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Internet of things based wireless sensor network: a review

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ABSTRACT

Recently, internet of things (IoT) technologies are developing technology with a variety of applications. The IoT is defined as a network of ordinary objects such as Internet TVs, smartphones, actuators and sensors that are smartly connected together to enable new types of communication between people and things as well as between things themselves. Wireless sensor networks (WSNs) play an important part in IoT technology. A contribution to wireless sensor networks and IoT applications is wireless sensor nodes' construction with high-speed CPUs and low-power radio links. The IoT-based WSN is a game-changing smart monitoring solution. ZigBee standard is an important WSN and IoT communication protocol in order to facilitate low-power, low-cost IoT applications and to handle numerous network topologies. This paper presented a review on the energy efficient and routing topologies of ZigBee WSN, applications of IoT enabled WSN as well IoT WSN security challenges.

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1. INTRODUCTION

An internet of things (IoT) is a substantial regional configuration that is linked to the standard characteristics of a traditional system that may connect and exchange data. IoT also known as the "internet of everything, it is a new paradigm that connects the physical and digital worlds via a network of sensors, computers, the internet, radio frequency identification (RFID), embedded systems and communication technology [1]. IoT architecture is shown in Figure 1. Any equipment, program, or sensors can be used in the system technique. Data and security management are provided through the Internet of things. IoT links people and things from all around the world. IoT may be used for a variety of purposes, including vehicle response, smart buildings, fast medical assistance, and smart cities. A big number of sensors may be replaced by a small number of sensors in current IoT systems, and IoT can be placed on one platform, consuming power and energy. An efficient detection technology was created with IoT in mind. In the context, detection technology was created with IoT in mind. The sensing, data response, and control phases are the three main stages of the detection and control architecture. In most cases, a wireless sensor node is required to run the sensing unit wireless Sensor network (WSN). The WSN receiver module uses an ultra-low power radio frequency (RF) signal to achieve data synchronization. The control framework can benefit from the employment of an electronic power converter to deliver the created control to the network. The IoT-based WSN is a game-changing smart monitoring solution [2].

Recently, the scientific group has developed a lot of interest in the IoT WSN because of its numerous applications for home, office or any rescue area tracking, control and automation [3]. Usually, a WSN consists of a few hundred intelligent and low-cost multimodal micro-sensor devices that communicate via wireless connections and basically involve the Internet for different applications. WSN has been employed either monitoring or controlling complicated environmental conditions; therefore, connection between intelligent sensors must be efficient and reliable. A wireless sensor network is characterized by energy constricts, intermittent mobility, localization problems. Among these networks, one of the most popular technologies is context to IoT based wireless sensor networks is based on IEEE standards 802.11s and 802.15.4 [4]. ZigBee standard is an important WSN and IoT communication protocol. An efficient energy WSN technology is an excellent option for an IoT-based system. ZigBee is a high level communication protocol utilizing low in power and small digital radios based on the IEEE 802.15.4 standard. The typical uses of ZigBee are: RF applications, long battery life with a low data rate and secure networking, therefore, it can be used for many applications [5].

Internet of things applications require lower power and a preference for cost-effectiveness. ZigBee was created to facilitate low-power, low-cost IoT applications and to handle numerous network topologies. Vishwas *et al*. [6] covers the fundamentals of ZigBee technology, two major ZigBee applications–home automation and smart irrigation systems and a comparison of ZigBee with other short-range protocols like Wi-Fi and Bluetooth. ZigBee is the most preferred networking solution in terms of power consumption, range, bandwidth, cost of installation, and data transfer rates. It also provides a high degree of protection for customers. ZigBee is an excellent technology for both residential and industrial automation. This article review presents routing protocols of ZigBee and the simulation as well as the application of IoT based wireless sensor network.

Figure 1. IoT architecture in three layers [1]

2. RESEARCH METHOD

This paper presented the research method in terms of: IoT enabled WSN energy efficient routing topologies which presented the tree, star, mesh and hybrid topologies for IoT based WSN. IoT enabled WSN energy efficient routing protocols which include the routing protocols for IoT enabled WSN. Security and trustwothiness of IoT based WSN presented a review of some of the security and trustworthiness of IoT based WSN. Applications of IoT based WSN presented some of the applications of IoT based WSN.

2.1. IoT enabled WSN energy efficient routing topologies

ZigBee network efficiency relies on support for the development of topology. Three topologies are basically supported: star, tree, and mesh as shown in Figure 2 [3]. Star network: reduced-function devices (RFDs) and full-function devices (FFDs) end devices connecting to the central personal area network (PAN) coordinator's star topology. Node network: It is called tree network which it has a top node (it is the sink node) with a branch/leaf configuration. Top (root) node inside the network is the PAN coordinator. Mesh network: often referred to as a peer-to - peer network, consisting of single central coordinator, multiple FFD routers, FFD and RFD end devices [7], [8].

But by combining these topologies, multiple hybrid topologies can be made. Topology structure depends upon the situation of devices: coordinator, router and end devices. Manpreet *et al*. [3] researched Zigbee 's output for tree and mesh topologies using optimum network performance (OPNET) modeler. In this work, the efficiency of these topologies in Zigbee has been measured, so mesh topology can be chosen in circumstances where cost is not limited, such as military or defense applications. Otherwise, tree topology can be used for consistent results with the drawback that it is less reliable and the fault cannot be self-healed. Future studies can carry out mesh and tree topology actions by taking parameters such as exponent back-off, increasing the number of nodes, generating small, medium and big Zigbee networks, and failing the coordinator. Varghese *et al*. [5], presented a comparative study for estimating the power consumption for a wireless network in terms of some parameters of network performance like delay, throughput, energy model and average jitter using two routing protocols ad hoc on demand distance vector routing (AODV) and dynamic source routing (DSR) with tree, mesh and star topologies of ZigBee. According to the findings, mesh topology is more prospective for IoT applications such as buildings automation and interior lighting, in which the focus is on the energy conservation. Because these applications typically transmit data at a low rate, they can accept some delay and jitter. In terms of some parameters such as media access control (MAC) load, MAC delay, and MAC throughput.

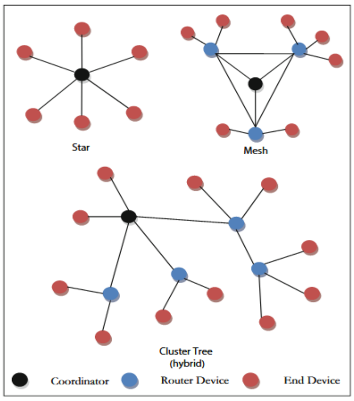

Figure 2. ZigBee network topologies [9]

Nath *et al*. [10], investigated wireless sensor networks using various ZigBee topologies with coordinator load, and investigated the use of synchronization with such networks. The OPNET modeler was used for this analysis. This simulation analysis discusses the use of mesh and tree routing synchronization to validate the topology suitability and illustrate some of the the ZigBee protocol functionality. Mesh routing Simulation results such as delay, MAC load and number of hops are lower than the tree routing. ZigBee-Simulated networks run in the event of failure and recovery protocols. Rao *et al*. [11] provides a performance overview of the various topologies of wireless personal area network (WPAN) provided by the IEEE802.15.4/ZigBee in terms of throughput, traffic of data sent and obtained using the Riverbed modeler. The findings of this analysis revealed that the cluster-tree topology is more effective and better appropriate than mesh and star topologies for the IEEE802.15.4 / Zigbee norm. Cluster-tree topology is ideal for diverse applications such as environmental surveillance, volcanic control, quality of the air and monitoring of an ecosystem. Nimi *et al*. [12] introduced a comparative study of the tree and mesh topology of ZigBee network utilizing various frequency bands. The operational frequencies of ZigBee network are 868 MHz, 915 MHz and 2.4 GHz bands. Output metrics such as throughput, media access delay, queue duration, queue delay, drop of data and number of hops are obtained and evaluated using OPNET Modeler 14.5. ZigBee mesh topology network provides a highr throughput and less latency and data dropped relative to the tree topology with various frequency levels.

Leão *et al*. [13] presented CT-SIM which is a series of suggested IEEE 802.15.4 / ZigBee-based simulation models that are capable of interacting with large-scale cluster-tree wireless sensor networks, concerning SD allocation, cluster scheduling, addressing, direct and indirect data transmission mechanisms. It's based on the simulator of Castalia. CT-SIM has been built in a flexible way that enables different networking contexts and network parameters to be modified. This allows researchers and engineers to plan and test new protocols and architectures for large-scale cluster networks based on IEEE 802.15.14 / ZigBee specifications. Moridi *et al.* [14] researched different sensor node setups of ZigBee networks for underground space surveillance and networking systems. The output of ZigBee topologies is evaluated in in different scenarios for stationary node deployment in underground conditions. Quality measurements include throughput, end-to - end delay packets, distribution ratio (PDR), energy usage, and security of packet delivery. The analysis results demonstrate that mesh topology provides an extra efficient control and connectivity network, higher throughput, packet distribution ratio and network security and an acceptable level of operation in tunnels and underground areas, whereas the cluster topology is favored in lower end-to - end latency and lower energy usage. Therefore, higher delay and power usage may not be a main concern for mesh topology in underground mining implementations on the basis of appropriate data delay and use of mine power.

2.2. IoT enabled WSN energy efficient routing protocols

There are three routing protocols used in Zigbee: proactive protocol (table-driven), reactive protocol (on-demand) and hybrid protocol [7], [8]. Improving the lifetime and efficiency of the WSNs is a critical issue. It is important to build its power consumption and efficiency for various applications. IoT-enabled WSN requires an efficient routing solution for data communication between smart devices. Several research mechanisms have been developed for an efficient energy routing. Shafiq *et al*. [15] proposed the reliable cluster based routing protocol (RCBRP), which is based on the number of CH nodes. It decreases the amount of energy needed to solve the clustering problem. When the BS is located outside of the network, RCBRP can transmit a large volume of data while using less energy. RCBRP achieves longer lifetimes in comparison to previous routing protocols such as energy efficient chain-based routing protocol (EECRP), low energy adaptive clustering hierarchy (LEECH), LEACH-centralized (LEECH-C), and game-theory-based energy-efficient clustering (GEEC). In the future work, the energy consumption at multiple paths from the cluster head (CH) to the base station (BS) will be found and the performance will be reviewed when an energy is disconnected. Rao *et al*. [16] investigated ZigBee and long range (LoRa) communication protocols power consumption. Efficiency of sensor nodes' energy was identified and tested for payloads at different distances with different intervals of sleeping time. This study presented that the LoRa communication is more efficient for data transmission in long range compared to Zigbee sensor node.

The performance of a heterogeneous WSN utilizing LoRa Zigbee hybrid communication was investigated by Truong *et al*. [17] in which two ZigBee sensor clusters with two LoRa sensor clusters are utilized with Zigbee to LoRa converters to communicate in a network administered by a LoRa gateway. Polling mechanism in the LoRa network and the token ring protocol in the Zigbee network are employed in the proposed system. When the Zigbee network's communication range is 630 meters and the LoRa network's communication range is 3.7 kilometers, the system can function with less than 0.5 % packet loss rate. The results show that the system's performance has vastly improved. Salim *et al*. [18] proposed a unique cluster-based technique for mining data of sensor node without transporting to the base station or the head of cluster head in a smart city IoT-WSN optimal performance. Main idea of the suggested task is that the power is computed at each sensor node to perform local computations, exchange minimum statistical summaries of the higher level thus would reduce communication power loss when the transferred data of sensors was decreased, which increases the sensor network lifetime. Furthermore, the suggested approach incorporates a privacy-preserving mechanism that sends just a data summary between the cluster members and cluster heads and between the base station and cluster heads and, to protect the privacy of the sensor data.

Verma *et al*. [19] investigate different data dissemination flooding and gossiping routing protocols for the evaluation of highly dense wireless sensor networks based on the Delphi random generator distribution platform in terms of performance metrics such as receive redundant counts, sense count, transmit count and receive count which is based on an event-based approach. Verma *et al*. [20] illustrated distributions of eight sensor network namely: normal, exponential, gamma, Weibull, generalized inverse Gaussian, beta, poison, and Cauchy for data dissemination in terms of performance matrices like sense count, receive count and receive redundant count over the routing protocol action for various distribution techniques. The sinulation results showed that if the sensor node distribution techniques are changed from one to another in the scenario, the simulation study demonstrated that the routing protocol for WSNs appears intractable.

Simulations were run to back up the accuracy of our assumptions. Haseeb *et al*. [21] describe an energy-efficient and secure IoT-based WSN architecture for smart agriculture. They used a multi-criteria decision-making process to select better-suited leaders for each of the clusters. Remaining energy, the distance to the BS, and SNR play a role in the decision-making process. This framework offers an intelligent data routing decision and lowers the energy consumption ratio while improving data delivery performance. The suggested architecture improved network throughput, packet loss ratio, latency and energy usage through simulation findings. A mobile-based IoT network and intelligent transportation system (ITS) will be the focus of future research.). Verma *et al*. [22] examined a wireless sensor network-based chi-squared distribution a novel visual representation (WSN). Propagation procedures have a significant impact on how well an operational system performs. Using a suggested model, the WSN system has been studied for its data propagation.

Energy consumption balancing to lengthen the life of a wireless sensor network is a hard subject for academics. Verma *et al*. [23] suggested a hybrid energy-efficient approach integrating the chains with tree-based routings. The Catenarian-trim medley (CTM) routing system has been developed to optimize the balance of energy consumption and transmission distance. ZigBee network routing methods has the following three categories: prohibited delivery of route, enable discovery of route and forced discovery of route. Each ZigBee network selects a routing protocol according to different topologies. For example, the mesh network use dynamic routing protocols, such as AODV and AODVjr; star or tree network using static routing protocols, such as cluster-tree [24].

We have provided the various\sparameters of our model for static, distance vector and on demand based routing protocols\salong with linear and service life estimator battery model. Xie *et al*. [24] merged cluster-tree and AODV routing protocols (cluster-tree+AODVjr) which showed that the overhead control is too high and the end-to-end latency is too high. Zone routing protocol (ZRP) is a hybrid routing protocol which is appropriate for most ad hoc networks. The comparison is made between ZRP and the cluster-tree+AODVjr routing protocol which is applied in the same network. The simulation was made under QualNet simulating platform in terms of control overhead, ratio of packet delivery and end-to-end delay. The network using hybrid routing protocols (i.e. ZRP) achieved a lower end-to-end latency and control overhead, but the packet performance ratio is lower than the typical cluster-tree+AODVjr. Therefore, it can be further optimized in terms of packet performance ratio of ZRP in ZigBee network.

Gurpreet *et al*. [25] Tests the efficiency of the Zigbee network through AODV, OLSR, ZRP and DSR routing protocols utilizing NetSim simulator. Output parameters such as throughput (Mbps), Latency (microseconds), transmitted and received packets had been evaluated. Gifty and Sumathi [7] proposed a comparative study of the reactive protocols such as DSR and AODV for tree, mesh and star topologies to optimize efficiency of the routing protocols in terms of average latency parameters, throughput and average jitter. It has been shown that AODV performs well in all efficiency parameters than DSR and the comparison of energy model. The study will be rendered in the future for the two topologies' mixture and the comparative study will be made in beacon disable and enable modes. Verma *et al*. [26] investigated a wireless sensor network system to address the influence of differents battery types on five routing protocols in an analytical approach in terms of performance indicators including average last and first packet, received jitter, received of total bytes, energy usage, average end to end latency and throughput. Verma *et al*. [27] created and showed an AODV-based model for wireless sensor networks to address concerns about scalability in the protocol. Also, they discussed how scaling impacts application, network, MAC, transportation and performance of physical layer.

Multipath routing is widely recognized for its extremely efficient success in streaming data applications. To date, however, a squeeze of research works only have examined the efficiency of WSN multipath routing systems. Li *et al*. [28] proposed a Zigbee MAC layer simulation platform using the OPNET Modeler, it is built with an enhanced AODV routing algorithm to enable node versatility, all of which are consistent with the Zigbee protocols layer process model and the kernel implementation procedures. Efficiency comparisons are provided between the suggested model and the Zigbee model in the OPNET standard libraries. Time periods between the event of a breakdown of the route and the recovery of the route are calculated in terms of node mobility assistance in order to test the performance of the new model. In addition, alternate routes may be easily developed by the new proposed model, where node mobility causes routing failures. The proposed model will achieve substantial improvement in the efficiency of networking, routing and mobility support for nodes. Shi *et al*. [29] studied an enhanced ZigBee simulation model to improve IEEE 802.15.4 MAC layer process model provided by OPNET which depends on the ZigBee architecture and the OPNET hierarchical modeling mechanism. ZigBee routing algorithm protocol, process model of network layer based on an OPNET embedded routing. The enhanced model improved end-to-end latency and network control overheads under different scales of network. The results showed that the enhanced model had more optimized simulation performance, and was more suitable for the practical application of WSN. Pathak *et al*. [30] examined the effectiveness of energy of the proposed method network by analyzing various routing protocols' performance in terms of packet delivery ratio (PDR), energy usage, life of battery, end to end latency by varying the transmitting strength of different routing protocols' ECG sensor nodes such as AODV, dynamic MANET on demand (DYMO) and landmark ad hoc routing (LANMAR). LANMAR is ideally adapted for both stationary and handheld patient problems. DYMO, which is very similar to LANMAR in the sense of the efficiency constraints addressed, but which breaches the end of the delay condition with amazing network life and throughput. So, DYMO may be used for data transfer of hospital information system.

2.3. Security and trustwothiness of IoT based WSN

WSN security is becoming a major focus of WSN research. Multiple attacks can compromise the availability of data, confidentiality and integrity. Because of wireless channel design features and radio characterristics, therefore, they are so vulnerable to a variety of active and passive attacks. Wireless sensor networks are susceptible to denial of service attacks because of their energy degradation and limited sensor nodes [31]. There are a number of security issues that need to be addressed in order for WSNs to become an integral part of the IoT. In addition to WSN, these difficulties may be applied to other key IoT technologies. Yadav *et al*. [32] addressed some of security challenges including (devices heterogeneity, scalability, ubiquitous data exchange through wireless technologies, energy-optimized solutions, localization and tracking capabilities, self-organization capabilities, semantic interoperability and data management embedded security and privacy-preserving mechanisms).

Sensors, high-speed networks, data analytics and cloud computing are the main challenges for next-generation security information systems [33]. The resource utilization and energy consumption are the most important concerns to determine trustworthiness of any reputation model associated with heterogeneous (WSNs). Verma *et al*. [34] presented bio-inspired linguistic fuzzy reputation and reputation model (LFTM) in terms of energy consumption of sensor node, accuracy and path length. Verma *et al*. [35] proposed a model including five trust and reputation models namely: eigen trust, peer trust, power trust, linguistic fuzzy trust and reputation and bio-inspired trust and reputation. The different wireless sensor network modes have been evaluated for their energy consumption and accuracy in comparison to models that have been deployed. Verma *et al*. [36] showed the effect of malicious servers over five different trust and reputation models in WSNs had been analyzed and the effect of malicious servers on the repetition and trust models had been discussed, so that an optimization model had been propsed for these models and the results had been carried out to support this study.

Singh *et al*. [37] evaluated LFTM as a revolutionary WSN framework-based examination into peer trust and reputation models. Sensor node accuracy, route length, and energy usage are all examined. The proposed sensor augmentation-based realization outperforms previous trust and reputation model research, as shown by analytical and simulation findings. Verma *et al*. [38] explained collision effect of wireless sensor networks (SW and DW), as well as the LFTM models used in the installed WSN platform to derive the joint resultant, were studied to determine the combined outcome, accuracy, path length and energy consumption of sensor node operations. When the number of fraudulent nodes is adjusted in the scenario, the simulation research demonstrated that collusion for wireless sensor networks seems intractable with static and dynamic WSNs.

The usage of the ZigBee protocol accommodates and encourages the introduction of protected communications, the frames ciphering and devices controlling, the security of the cryptographic keys production and transportation. Biddut *et al*. [39] presented the modification of the MAC layer as a protection optimization strategy for ZigBee protocol. This work has helped to enhance the network and application layer protection framework by utilizing the techniques of proxy firewall and RFID. Riverbed v17.5 has been used to simulate and examine various ZigBee layers to improve security. Work's advantages include privacy, end-to-end protection, validity of data packets, authentication of message and system. Finally, the purpose of this study is to secure the ZigBee network from unauthorized data communication of sensor nodes. Santos *et al*. [40] developed an IoT platform to secure ZigBee WSN. Killerbee had been utilized to monitor the traffic communication between the motes and the network administrator. During three separate trials, Wireshark and targeted regular expressions were used to evaluate the obtained datasets in great detail. Data transmitted in plain and encrypted communications was then used to rebuild the network architecture in order to determine the function of the motes, as well as their capabilities and activities. Large-scale ZigBee WSN implementation, particularly for smart home applications, is hampered by these serious privacy flaws. Simple and practical solutions are proposed in order to protect ZigBee WSNs' privacy. The next phase of the project will focus on assigning dynamic pseudonyms.

Cao *et al*. [41] examined ghost which are serious attacks on ZigBee networks, which impact the inherent weaknesses of IEEE 802.15.4 protection suites to exhaust the resources of the nodes through which the attacker transmits a number of false messages in attempt to attract the receiving prey node to conduct unwanted safety computations, contributing to battery exhaustion. The results of simulation indicate that by initiating ghost attack, the attacker could reduce the ZigBee nodes' lifetime from years to days easily. The effect of ghosts is very high and could enable a range of challenges, including DoS and replay attacks. Extensive simulations are presented to illustrate the effect of the ghost attack and the implementation of the developed recommendations. Several guidelines about how to find and resist ghosts and other similar attacks in ZigBee networks have been suggested and physical tests on ZigBee nodes have been performed and are fascinating.

Sharma and Verma [42] presented a comprehensive analysis of the security solutions presented in both the WSN and IoT areas is granted as well as a thorough examination of several WSN and IoT systems, the advantages and drawbacks of each are discussed. This research evaluates several solutions based on performance measures such as security, flexibility, energy efficiency, mobility, reusability, scalability, latency, as well as large amounts of data. Sharma and Verma [43] modelled the three RPL attcks (hello-flood, decreased-rank, and increased-version) utilizing the RPL attack architecture. Separate and simultaneous attacks are being simulated. Attacks can be detected through artificial neural network (ANN)-based supervised machine learning technique. If the malicious nodes were detected accurately, the network would be prevented from severe attacks. In addition to accuracy and recall, the F1-score and the Mathews correlation coefficient (MCC) were examined in this study. Sharma and Verma [44] focused on the current investigations of Contiki-based IoT networks in order to investigate the impact of three well-known low power and lossy networks (RPL) security threats (Hello flood attack, increased version attack and decreased rank attack. Over simulated IoT networks in Contiki, the impact of various security vulnerabilities was examined for scalability, energy efficiency, and destination-oriented directed acyclic graph formation. All three attacks have been proven to have a negative impact on the DODAG architecture, increasing network traffic and power consumption in some way.

2.4. Applications of IoT based WSN

There many applications of IoT based WSN as shown in Figure 3. IoT based WSN is used in many applications such as medical applications, smart cities, greenhouse monitoring system and other applications including environmental and air, water pollution. Some oth these applications are presented below:

Figure 3. Taxonomy of WSN applications [45]

2.4.1. IoT Based WSN in medical application

In today's medical system, IoT utilizes various kinds of sensors which supports different people to benefit from the services of medical healthcare anywhere at any time. Modern management of health care utilizes an IoT technology to connect several medical institutions, making it easier for physicians and patients to access one another. Physicians could stay updated on all of a patient's vital signs. Using the IoT, doctors and patients could exchange information more easily. Prabhu *et al*. [46] demonstrated a revolutionary healthcare diagnostic system based on web which offered essential medical live video pictures and data of a patient located in a village which accessible to a health expert available elsewhere in metropolitan center.

An IoT-based device developed by Yeotkar and Gaikwad [47] would be able to efficiently track and measure a wide range of human bodily characteristics simultaneously. The system utilizes wearable sensors to monitor physiological parameters of human body utilizing accelerometer, heart-rate sensor and pulse oximeter, temperature sensor. Wireless fidelity (Wi-Fi) standard wireless communication protocol is used for data transfer between the sensors node and coordinator to monitor physiological characteristics of the human body. The system employs wearable sensors. All human body parameters may be efficiently monitored on the IoT platform according to the coordinator's ability to send data from sensor nodes to the IoT cloud environment. Mane *et al.* [48] developed a healthcare monitoring system-based patient's location and the surrounding emergency help providers, such as ambulance services and hospitals. Using body sensors like electrocardiograms (ECGs) and thermometers, the system can keep track on a patient's health and correlate that information with their current position. It is common to refer to health care systems as preventative measures to avoid deadly health concerns like heart attacks or any other cardiac consequences that need to be prevented or healed in a particular period of time. A patient's location must be taken into consideration when a medical emergency occurs, as time is critical.

Patil and Pardeshi [49] developed a system in which body heart rate and temperature could be measured using LM35 and pulse sensors. Using an Arduino uno board, these sensors are connected to the system. Wi-Fi module on Arduino is used to transmit data wirelessly. IoT platform uses ESP8266 to transmit data wirelessly. Data records may be kept in web server for over a period of time so this data could be read and accessed. Tariq *et al.* [50] presented the arrangement which referred to as IoT-based accommodating bloom ecological arrangement using Lab VIEW and WSN. In this system, the Xbees will be used to wirelessly address the patient's physiological range, which will be shown on LabVIEW and broadcast on the website to allow extra bloom affliction providers from distant locations to see, control, and advise through internet access.

Evaluation of biomedical signals utilizing wireless body sensor networks (WBSNs) is an increasing need. It may be utilized to deliver health services to people at high risk. WBSN's compact, nonintrusive and lightweight sensors are suited for the acquisition and transmitting of electrocardiogram (ECG) signals for tracking and control purposes. ZigBee wireless technologies could be utilized for the propagation of ECG signals for a variety of reasons: appropriate usable capacity, ad hoc coordination and low power consumption [51]. Venkateswara and Puviarasi [52] set up and executed a stable, low-control and accurate system that can be carried all the time and monitors the vital indications of physical factors (e.g. warm temperature, cardiogram, and body pressure) in a lightweight Zigbee network. This work described a remote body sensor constructed in the context of the development of ZigBee. Essentially, it is used to assemble and trade different testing details using a temperature to monitor, a heartbeat sensor for patients in recovery centers or in their houses. It is essentially used to track the temperature of the patient's body and the pulses. Matlab's window address basis displays the latest state of patients graphically. The unit is proposed for usage by the aged, within the home, where the administrator is available but cannot be in reliable visual communication with the patient.

Pathak *et al.* [53] compared the energy performance of ZigBee sensors with different percentages of duty cycle on energy usage parameters basis under variable load conditions. For this efficiency analysis, the Qualnet 5.0.2 simulator had been used in terms of power usage in transmission mode, retrieved and idle modes. QoS parameter efficiency was stronger with a higher duty cycle and weakens with a lower duty cycle under various packet loads. In terms of power usage, lower duty cycle efficiency is greater than higher duty cycles, and will increase the average existence of the network. Adi and Kitagawa [54] described a simulation platform in which the Patients are required to be able to monitor blood pressure at home and no data will be obtained from Hospital Officers at the Hospital. Zigbee had job of submitting data of blood pressure (mmHg) to the servers in the real time. The data is then transmitted to Internet from the Zigbee end device interaction to the coordinator. The sensor node works fine, and uses Raspberry Pi3-based Python programming language, blood pressure data can be saved in MySQL database to be viewed on the JSON's web page. This study also utilizes Local host, which must be enhanced by transferring local host to the area in which the data can be accessed on all devices, like tablets and smartphones linked to the Internet.

Sensitive medical problems, such as radiation, surgery and preterm birth, need continuous monitoring of health. It is handled in the intensive care unit (ICU) manually using wired physiological medical devices (PMDs) located by nursing personnel near patient's bed. Through the introduction of (WBANs), essential patient parameter details could be remotely tracked by clinicians for prompt emergency steps. The WBAN is created by a three-tier architecture. Tier-1 has allowed a ZigBee coordinator and sensors to adapt data which is sent by sensor nodes. Tier-2 has Wi-Fi as a bridge for the transition of critical data to Tier-3 data system of hospital. As all networking methods (ZigBee and Wi-Fi) utilize the same 2.4 GHz ISM band, which results in the problem of interference. Dangi *et al.* [55] provided the modeling of MAC coexistence protocols for ZigBee and Wi-Fi for HCWBAN which is the hospital centered wireless body area network. This simulation research had been carried out by using ns-2 to consider an efficiency of ZigBee device under control of Wi-Fi. The investigation is carried out in order to understand factors that influence the coexistence between Wi-Fi and ZigBee. Finally, the findings were contrasted with related experiments which shown to be best for the delivery of vital emergency data packets. The proposed HCWBAN method will prove to be very helpful in classifying every hospital and its emergency responders.

2.4.2. IoT Based WSN in smart cities

Networks of wireless sensors consist of independent sensors which are transmitted throughout the network to other areas to track physical and environmental conditions and are known to be one of the core elements utilized in smart cities applications. WSN offers the capacity to collect all the required information so that the control and tracking capability is needed to save time, effort and resources automaticall. Allahham and Rahman [56] developed a smart campus control system to regulate the doors closing and opening of several halls with the probability of incorporating lighting appliances and systems. This architecture was based on ZigBee technology, the data sent via routers from the sensors to coordinator and then the data is transmitted to control center over the Internet. OPNET modeler software is used to implement tree and mesh topologies. It was shown that mesh topology is better in terms of PDR and latency, while the results is best in the tree topology in terms of throughput and load and thus providing choices for the designers to develop their networks and select the technology which fits their project. The smart home, which is built on IoT and WSNs is becoming a significant assisted living environment for individuals, where the required care can be supplied when needed and health can be assessed and expected. An ancient home built in 1938 was turned into a smart home with the use of sensing technologies and has been in service since May 2013. Ghayvat *et al*. [57] begun the study by developing a smart home strategy and implementing it in various home settings (houses) to monitor an inhabitant's behavior for health detection. The smart home system’s study was extended to smart buildings and the design issues were modeled with the smart building environment, which are related to system performance and dependability.

Ahmad *et al*. [58] integrated two separate technologies, the IoT and a WSN, to create a smart crops’ monitoring system. In the fields, sensors are placed to collect data on many aspects that affect crop productivity, such as: air pressure, soil moisture, UV index, humidity and rain. These measurements are presented on the transmission side and then sent to the base station over an XBee sensor network. This data is saved in the cloud and accessible by the end user via a graphical user interface. The receipt of data at the base station is examined in real time. The hardware may also be used as a micro weather station. Jaladi *et al.* [59] designed a wireless sensor network system to collect monitored data about physical phenomena in a variety of applications including habitat monitoring. The web server can access this real-time data and display it. Using the Internet, a user can access this information from any location. Raspberry Pi had been used as a base station to communicate with a number of distributed sensors via zigbee and XBee networking protocols, and the sensor nodes are combined of sensors and controllers, making this system inexpensive, low-power consumption, and easy to maintain.

Pirbhulal *et al*. [60] created a new IoT-based safe smart home automation system with safe transmission of data over a long convergence area across several related networks' sensor nodes. In this study, a triangle based security algorithm (TBSA) based on an efficient key generation mechanism was presented. All the relevant security criteria, such as network security and data security, are fulfilled by the proposed IoT-based system, which performs very well overall. Experiment findings demonstrated that the suggested TBSA algorithm was more energy efficient than other methods. Different applications, such as medical monitoring and emergency response, agriculture, health care, energy management, and industrial automation, will make use of the developed IoT platform in the near future. Ganesh [61] developed a cyber-physical system for remotely monitoring interior environmental conditions at remote locations. The existing IEEE 802.11 infrastructure served as the foundation for the creation of a CPS. It makes use of sensors to monitor the data on surrounding area, and then sends these data to an IoT platform through UDP. It is possible to achieve low power consumption owing to the communication protocol and the architecture of the nodes. The system had the ability to log data whenever the Wi-Fi network connectivity is available.

Lee *et al*. [62] developed a system framework for ZigBee wireless sensor and control-based bridge safety monitoring. Using this method, a bridge and its surrounding environment may be constantly monitored and analyzed in real time. Users of mobile communications devices can keep track of bridge conditions in real time by transferring the collected data and photographs to a server and database. The collection of simulation or real-world data for the development of more complex computer models and operational techniques for the system might also be the topic of future study.

Baqer *et al*. [63] deal with the usage of ZigBee WSN for smart home controlling. This model includes a smart home with several rooms, in which each room had sensors for a varied environmental condition. ZigBee end device represented the sensor nodes that transmitted the traffic to a master node which it is represented by the ZigBee coordinator. In this simulation study, seven separate WSN models using OPNET modeler V14.5 were applied in terms of data traffic and delay acquired to optimize WSN efficiency, in terms of the number of coordinators, routers, rooms and sensors. It was shown that single coordinator system created more delay compared to several coordinator systems, in which the router caused additional delay. This model is intended to help electrical engineers to build smart homes that use WSNs. Ghayvat *et al*. [64] researched ZigBee mesh routing and efficiency in a simulated setting for a smart home. In a real smart home, the researcher does not get any study and tests. ZigBee's simulated smart home experience has therefore been built and established on the Qualnet simulator. Finally, a mixed-mode simulation approach that combines the smart home ecosystem with real wireless network sensor verified hardware to improve performance of the device.

Cetin *et al*. [65] developed IoT enabled WSN to track temperature, humidity, room entrance, water level, smoke and burnable gas values in timely manner and was checked in campus network server rooms of the University of Muğla Sıtkı Koçman. The Ardunio Uno R3 microcontroller was used in sensor nodes to receive data in the WSN infrastructure and the IEEE 802.15.4/ZigBee-based XBee technology protocol was used to wirelessly transmit sensed data to the required location. An ASP.Net-based software application has been built to display and document all the data gathered by the WSN to users graphically. The approved individual has been advised via e-mail and SMS of the web application for sensitive circumstances that may exist in the framework. Ghosh *et al*. [66] addressed the implementation of Zigbee technology to smart homes. It has been demonstrated that a single remote-controlled unit may monitor multiple units with different applications. The remote controller monitors items such as air conditioners, lights, garage shutters, music players, etc using ZigBee utilizing QualNet program version 6.1. It can be observed that a single remote controls four other units utilizing Zigbee technology. The remote controller functions like an FFD and forms a network, monitoring other RFDs with lower power consumption. It is understood that time and usage of energy are main parameters for the consumer to save both time and energy while utilizing this framework.

Wei and W. Min [67] improved the use of ZigBee technologies in smart lighting and improved the current ZigBee routing scheme by lighting quantity and efficiency. This paper suggested a modern routing algorithm focused on a standard algorithm-address redistribute and path reselection ADPS). The current routing algorithm will essentially optimize the real-time efficiency and durability of the smart lighting device, which will significantly enhance the rate of data transmission, accuracy and consistency of the data transmitting mechanism, thereby paving the way for the wireless network applications used in an intelligent lighting.

AI-Ali *et al*. [68] proposed a wireless irrigation platform for landscape of a smart home which could be built into established control systems of smart home. A master station and Slave nodes are components of this platform each configured with a wireless microcontroller. Every slave node is also configured with a sensor of temperature, a water tube, land humid sensor and a ZigBee transceiver. The slave microcontroller monitors and frames the surrounding temperature of lawns and trees in the garden together with the land humid. The frame is then redirected to the master station using an ad-hoc ZigBee network. Garden grass and trees could be irrigated by home owners automatically or manually through local or remote control over Internet. The outcomes of the simulation and an experimental set-up output were satisfactory and as estimated. This platform could be combined with other home automation platforms with a few alterations.

2.4.3. IoT WSNs-greenhouse monitoring system basis

The greenhouse has become a significant part of productive agriculture. In precision agriculture, the greenhouse idea has been widely employed to obtain the greatest quality for the production of fruits and vegetables. Plant development is influenced by a number of factors, including irrigation, humidity, temperature, soil moisture light radiation, CO_2, and pH level. The key role of the system of greenhouse monitoring is to track and control the greenhouse environment so that the climate can be managed at an optimal level for the crops' growth of in order to increase the production and crops' quality [69], [70]. Liu and Bi [69] developed a system focused on the IoT Wireless sensor network and the greenhouse ecosystem that is sensed by a slave machine. The data obtained would be sent to the host machine to execute a particular task. The host machine will track and control greenhouse' environmental parameters such as: temperatures, light, moisture, air pollution and other parameters in real time. The results of the simulation indicate that the system has a low energy consumption, strong reliability and a good real-time monitoring effect. Ashraf *et al*. [70] presented the use of IoT technology in agriculture, with an emphasis on Zigbee technology for greenhouse monitoring and management. The system monitored the greenhouse's irrigation, humidity, temperature, light radiation, and soil moisture with each sensor collecting data on a regular basis and sending it to the microcontroller. The data was delivered from the transmitter to the receiver and from the reception to the device (laptop and smartphone). In the future, the system will be upgraded to employ a multi-hop network to monitor the entire greenhouse with other sensor parameters can be added to make this system more appropriate for plant requirements.

In order to meet the demands of a growing population, ongoing research into low-cost, smaller, more energy-efficient community nodes is necessitating the development of an internet of things. In agriculture, computer systems are commonly used for water irrigation control. Suresh and Koteeswaran [71] designed an innovative IoT architecture for water irrigation systems. It's reasonable to expect good effects from the suggested approach. End-to-end latency, dependability, and packet delivery ratio are all improved using the technology described in this study. In agriculture, quality of water is an important environment for all aspects of life. The temperature and cloudiness of the water are determined by transmitting data to the lab station in real time. It allows the controlling data of water quality in distant regions to be obtained and distributed wirelessly to a laboratory or testing center. Low cost, secure data transfer, effective collection of data and easy utilization are the main strength features of ZigBee's wireless device [72].

For hydroponics plants, Samijayani *et al*. [73] constructed an IoT-WSNs platform in agriculture with Hydroponic plants. Plant development is increasingly dependent on the availability of water and the surrounding environment. Water quality in the Hydroponic plants could be monitored remotely using WSN. Zigbee and Wi-Fi technologies are combined in this WSN system architecture. Sensor nodes employ a Zigbee transceiver, whereas coordinators use a Wi-Fi based gateway. Received signal strength indicator (RSSI), Throughput Packet error and loss are all tested as part of the experiment to evaluate WSN performance Zigbee-Wi-Fi networks with integrated Zigbee-Wi-Fi have lower RSSI values and lower throughput than networks without integrated Zigbee-Wi-Fi. There is a drop in throughput with increasing distance between nodes. Many sensors, such as light intensity sensors, CO_2 sensors and soil moisture sensors were proposed by Dhineesh *et al*. [74] in their study. Using the Wi-Fi module, farmers are informed of the present status of their fields. Improved sustainability may be achieved by using this irrigation technique in areas with limited water resources. Process and functioning are handled by the Raspberry Pi in this system.

Baqer *et al*. [75] analyzed WSN throughput in the greenhouse ecosystem monitoring framework using ZigBee system to enhance network efficiency. Seven separate testable scenarios of OPNET Modeler are applied with different sensor settings for the greenhouse ecosystem. ZigBee end device represented each sensor to send the traffic to a ZigBee coordinator which acts as a master node. The system is connected to the server via the ethernet LAN in order to access the collected data. In terms of throughput, the study indicated that the usage of one coordinator model caused increase in throughput than multiple coordinators model to maximize the performance. The impact of utilizing routers had been measured negatively from a throughput point of view.

2.4.4. Other applications of IoT based WSN

An IoT-based WSN for hydrometeorological data collecting and flood monitoring for the urban region of Colima-Villa de lvarez in Mexico was developed and tested by Mendoza-Cano *et al*. [76], IoT message queuing telemetry transport protocol is used to transport real-time fluvial water level, soil moisture, and weather data to the server and a web application using 3G and Wi-Fi networks. When tropical storms strike, it is clear that the smart water network is capable of gathering hydrometeorological data in real time. Hydrological and hydraulic models were developed using the obtained data, which was used to construct flood inundation maps and identify vital infrastructure. Hendra *et al*. [77] designed an IoT-based environmental monitoring networks to monitor environmental safety in real time. WSN safety control system is designed to provide continuous monitoring of the environment's potential danger of fire or crime, as well as many others. Real-time information, such as environmental crimes, possible fire threats or short circuit problems were enhanced by this suggested method. The authorities can then take prompt action, such as evacuating people or dispatching emergency security personnel, based on this information. Because of these tests, it's been concluded that the proposed system can be used anywhere. Because of low power consumption of this system, it might be used for extended periods without needing to be recharged. More sensors could also be used to enhance environmental safety monitoring in the design process. IoT-based mobile robots for farming applications had been proposed by Khan *et al*. [78]. Sensor data is reliably shared between master and slave robots using a wireless sensor network that is connected via the NRF protocol. There is also an IoT server that receives this data from the master robot. Weeds may be detected using image processing and sensors that collect data on humidity, light, temperature and wetness. Ultrasonic sensors let robots avoid obstacles while on the move. It is possible to extend this work in the future by incorporating a mobile application into the suggested system. When it comes to working autonomously or manually, the robot may do it using a smartphone app.

In pipeline monitoring applications, since the power is not always present, therefore, problems of performance with power consumption exist in conventional wireless nodes. Furthermore, they are not typically practical for this sort of application owing to performance and memory limitation, thus designing a new IoT WSN system that satisfies the application's needs is vitally crucial. Karray *et al*. [79] presented, a water pipeline WSN node prototype named (WiRoTip). Many experimental and comparative testing had been performed to arrive at a final design that works. In the future, a PCB board with sensor board extension will be produced for our own low power product. In addition to the demonstration, real-world tests and experiments will be carried out. Wireless multimedia sensor networks (WMSNs) are a new and upcoming IoT application that includes sensor nodes outfitted with cameras, microphones and other sensors capable of creating multimedia material. With its low cost and low power characteristics, ZigBee has become the most popular radio protocol for usage in WMSNs. ZigBee connection enhancement mechanism (ZCEM) was suggested by Chang *et al*. [80], it was based on the improvement probability in ZigBee networks. In order to improve ZigBee network connectivity and decrease the number of orphan nodes, the ZCEM selects the nodes with better internet protocol (IP) to connect to other parent nodes. The results suggest that the proposed ZCEM enhances ZigBee network connection. Six percent more efficient than the typical ZigBee method is possible with the suggested approach.

A street light is a light that illuminates the roadside at night for the benefit of pedestrians and drivers. Gehlot *et al*. [81] developed a system to monitor the operation of street lights using 'N' local controller units. A LabVIEW-created graphical user interface is used to monitor the system. Zigbee is the communication medium between a street light and a local controller unit and IoT is used to transmit data across long distances to the main server. An intelligent modern stage is brought to IT with an advent of the IoT. By using IoT, the system can monitor a broad area's street lights from a remote place without having to physically visit the site itself, and the collected data may then be published on a website for further distribution and storage.

Pollution of air is one of the main issues that needs to be resolved in an acceptable manner; else in the future, all living creatures would be harmed by its threatening impact. As a result of the IoT-wide WSN's range of communication and great computing power, a ZigBee-based air pollution monitoring and control system was shown by Kusrey *et al*. [82] in their paper. A Zigbee module and an 8-bit microcontroller are used in each sensor node. Consequently, in a real-time environment, this network collects data on variables such as Co2 levels and relative humidity over extended periods of time. A cost-effective solution to Smart Cities concerns is offered here. Using the MHz radio frequency band, we plan to enable the IEEE 802.15.4 protocol in the future to deal with increasingly sophisticated WSN mesh networks in urban areas. Bhowmik *et al.* [83] focuses on the ZigBee module usage for the measurement of poisonous gas in the atmosphere utilizing of sensors in IoT enabled WSN. The data was kept on the platform and compared to the threshold limits of the toxic components. It has been observed that the existence of poisonous gasses in nature has been effectively identified and that the system should be utilized in all cities due to its proper usage. With proper procedures and protocols, a single worker is able to manage multiple transmitters to be controlled across a broad variety of regions. The price is significantly smaller than that of traditional commercial instruments.

Smart metering (SM) is a technology which it uses electronic devices to record electricity usage and achieve almost real-time connectivity with power stations. Chi *et al.* [84] suggested a multi-channel multi-radio ZigBee metering network for occurrences of high-density traffic high altitudes. The new network increases efficiency of data and combines multi-channel multi-radio transmitting technologies. The latency evaluation of the designed network is measured by OPNET. A multi-radio multi-channel hop framework has been created, as the load of network traffic on the backbone network is much higher than the traffic on the ground network (for residential households). Prabhu *et al.* [85] addressed the usage of WSNs for military applications in the appropriate scenarios. The network could handle, define and diagnose threads by having sufficient sensors on the basis of the number, type, whether military cars or men in the foot, weapons quantity and type they hold, which can be identified in advance. This device offers an accurate description of real-time war and greater situational knowledge. Mahamuni *et al.* [86] addressed the usage of optimum scheduling of node dependent on the existence of an active node within the range of its probing node and the probability of its inability to provide WSN energy-efficient coverage for military monitoring applications. As soon as some motion is observed, an SMS will be sent via a GSM modem through the XBee module. The camera is going to take pictures. The captured photos can however be accessed through the internet. The network connectivity and power supply specifications may limit the framework to be established since it is intended to be used in scenarios of severe ad-hoc networking.

3. RESULTS AND DISCUSSION

This paper presented the simulation and performance evaluation of IoT based WSN. The collection of sensor nodes systematized in a network is named WSNs. A sensor is a tiny instrument that tests the atmosphere for physical parameters such as friction, temperatures, noise, gases, contaminants or vibration and other applications. Bi-directional are the new networks that can still monitor the operation of the sensor [25]. WSN is one of the most essential IoT technologies. Several devices of IoT are linked to the internet via WSN, which is made up of various sensor nodes and actuators that cooperate and perform tasks in a dynamic manner. The primary goal of deploying IoT applications is to produce high observations in real-time, which is too difficult due to the resource constraints, the limited computing power of sensors, such as speed, energy, bandwidth, computation, ands memory, and a large volume of heterogeneous, high-speed WSN data [18]. Imran *et al.* [87] have outlined a few key challenges in IoT and sensing technologies, as well as key issues such as self-organization, energy efficiency, security and scalability that must be considered when utilizing these newer technologies for the benefit of the society. Furthermore, advances in sensing technologies will pave the way for successful IoT solutions, as discussed in this article, and would support a variety of sectors, including healthcare, buildings, transportation, education, supply chains with many other fields of our everyday lives. The increased of industrial requirements for low power and low data rate protocols for IoT communication over the past few years has contributed to the evolution of ZigBee technology. Deep *et al.* [88] introduced the digital architecture and deployment of FPGA PoC for the band of 2.4 GHz ZigBee's digital transmitter. The recommended hardware architecture of the transmitter is defined using the verilog hardware description languae (VHDL). Simulator results validates transmitter functionality and its low energy consumption and low data rate appropriateness for applications of IoT. Energy-efficient connectivity is becoming essential with the internet-of-thing’s expansion. The connection between limited energy devices (e.g. batteries powered or energy gathering from their ecosystem) must be energy-efficient, extending their runtime or maximize throughput of data. Gočal *et al.* [89] proposed energy-efficient regular intervals of communication over the ZigBee protocol for devices and it is battery powered. The experimental results indicate that the suggested solution is more energy effective in most situations where collisions exist and the sensor nodes gather varying volumes of data with different preferences (often in ZigBee networks).

Quality measurements include throughput, end-to-end delay packets, distribution ratio (PDR), energy usage, and security of packet delivery. The analysis results demonstrate that mesh topology provides an extra efficient control and connectivity network, higher throughput, packet distribution ratio and network security and an acceptable level of operation in tunnels and underground areas, whereas the cluster topology is favored in lower end-to-end latency and lower energy usage [14]. In terms of routing protocols, It has been shown that AODV performs well in all efficiency parameters than DSR and the comparison of energy model in a comparative study of the reactive protocols such as DSR and AODV for tree, mesh and star topologies to optimize efficiency of the routing protocols in terms of average latency parameters, throughput and average jitter [7].

4. CONCLUSION

This review paper presents a review of IoT WSN. WSNs play an important part in IoT technology. When using WSNs, sensor nodes collect data from sensors and send it to other nodes, which in turn collect data from end tags. The end tags then send their data to routers, which in turn send the data to the cloud (Ethernet). The routers then provide services to multiple clients, including data display, and the data is stored in the base station. The client can visit the base station remotely via (website) ethernet. The ZigBee standard is an important WSN and IoT communication in order to facilitate low-power, low-cost IoT applications and to handle numerous network topologies. It is well tailored to a broad variety of energy control and productivity applications in areas such as medical and health care, building engineering, manufacturing and home automation, as mentioned out in this study. Securing WSN is becoming a major focus of WSN research. WSN they are so vulnerable to a variety of active and passive attacks because of their features, their energy degradation and limited sensor nodes, therefore, there are a number of security issues that need to be addressed in order for WSNs to become an integral part of the IoT. Riverbed modeler academic edition is the best simulation platform for ZigBee WSN and the configuration of cluster tree topology is more effective and best adapted than Zigbee star and mesh topologies. The paper also presents IoT based WSN in various applications for smart cities monitoring, WSN security challenges. ZigBee technology has also been developed for IoT communication over the past few years because of a growing of industrial need for low power and data rate networking protocols. Research is continuing to examine ZigBee as the usage of cloud of things (CoT) combined with the next generation network specifications. In addition, the quality of experience (QoE) of the ZigBee network will be analyzed.

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