

**COMPARATIVE STUDY OF VARIOUS IOT NETWORK STRUCTURE IN ACCORDANCE WITH SECURITY BASED ON PACKET PROCESSING****<sup>1</sup>Ms. Shilpa B. Sarvaiya, <sup>2</sup>Dr. D. N. Satange**Department of Computer Science Vidyabharati Mahavidyalaya, Amravati<sup>1</sup>, Director, Student's Development  
S. G. B. A. University, Amravati<sup>2</sup>sarvaiya.shilpa@gmail.com<sup>1</sup>, dineshnsatange@rediffmail.com<sup>2</sup>**ABSTRACT**

The Internet of Things (IoT) exemplifies that the network of devices capable of acquiring and sharing the information. Often, these network devices use internet protocol (IP) to communicate with one another. In the Internet of Things (IOT), data blocks are packetized from different variety of sensors by IOT devices, which are located different regions and data is transferred across different networks. By 2030 several hundred billions of IOT devices are going to be connected, so communication techniques should be optimized, and even though transmission capacity and processing power of network equipment is enhanced. This paper studied various IoT network structure for IoT devices, which uses ZigBee, Bluetooth, WSN, Wi-Fi and 5G communication technologies. Each technology has some security features and also provides the security protocols that are used to communicate. The characteristics as well as drawbacks of these technologies and applications are discussed in comparative manner. The main objective of this paper is to compares the various communication technologies on distinct parameters specially based on packet processing performance that are best suited for such an applications of IoT.

**Keyword:** *Internet of Things (IoT), ZigBee, Bluetooth, Radio Frequency Identification (RFID), Wireless Sensor Network (WSN), Wireless-Fidelity (Wi-Fi), 5G.*

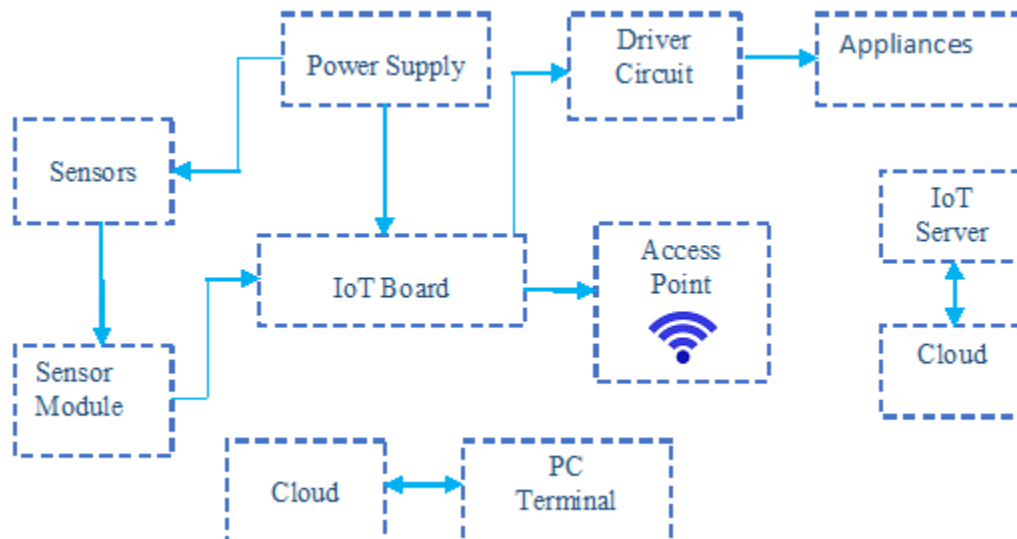
**INTRODUCTION**

The Internet of Things (IoT) is a concept that where the physical objects are interconnected to each other through an internet and can able to identify themselves. The communication among itself is through IP address without human interference [1]. Internet of things is a huge network with a combination of various sensing devices like RFID, GPS etc., used for identifying, managing & controlling the devices [2].

Over the years many wireless and wired broadband communication technologies have been reserved and developed like 5G mobile systems in access networks and 10Gbits/s Ethernet-based passive optical network. A communication device like Gateways and routers has been enhanced by increasing in CPU processing power, so that in addition to transmission capacity of broadband technologies, performance of these communication devices also increased. One of the challenges in the large number of IoT devices is needed for reduction in number of packets for IoT communication at the network edges to mitigate packet processing load [3].

The Internet of Things (IoT) consists of IoT Board, Sensors, Sensor Module, Access Point (Wi-Fi/5G), and IoT Server & along with Cloud. The Figure 1 shows the block diagram of Internet of Things (IoT) the IoT Board is the heart of the application where we can write the program and dump on it. The IoT Board may be either Arduino or Raspberry Pi depending upon the application. Arduino Suite can be use as a platform to dump the program [4].

The Sensor Module will measure the physical parameters and provides an output in terms of voltage which is given to an analog input of an IoT board .For Transmitting/Receiving the radio signals a Sensors will be used. During the IoT application the configuration of a network is required [4.5].



**Figure 1: Block Diagram of Internet of Things (IoT)**

The IoT Server can be used for monitoring and data gathering the information. The data received or transmitted through gateway server will be securely stored in Big Data Analytics.

## WIRELESS CONNECTIVITY TECHNOLOGIES

Over the years, some studies have been carried out to assess IoT communication Technologies. Since there will be billions of different kinds of connected devices in future IoT applications, it is urged to develop various technologies to support their connectivity. In this section, discuss the existing wireless technologies for IoT connectivity and classify them into two categories in terms of coverage range, namely short-range technologies and long range technologies. For short-range technologies, dominant technologies like Bluetooth, ZigBee, and Wi-Fi the emerging technologies are to be study. For long-range technologies, depending on service features and requirements, RFID, WSN and 5G technologies are study with respect to data rate, coverage range, security, packet size and packet processing.

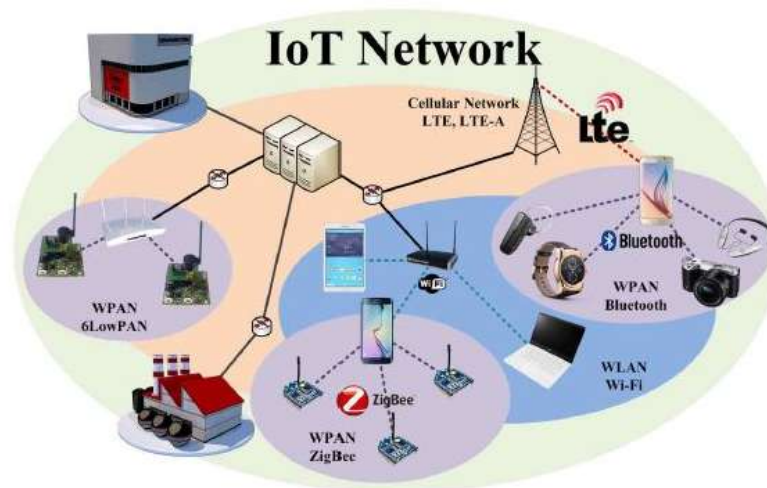
In 1999, the MIT Auto-ID centre coined the term of the Internet of Things (IoT), for the first time, where the "things" can be any physical object that sends data and communicates with a network [4]. In 2003, at the beginning, radio frequency identification (RFID) systems were the first deployed technologies for simple IoT applications that had enabled objects to communicate with other objects or a server without human interaction [5].

In 2009, European Commission proposed a framework, with financial support of governments, to start an extensive research on a compatible IoT network for all available and future applications [4]. Throughout the last few years, with the introduction of the 5th generation (5G) wireless technology [5], the IoT has drawn much attention in particular with the emergence of machine type communications (MTC), which refers to automated data communications among devices or from devices to a central MTC server or a set of MTC servers [6].

## CONFIGURATION OF IOT NETWORK STRUCTURE

The configuration of IoT network includes devices, which is shown in the below figure 2.

The basic building block of IoT devices accommodates many sensors and those sensors are associated with the IoT area networks that assemble the packet containing signals from these sensors [7].



**Figure 2: IoT Network Structure**

The data chunks collected by these sensors are processed by the processor and transferred to gateways over the IoT area networks, which are configured using several transmission technologies of which majority are wireless network technologies. Some of the technologies which rule in IoT network are wireless Personal Area network (WPAN). This WPAN includes network like ZigBee, Bluetooth, WSN, Wi-Fi and 5G [7].

On a slightly larger wireless network area scale, WLAN (Wireless Local Area Network) which includes Wi-Fi is to be used. On a larger scale, the mobile communication technologies like 3G, 4G, 5G, LTE remains. Smart phones and mobile communication system will be used and they will connect to the base stations and base stations will provide connectivity to the Wide Area Network (WAN), which is the Internet. The WPAN are connected to a Smart phone and the smart phone can bring the signal up through 3G, 4G, 5G and LTE through the base station and the base station will connect that to the WAN [8].

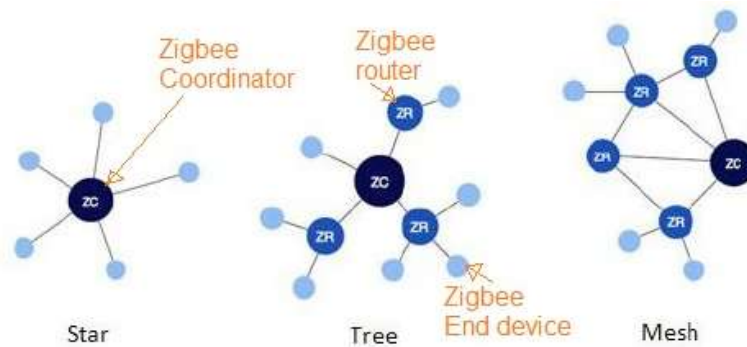
### **SECURE TRANSMISSION OF IOT NETWORK STRUCTURE**

Secure transmission is the important asset in IoT which gives assurance to error-free communication. A popular hardware platform for both IoT basic devices and advanced devices such as gateway can be used for secure transmission. In IoT, the security protocols are used for secure data access at the device level as well as a secure transmission.

### **ZIGBEE TECHNOLOGY**

ZigBee is an open global standard to address the unique need of low-power, low-cost wireless IoT network. ZigBee is a low data rate, low power and close proximity wireless ad-hoc networks. ZigBee is an IEEE 802.15.4 based specification for a suite of high-level communication protocols used to create personal area networks with small, low power digital radios such as medical device data collection, home automation and other low-power, low-bandwidth needs designed for small scale projects which need wireless connection [9].

ZigBee provides the application and network layer protocols. ZigBee works well in isolated network environments.



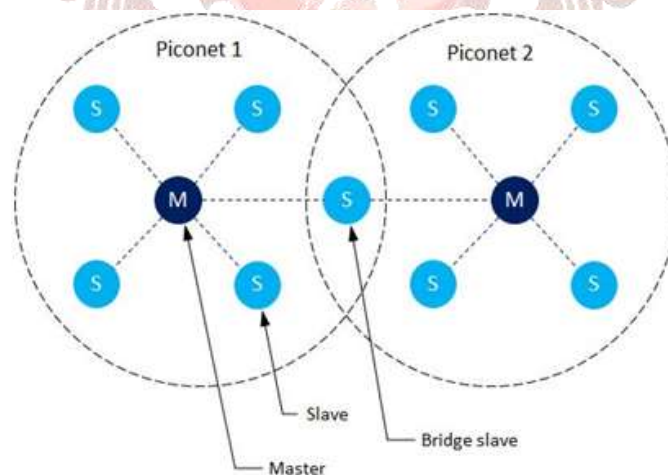
**Figure 3: ZigBee Network Structure**

ZigBee network is made up of Coordinator (ZC) which is required to establish a network connection. “C” establishes PAN, Router (ZR) which provides the network connection to the end devices and End Device (ZE) which is the IoT devices connected to the network [9].

## BLUETOOTH TECHNOLOGY

It is short-range communication technology and can be considered in wearable products. It can be connected to the IoT through smart phones. It operates in 2.4GHz range. It covers a range of 50 to 150 meters with data rate of 1 Mbps [10].

Traditionally, Bluetooth is used in a connection-oriented manner and it cannot directly connect to the internet. Once it is connected; a link is maintained even there is no data flow. The new Bluetooth low energy (BLE), old name is WiBree, is a subset to Bluetooth v 4.0. It has new protocol stack and new profile architecture. This version has been adopted as of June 2010. It provides new advertising mechanism, quick discovery and enable connection and uses Asynchronous connection-less MAC for low latency rate and fast communication [10].

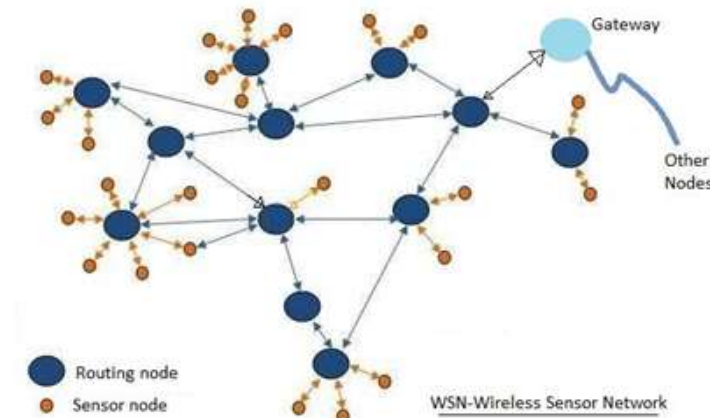


**Figure 4: Bluetooth Network Structure**

BLE, known as Bluetooth Smart, part of the Bluetooth v4.0 and the recent v4.2 stack, is a global personal area network protocol built for transmitting small data pieces in frequently at low rates with significantly low power consumption per bit. It constitutes a lightweight version of the classic Bluetooth destined for low energy resource-limited devices. BLE provides many benefits over its competitors; however, it is not an open wireless technology standard and does not support open firmware and hardware. Bluetooth 4.0 is users friendly as it introduces New Generic Attribute Profile which is simpler to use [11].

## WIRELESS SENSOR NETWORK (WSN)

Wireless Sensor Network (WSN) refers to a group of spatially dispersed and dedicated sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location. The WSN network structure consists of sensors and local servers connected via the Internet. The generated data comes from several electronic sensors, such as proximity sensor and fire sensors, all of which are connected to the local server via the gateway. Figure 6 represent typical WSN network structure. It consists of Sensor nodes, Routing nodes and a base station [12].



**Figure 5: Wireless Sensor Network Structure**

WSN has become very popular due to availability of low cost sensors as well as long life of the power supply batteries. It can also be deployed anywhere. WSN is a variant of Ad-hoc network. In a typical Ad-hoc network, multiple nodes can transmit packets to the base station. In WSN collaboration is needed between multiple different types of sensor nodes. Gateway is located at the boundary of the monitoring coverage area. The gateway helps connect micro-sensor network with the outside world such as internet or similar other WSN [13].

## WIRELESS-FIDELITY (WI-FI)

Wireless fidelity is known as Wi-Fi, the IEEE 802.11x standards, is the most common way to connect devices wirelessly to the Internet. Laptop, Smartphone and Tablet PC are equipped with Wi-Fi interfaces and talk to wireless router and provide two way accesses to the Internet. The Wi-Fi standard family allows establishing wireless network on short distances [14, 15].

The Network structure of Wi-Fi is shown in figure 7. It has limited range of approximately 120 feet indoors and 300 feet outdoors. It consumes more power compared to other standards. Wi-Fi access point can handle up to 255 connected devices. To support more devices multiple access points can be deployed. In view of reliability, it provides a high degree of interference immunity. Depends on standards different bandwidth can be considered. Generally, 802.11a and 802.11g support up to 54 Mbps bandwidth and 802.11n support 100 Mbps. Because of Wi-Fi's ubiquitous wireless technology, it can be considered for most of the IoT applications and devices.

Wi-Fi connectivity can be considered for all smart phones, tablets, and laptops and so on. Wi-Fi ubiquity is one of the fundamental factors in the rapid growth of IoT. The Wi-Fi group is working on unlicensed spectrum of 2.4 GHz (ISM) band.

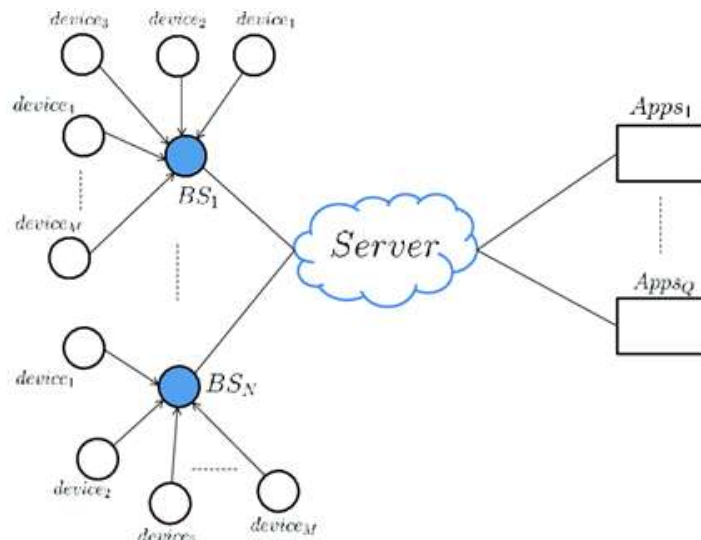


Figure 6: Wireless - Fidelity Network Structure

**CELLULAR NETWORK (5G NETWORK)**

5G wireless network is coming up with a heterogeneous communication. In context of 5G IoT, catching and computational resources should be used intelligently to support big data application in heterogeneous networks. All these properties are used to reduce the communication link. Cellular networks, quickly embracing new high-speed cellular networks like 5G. Cellular networks provide high bandwidth and reliable broadband communication for voice calls or video streaming but with high operational costs and power consumption. Cellular networks can be viably used connected IoT devices. GPS System and cellular networks can help track road traffic in real-time as cellular networks can transfer high quantities of data over the network [16, 17].

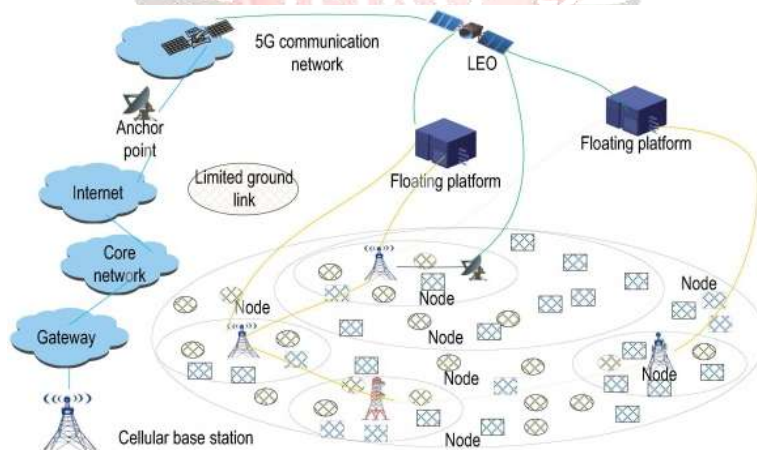


Figure 7: Cellular Network Structure

Hence, to accommodate such huge devices need for energy efficient system design and operation is an important need. The one aspect to overcome with energy efficiency problem is the use of small cell base station. The purpose of small cell base station is to increase the capacity in the high-density user areas. It also improves the coverage; increase data rate and extend the battery life by reduced power consumption [18, 19].

**COMPARATIVE ANALYSIS OF IOT NETWORK STRUCTURE**

There are several technologies and sensors used to implement the idea of IoT. The communication technologies which are used to implement the idea of IoT are ZigBee, Bluetooth, WSN, Wi-Fi and 5G. One of the challenges in the large number of IoT devices is needed for reduction in number of packets for IoT communication at the network edges to mitigate packet processing load. The Table 1 shows the comparison of various communication

technologies for securing data over IoT network structure based on packet processing performance along with various parameters [20, 21].

**Table1: Comparisons of Various Communication Technologies Used in IoT Network Structure**

Technology/Parameters	ZigBee	Bluetooth	WSN	Wi-Fi	5G
<b>Mechanism</b>	Wireless	Wireless	Wireless	Radio Signals	Wireless
<b>Topology</b>	Star Mesh Cluster Tree	Mesh	Star, Mesh	Star	Hybrid , FDDI
<b>Frequency</b>	2.4 GHZ	2.4GHZ	2.4 GHZ	Sub GHZ, 2.4GHZ,5GHZ	Cellular Bands
<b>Protocol Used</b>	IEEE802.15.4	Baseband	Routing	IEEE 802	Internet Protocol(IP), GPRS
<b>Data Rate</b>	250 kbps	1,2,3 Mbps	250 Kbps	0.1-54 Mbps	100 + Mbps
<b>Range</b>	30 m	~300 Feet	~ 300 Feet	<300 Feet	Several Miles
<b>Processing Speed</b>	250 Kbps	10 m	High		3 Gbps
<b>Power Usage</b>	Low 10 to 100 mW	Low	Medium	Medium	High
<b>Cost</b>	Low	Low	Medium	Low	High
<b>Security</b>	Encryption, Integrity (AES)	Encryption, Authentication	Key, Encryption, Authentication	Authentication, Authorization	Authentication, Authorization
<b>Network Structure</b>	LAN	PAN	MAN, WAN	WLAN	RAN
<b>Bandwidth</b>	Low-Channel 1MHZ	Low 800 kbps	Enough 5 MHZ	High 20 MHZ	Sub-6 GHZ
<b>Packet Size</b>	127 Bytes (1016 Bits)	9 Bytes ( 72 Bits)	71 Bytes (568 Bits)	1500 Bytes (1200 Bits)	1480 Bytes (11,840 Bits)
<b>Packet Performance</b>	Reduce	Reduce	Reduced	Reduced	Optimized
<b>Applications</b>	Home and Industry	PDA,Mobiles and Laptops	Buildings and Health Care	PC,Phones and Cameras	Phone, IoT and Multimedia
<b>Characteristics</b>	Low Consumption, Cheap	Cable Replacement, Low Cost	Low Cost, Power, and Resilience	Faster, Secure, Convenient	Faster, Secure, Convenient
<b>Advantages</b>	Large Network Size, Low Power Consumption	Easily Upgradeable, Lower Power Consumption	Flexible, Additional of New Device, Avoid wiring Save Cost	Convenience, Mobility, Productivity, Deployment, Expandability.	Greater Speed, Lower Latency, Greater Capacity
<b>Drawbacks</b>	Fixed Key	Blue Jacking, Blue Snarfing	DOS Attack	Eavesdropping	Distributed DoS

## ANALYSIS AND DISCUSSION

This paper was focused on conducting a detailed analysis, comparison, and discussion of qualification on various communication technologies suitable for the IoT networking structure platform. Through the proposed

comparative table, each technology's role was presented, based on a packet processing point of view of the IoT devices at the edge of IoT network structure.

The main area of utilization of ZigBee technology is in Home Automation, Smart Energy devices, lighting, HVAC and security etc. Due to its low-power, high level communication protocol using small digital radios, it comes under wireless personal area network (WPAN). It also has a unique functionality of self-organizing, multi-hop and reliable mesh networking.

It is designed for limited range network monitoring and controlling due to its low data rate and short range.

Bluetooth has been one of the first wireless communications Protocols designed with lower power consumption for replacing short-range wired communications, short distance data sharing and devices' mobility support. It has an exceptional property of creating personal area network during communication and discovers also communicates to its neighbour without need to be in visual line of sight. Due to its global standard it is also known as WPAN. It is very important for the case of IoT since many of the devices that one would like to interconnect to the IoT (sensors, actuators, etc.) having limited power resources. A major drawback of Bluetooth is that it cannot provide direct connectivity to the Internet.

A wireless sensor network (WSN) is a network formed by a large number of sensor nodes where each node is equipped with a sensor to detect physical phenomena such as light, heat, pressure, etc. WSNs are regarded as a revolutionary information gathering method to build the information and communication system which will greatly improve the reliability as well as efficiency of infrastructure systems. Compared with the wired solution, WSNs feature easier deployment and better flexibility of devices. With the rapid technological development of sensors, WSNs will become the key technology for IoT.

Wireless fidelity is known as Wi-Fi, the IEEE 802.11x standards, is the most common way to connect devices wirelessly to the Internet. Laptop, Smartphone and Tablet PC are equipped with Wi-Fi interfaces and talk to wireless router and provide two way accesses to the Internet. The Wi-Fi standard family allows establishing wireless network on short distances. The group of Wi-Fi is working on unlicensed spectrum of 2.4 GHz (ISM) band.

The vision and mission of 5G IoT is to connect multiple numbers of devices within the same network architecture. Many advance applications in 5G wireless application like smart cities, Internet of Vehicle (IoV), smart factories, smart agriculture and smart healthcare leads to IoT revolution. Such huge ranges of smart applications are expected to be supported with high speed massive connectivity under the same roof of 5G wireless communication.

## CONCLUSION

IoT is a new and emerging concept that gaining popularity day by day. It involves smart devices available all around us and networked them as WPAN locally while globally as Internet. Such connectivity requires wireless communication technologies like ZigBee, Bluetooth, WSN, Wi-Fi, and 5G. In this, paper discussed various communication technologies specially related to packet processing performance in IoT devices at the edges of IoT networks structure. Using which communication technologies we can reduce the burden on the core network in the wide area Internet due to the huge amount of short packets. IoT is the future and strong networking structure need bases on packet processing performance to be set, by improving and upgrading the suitable communication technologies applied. Critical analysis presents Wi-Fi and 5G as suitable communication technologies for future IoT but many issues are still to address for which some new technologies are in demand.

**REFERENCES**

- [1] C.R.Srinivasan, B.Rajesh, P.Saikalyan, K.PremSagar and Eadala Sarath Yadav, "A Review on the Different Types of Internet of Things (IoT)", Article in Journal of Advanced Research in Dynamical and Control Systems, ISSN: 1943-023X, Vol 11, No.1 PP 154-158 January 2019.
- [2] Wu, D. Shi, H. Wang, H. Wang, R. and Fang, H, "A Feature-based Learning System for Internet of Things Applications. ", In IEEE Internet of Things Journal 2018.
- [3] Soumyalatha, Shruti G Hegde, "Study of IoT: Understanding IoT Architecture, Applications, Issues and Challenges ", International Journal of Advanced Networking and Applications(IJANA), ISSN:0975-0282, PP. 477-482, 19 January 2019.
- [4] Srinivasa A H, Dr.Siddaraju, " A Comprehensive Study of Architecture, Protocols and Enabling Applications in Internet of Things(IoT)", International Journal of Science and Technology Research, ISSN:2277-8616, Vol.8, Issue 11, PP.1768-1779, November 2019.
- [5] Anna Triantafyllou, Panagiotis Sarigiannidis and Tomas D.Lagkas, " Network Protocols, Schemes, and Mechanisms for Internet of Things (IoT): Features, Open Challenges, and Trends", Review Article in Wireless Communications and Mobile Computing, Volume 2018, Article ID 5349894, PP.1-24 10 November 2018.
- [6] Jie Ding, Mahyar Nemati, Chathurika Ranaweera, and Jinho Choi, " IoT Connectivity Technologies and Applications" arXiv, PP.1-26, 28 February 2020.
- [7] Nityashree N.M., "IoT Network Architecture and Packet Processing In IoT Devices", International Journal of Advance Engineering and Research Development (IJAERD), ISSN: 2348-4470, Vol.5, PP.222-226 Issue 05 May, 2018.
- [8] I.R.Karunaratne et al, "Wireless Communication Technologies in Internet of Things: A Critical Evaluation", ResearchGate, PP.1-9, 05 June 2020.
- [9] Syed Sultan Mahmood and Pramod Sharma, "IoT Based Industrial Automation using Zigbee Communication Standard", International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Vol.9 Issue-4, PP.379-383, February 2020.
- [10] Mukhtar Ahmad Sofi, "Bluetooth Protocol in Internet of Things (IoT), Security Challenges and a Comparison with Wi-Fi Protocol: A Review", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol.5 Issue 11, PP.461-467, November 2016.
- [11] Saminath.V, and Jung Su, " Understanding of Internet of Things(IoT) and Experimental Approach using WICED sense in Android", International Journal of Scientific and Research Publications, ISSN:2250-3153, Vol.5, Issue 7, PP.1-6 & July 2015.
- [12] Lin Zhang, Ying Chang Liang, and Ming Xiao, "Spectrum Sharing for Internet of Things: A Survey", arXiv PP. 1-8, 10 October 2018.
- [13] A Hendra, E Palantei, Syafaruddin, M S Hadis, N Zulkarnaim, and M F Mansyur, " Wireless Sensor Network Implementation for IoT-Based Environmental Security Monitoring", The 3<sup>rd</sup> EPI International Conference on Science and Engineering 2019 ( EICSE2019), ISSN: 1757-899X, Vol.1, PP.1-5, 2019.
- [14] Chijioke Worlu, Azrul Amri Jamal, Nor Aida Mahiddin, " Wireless Sensor Networks, Internet of Things, and Their Challenges", International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN:2278-3075, Vol.8 Issue-12S2, October 2019.

- [15] Olaide O.Kazeem,Olubiyi O.Akintade, and Lawrence O.Kehinde, “Comparative Study of Communication Interfaces for Sensors and Actuators in the Cloud of Internet of Things”, International Journal of Internet of Things, Vol 6 No.1,PP.9-13,2017.
- [16] Jekishan K.Parmar, Ankit Desai, “IoT: Networking Technologies and Research Challenges”, International Journal of Computer Applications, ISSN: 0975-8887, Vol.154, No.7, PP.1-6, November 2016.
- [17] Lalit Chettri and Rabindranath Bera,” , “A Comprehensive Survey on Internet of Things (IoT) Towards 5G Wireless Systems”, In IEEE Internet of Things Journal, ISSN: 2327-4662, PP.1-18, 2019.
- [18] Thays Moraes, Bruno Nogueira, Victor Lira and Eduardo Tavares, “Performance Comparison of IoT Communication Protocols”, In 2019 IEEE International Conference on Systems, Man and Cybernetics (SMC), ISSN: 7281-4569, Vol.3, PP.3249-3254, 10 December 2019.
- [19] Lin Zhang and Ying-Chang Liang, “Average Throughput Analysis and Optimization in Cooperative IoT Networks with Short Packet Communication”, IEEE xplore, ISSN: 0018-9545, PP.1-14, 2018.
- [20] Daisei Uchida,Takafumi Fujita,Ken Hiraga,Takashi Shimizu,and Kazunori Akabane,” , “ A Study on Wireless Technologies Improve Communication Performance by Utilizing Multi-frequency Bands”,Vol.3,No. 3 PP.1-6, March 2017.
- [21] Naresh Kumar and Deepak Upadhyay, “Analysis and Modification of IoT Packets”, Journal of Emerging Technologies and Innovative Research (JETIR), ISSN: 2349-5162, Vol.6, Issue 4 PP.57-65; 26 May 2019.

