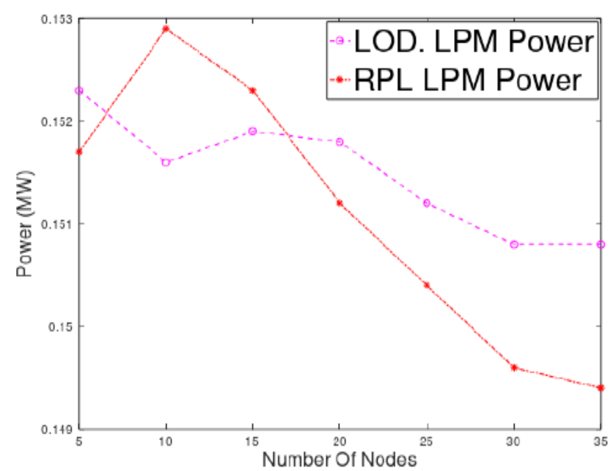

Figure 1 by Zibuyisile Magubane et al., 2020

The simulation result show that power is higher for RPl when small network is involved and is lower when network is larger.

Depending on the structure of the wireless sensor network, clustering algorithms have been classified into Voronoi-based and Non-Voronoi-based algorithms [1]. The properties of both these network structures are different and thus require different algorithms for clustering. The clusters formed in Voronoi structures form a star shaped network. A node at a time belongs to just one cluster. LEACH and HEED are the classic clustering protocols for Voronoi based structures.

LEACH Algorithm consists of two phases – set up phase and steady state phase. In the set-up phase, cluster heads are chosen, and clusters are formed. In the steady state phase, the cluster along with the cluster heads are maintained, are in operation and the data transmission is carried out. The steps carried out in both the phases of the algorithm [1] are explained in detail as follows:

Set-up phase –

1. Some nodes from the group of nodes that were not CHs before, randomly appoint themselves as CH. This is to ensure that the energy used in data transmission is distributed among the nodes equally. The self-election is based on some probability P of cluster-head formation.
2. The nodes that become CHs transmit their signal to the other nodes with the same transmit energy. The nodes then select their cluster head or the cluster they will belong to for the current round of clustering. Received signal strength indicator (RSSI) is the parameter which the nodes use to compare the signals of different CHs to determine which cluster to join so that the energy required to communicate with the CH is minimum. All nodes that are not CHs keep their receivers active during this step. Every node informs the CH it has selected.
3. Every CH prepares a transmission schedule for the nodes in its cluster. The schedule involves one-hop TDMA scheme of communication about when a particular node communicates with its CH.

Steady-state phase –
Communication and data aggregation take place inside every cluster according to the transmission schedule set by the cluster head. Every node sends data and communicates with its respective CH only. Data received by the CH is collected and sent to the base station (BS) using CDMA MAC protocol.
There are many versions of the LEACH algorithm that are developed for different scenarios. LEACH-C, LEACH-TL and HEED are some of them. LEACH-C adds latency to the network.

HEED clustering algorithm uses the residual energy of the nodes as the parameter to select the CH instead of the random approach followed by LEACH. Earlier some nodes are randomly selected as tentative CHs. Then the nodes are selected as final CHs after considering their residual energies. The complete algorithm of the HEED clustering technique is shown in Fig. 2. HEED allows multihop intercluster communication

Non-Voronoi based structures are chain and spectrum. For chain structures, the nodes form a chain, and each sensor communicates with the node to its left or the node to its right. The data mostly flows in one direction. But if a node receives data from both its neighbouring nodes, it sends it to the base station thus acting like a CH. Both PEGASIS and CSS use this approach of clustering. The only difference is that PEGASIS uses a single chain approach whereas CSS uses a multi-chain approach for clustering. The CH at each level in CSS send the collected data to the CH of the lower level until it reaches CH of level 1 from where the data is sent to the BS.

For spectrum structure, the nodes are set in multiple layers. S-WEB is the clustering algorithm widely accepted for spectrum structured networks. The base station creates cluster cell based on the angle and layer from itself, at which nodes are present. The node having the highest energy remaining is selected as the CH for each cell of the network. The cluster cells remain fixed whereas the role of CH is rotated among different nodes within the cell. A disadvantage of S-WEB is that the network no longer remains dynamic or flexible once the cells are formed.

V. 5G Backhaul Scheme

The backhaul network communicates through medium such as optic fibre, copper wires, microwave signals or satellite communication. Backhaul network implied using the classic CRAN architecture improves the efficiency of resource usage along with reducing the net energy exploited and cost of processing data. But it comes with a disadvantage of installing high cost optic cables or copper wires, or LOS requirement for microwave communication. In the CRAN architecture, the BU is like a processing unit that controls the RRHs present at remote locations. The functions of the CRAN are split among the layers as follows:

1. C-RAN layer – the split is defined such that all the RF functions of signal conversions and amplification occurs at the RRH whereas the signal processing operations are centralized at the BU. Due to this split the network experiences better energy and spectrum efficiency, heterogenous computing. However, it has some necessary fronthaul requirements that somewhat decrease its utility.
2. MAC layer – the RRH side is assigned functions like Fourier conversion, MIMO processing, subcarrier mapping and subcarrier de-mapping. This eases the latency and bandwidth requirement in the medium between the BU and RRH. The concept of multi-cell scheduler is required to share the CSI (Channel State Information) in high capacity. MAC layer functional split improves the centralized concept of CRAN by enhancing the coordination and management between different units of the backhaul network.
3. PHY layer – The functional split at the PHY layer is performed so that the Hybrid ARQ acknowledgement mechanism function is present at the RRH while other MAC functions are aligned towards the BU. It allows better use of spatial availability and reduces interference between clusters or cells.

VI. Conclusion and Observation

The previous generations of cellular networks concentrated on providing a reliable and fast data services to users. The 5G IoT system architecture is designed to support data connectivity and services. In this paper, we have discussed in detail the architecture of 5G IoT, 5G NR physical layers such as beam formation in MIMO antennas, waveform, mmWaves, etc. We have also focused on budding technologies like 5G NR, various LPWAN technologies, and the integration of cloud-computing in 5G IoT systems. This paper also describes an improved CPZ algorithm, MMIMO in place of single antenna RRH as being energy-efficient techniques to improve the lifetime of the 5G-IoT system. Precaching mechanism shortened the transmission lines by making use of copy servers for frequently asked data and hence saved energy. Routing algorithms form a major part of successful communication between sender and receiver. Choice of the routing algorithm is essential for increasing the lifetime of the 5G-IoT network. It is seen that RPl is more cost and energy-efficient than LOADng when network scalability is taken into account. Power usage reduction and load balancing are the main tasks that clustering algorithms perform. LEACH and HEED are the benchmark clustering techniques in WSN used because of their advantages over others that they are distributed algorithms, have a few requirements, are easier to deploy and extend over various situations. 5G, the next generation of networking, would be a very advanced and robust network, but would still require clustering for energy efficiency, distributed processing, and management hierarchy. A unique algorithm for Ds2Ds has been reviewed, where many source IoT devices transmit data on multiple radio air interfaces to multiple destination IoT devices. The tree search algorithm used in Ds2Ds has proven to be more energy-efficient and provide better data throughput when compared to Ds2D. In addition, when compared with MH D2D, Ds2Ds is superior when energy consumption per device is considered. Thus, satisfying the requirement for green communication. Finally, the Backhaul network is a key part of any network when talking about energy as the most long-distance communication takes place in the backhaul network, and the longer the distance, the more is the energy required to transmit data. The challenges in clustering towards 5G IoT are heterogeneous diversity, hardware limitation, the cost for transmission, improving user utility, the requirement of specialized services, proper utilization of intelligent components, and management and utilization of mobility. In addition, there are various challenges that need to be taken care of in the backhaul network like latency, throughput, and cost of installing. The functional split architecture discussed in this paper improves the energy efficiency but still, there is a scope for improvement.

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