RECENT TECHNIQUES OF IOT IMPLEMENTATION USING LOW POWER WIRELESS TECHNOLOGIES

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Abstract : Internet of Things (IOT) is used for multiple industries connectivity and potential transformation. The network connectivity grow is refer by the Internet of Things. The embedded sensors are helpful to collect a data and exchange it. In globally wireless technology of NB-IOT (Narrowband - Internet of Things), LoRa, and Sigfox are used in the market for matures connections. The mobile network operators' technologies are LoRa Alliance, adopter LoRaWAN, and SigFox. The low power, wide-area networks (LPWANs) are used an IOT. The designs of IOT applications are consist of the long range, short range, and personal area wireless network technologies. IOT wireless technologies are includes a ZigBee, 6LoWPAN, low energy Bluetooth, WI-FI different versions, and used an IEEE 802.11ah protocol. The data rate range, size of network, RF Channels, Bandwidth, consumption of power are evaluate in this technology. In IOT interoperable and secure communications are used to develop a multifaceted technology. Wireless personal area networks of 6LowPAN, ZigBee, and the IEEE 802.15 protocol are a unique combination in the IOT network. The 6LoWPAN and ZigBee connectivity are used to run by the operation of Medium Access Control and the physical layer. Wireless LAN Wi-Fi technology is includes a protocol of wireless local area network, a larger scale, and technology of mobile communication etc. The internet connectivity is provided by the LTE of wide area network. The need of technology and IOT connectivity is focused in this paper.

IndexTerms-IOT,NB-IOT,ROI,FFD,RFD,IBSS,AID,TIMandBLE

I. INTRODUCTION

LPWAN- Low-Power Wide-Area-Network is designed to allow long range communications and it is describe as one of the type of wireless communication WAN in the lower bit rate. The battery is operating by the sensors or connected objects (Things).Some of a network is distinguished the use of a power low, bit rates low in the wireless WAN. The high power is require for connect more business, large data carry and the users. A third party is providing an infrastructure or service in LPWAN. In the field sensor network of wireless private is created and deploy a sensors owners [1].

1.1 LP-WAN Essentials

The LP WAN attributes are:

1.1.1 Cost:

The networks of IOT and sensor are used the LPWAN. The networks of IOT or sensor are need to sensors or things in the work process. Return of Investment (ROI) application is determining a unit price, it is very important one [2].

1.1.2 Low energy consumption:

IOT and wireless sensor network is remotely worked. The battery life of nodes (sensors) is an important one it is use for long life so not necessary to replace it. The less possible energy consumption is necessary one.

1.1.3 Extended range:

The area of application is coverage by the range. An infrastructure range is longer in the lower cost. The application range is describes as inversely proportional to the cost of infrastructure.

1.1.4 Scalability:

The number of users increases with time and frequency is available. Multiple users are installed a possible application. The common access point installation is used by a shared tower and the cell phones. The access points are support by the number of devices and new infrastructure is required. The access point is not used and the frequency is working then a channel is available and it is used to prevent go down and installation of future [3].

LPWAN technologies are explained below. LoRaWAN is maintained by the LoRa Alliance. End-node devices and gateways of LPWAN are managing a communication by the use of MAC layer protocol. The physical layer chip is called as the LoRa. The network is used a LoRa WAN and it is describe an architecture of system and the communication protocol. The devices of data rate manage, power frequency are responsible by the LoRa WAN. The data is available and send then a network is transmitting a devices. The network server is centralized then end-node forwards and receives a data using multiple gateways. The security is checks, network is managed and duplicate packets are filter by the use of network server. The application server is carried a data and it is consist of the high reliable technology. The mobility, service location and bidirectional communication secure is called as a basic need of IOT.

1.1.5 RPMA:

A method is access by the multiple phases, communication of machine to machine in the internet of things and it is includes a channel of low power wide area. Multiple accesses are used in the Direct Sequence Spread Spectrum of RPMA employs. RPMA is self modulates and it is used a level of device and network, it is identify a clear signal. Battery efficiency technology is enabled in this process. A special connection protocol is used to check a device status, receive data, and a closed connection. It is used to save a life of battery. High battery life is requiring for the connection of IOT and M2M then low data.

Narrowband – Internet of Things (NB-IOT): The latest communication way is called as the Narrowband Internet of Things. The transmission of small chunks of data is allowed for long periods. The category of Low Power WAN is used by the NB-IOT technology. Wide range of services and devices of IOT is developed by the Low Power WAN. The capacity of system, end devices power consumption and spectrum capacity are improved with the help of NB-IOT. The demand is increase by the designing technology of low device complexity. The technology demand is based on the increase or decrease of cost. Compare of GPRS and GSM it is very simple. Privacy and security features of mobile network are includes the authentication, integrity, confidentiality, identification of device etc. Some of the features are includes. They are, low power consumption of ultra, network of reliable and secure, component of low cost, current cellular network architecture easy, underground and remote areas range is extended [4].

1.1.6 SigFox:

It is used to a proprietary technology of longer range and also uses a rate of slow modulation. The application is requirement for sending infrequent, small data bursts. The smart dustbins, water meters, parking sensors, etc are the application of the SigFox.

II. COMPARISON

LPWAN technologies are LoRaWAN, SigFox and RPMA is compared. An application of the technologies are includes the uplink, downlink, frequency, width of channel, range and size of packet, status of deployment etc.

Table: 1 Comparison of the LPWAN technologies

Technology	RPMA				Sigfox				LoRa			
Regulatory	Australia, Americas		EMEA		Australia, Americas		EMEA		Australia, Americas		EMEA	
Uplink/Downlink	UL	DL	UL	DL	UL	DL	UL	DL	UL	DL	UL	DL
TX Power	23	30	23	21	20	30	14	21	20	30	14	21
RX Sensitivity	145	133	145	133	134	129	142	137	132	132	137	137
Antenna Gain	9	9	9	9	9	9	9	9	9	9	9	9
Sub GHz Benefit	0	0	0	0	9	9	9	9	9	9	9	9
Antenna Diversity	0	0	0	0	-8	-8	-8	-8	-8	-8	-8	-8
Noise Floor	0	5	0	5	-15	5	-5	5	-5	5	0	5
TOTAL	177	180	177	168	149	174	161	173	157	177	161	173
Link Budget	177		168		149		161		157		161	
Square Miles (Urban)	176		33		1		9.2		4.4		9.2	

The specific application is used a LPWA technology and it is very suitable for it. Agriculture is used an application of the LoRaWAN. Smart garbage, parking sensors application is suitable for the SigFox. An environmental analysis is applying RPMA. An application falling Industrial IOT is the suitable for NBIOT.

III. COMPONENT TECHNOLOGIES

3.1 Wi-Fi

WLAN- Wireless Local Area Network technology is called as the Wi-Fi and it is based standards of IEEE802.11. Smart phones, smart tabs, notebook computers are some of example WIFI. A wireless communication range is described as the 30 meters indoor in the access point of Wi-Fi devices. The type of protocol is used to identify a Wi-Fi data range [5].

3.2 Bluetooth

The protocol of Wireless Personal Area Network is called as the Bluetooth. Special Interest Group, SIG of Bluetooth is designed. Rid of cables are possible in the Bluetooth. Bluetooth wireless headset is an example of it. Using Bluetooth link heart monitors and medical equipment are connecting with smart phone. Bluetooth wires Standard area network range is calculated as the 10 meters. Bluetooth 4.0 standards are consisting of low energy and it is provide a reduction of power consumption and cost. The communication range is maintained. EDR provide 2.1 Mbps data rate and it is support by the Bluetooth.

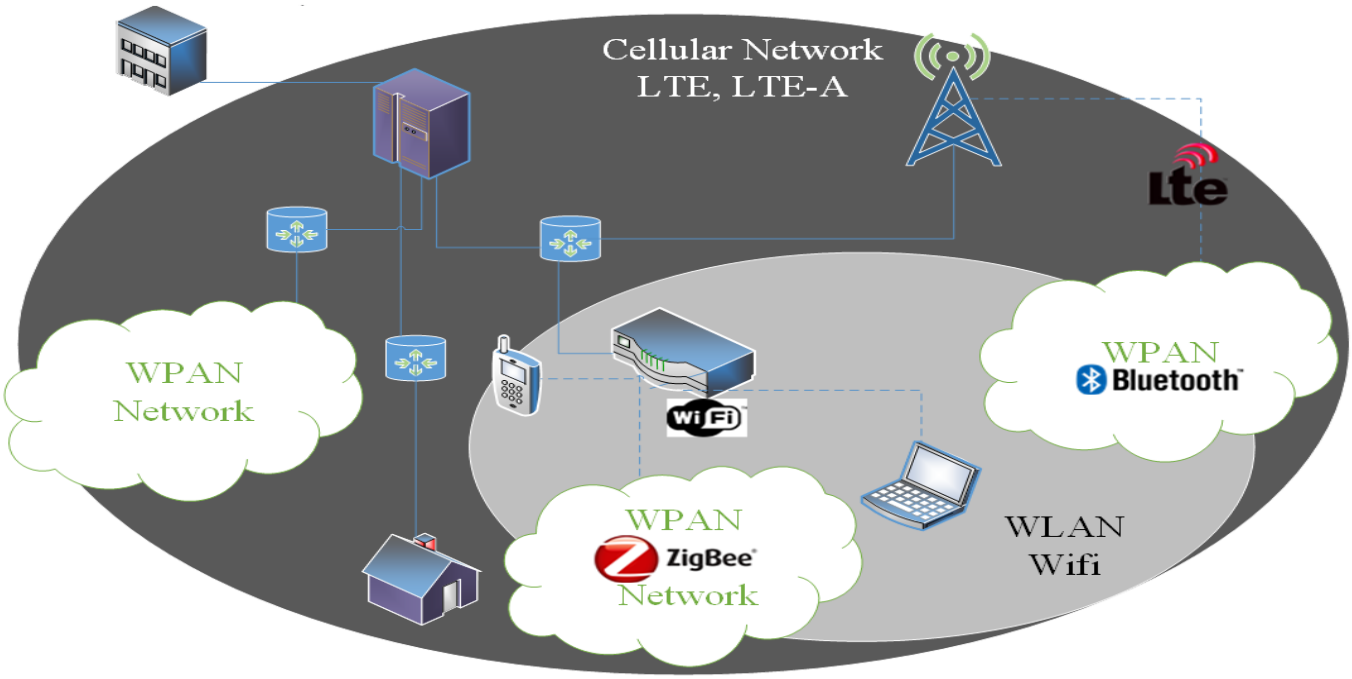

Figure: 1.Basic diagram of IOT Networking

3.3 IEEE802.15.4standards

Wireless communication protocols are used an application of the ZigBee, 6LoWPAN. ZigBee and 6LoWPAN are the important in these techniques. 802.15.4 Is used because of the low cost, speed, power, protocol of personal area network wireless.IOT is used in the different ways.

3.4 Devicesupportfor802.15.4standard

Two devices are used basically. They are full function device (FFD) and the reduced function device (RFD). Full functionality is equipped by the FFD. Clusters are form and the data is received, send, and route. A full functional device is the PAN coordinator and it is release needs of devices. RFD is used to reduce a device function. The full functional devices are communicate and a PAN coordinator is cannot serve then a routing functionality are cannot provide in the simple sensor. A star topology network, a peer-to-peer, P2P topology network are form by 802.15.4. A cluster tree is form by the large scale network. Network coordination and service features are added to the function of FFD. The network controlling is performed by the FFD [6].

IV. NETWORK TOPOLOGIES

The star topology is explained in the table. FFD is identified by the green color, RFDs is identified in the blue color. The star topology formation is explained in the middle (PAN Coordinator) FFD.

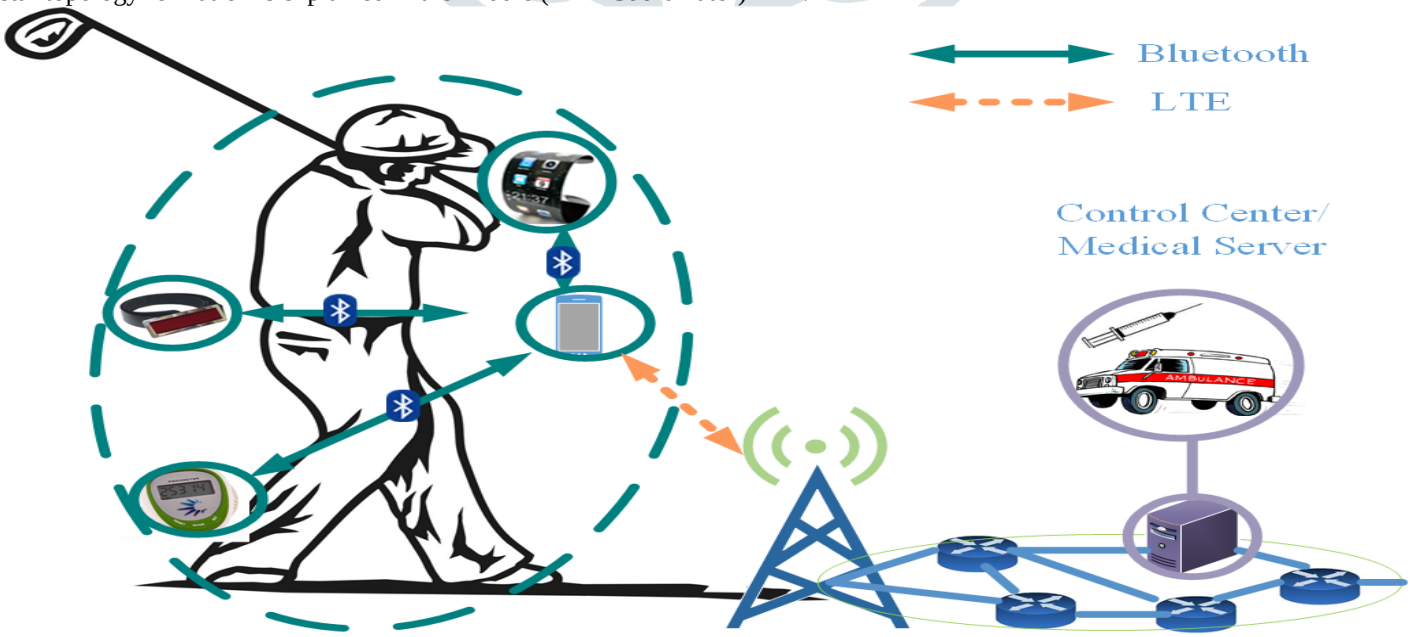

Figure: 2 Wearable IOT Networks

A central PAN coordinator communication is defined as the middle of FFD. P2P topology is explained. Through the PAN coordinator is used to communicate the node. Point-to-point links are used to establish sides. The cluster tree topology is the next one. The FFDs form different clusters.

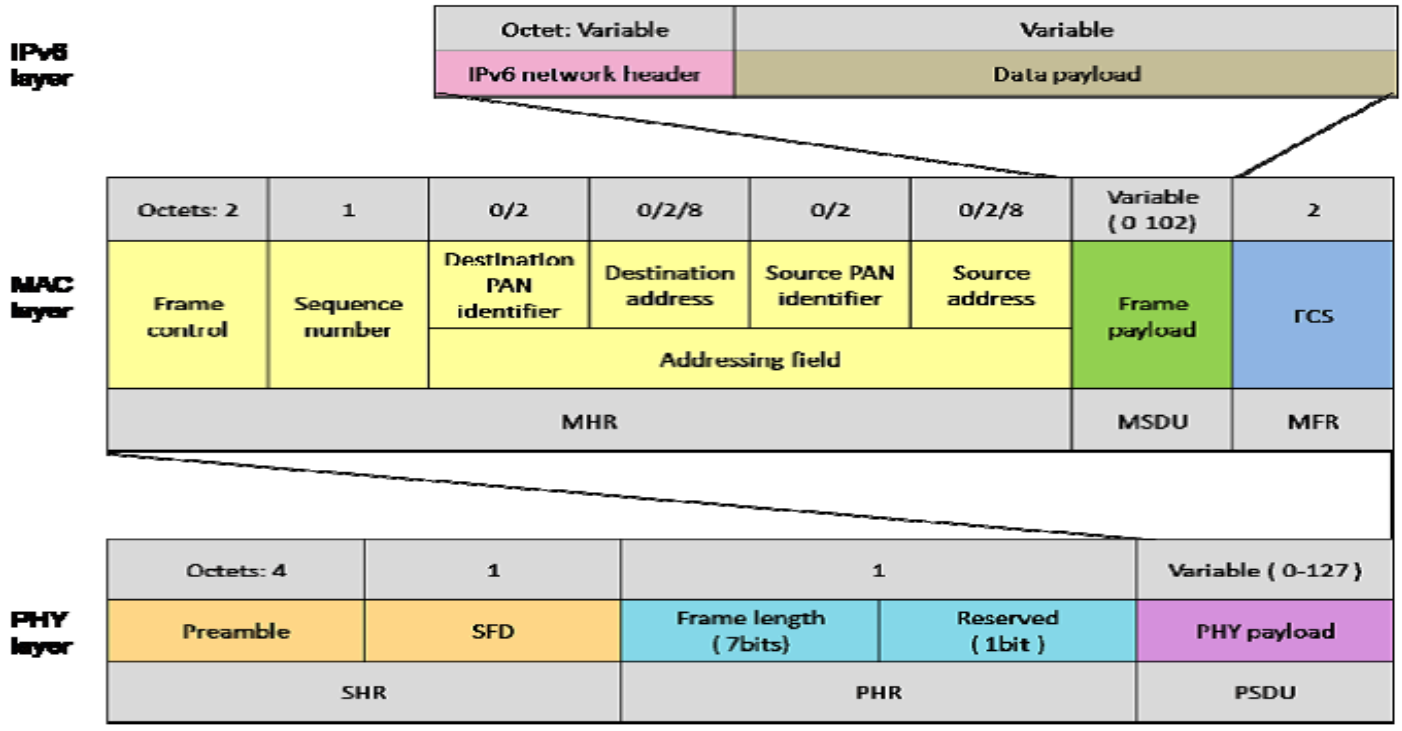

Figure: 3 IEEE 802.15.4 General Frame Format

The individual FFDs are form the star or P2P network and it is connects a FFD. Through RFD devices cluster trees are same as star. Multiple end devices are used to connect the coordination of FFD. The following figure is explaining it.

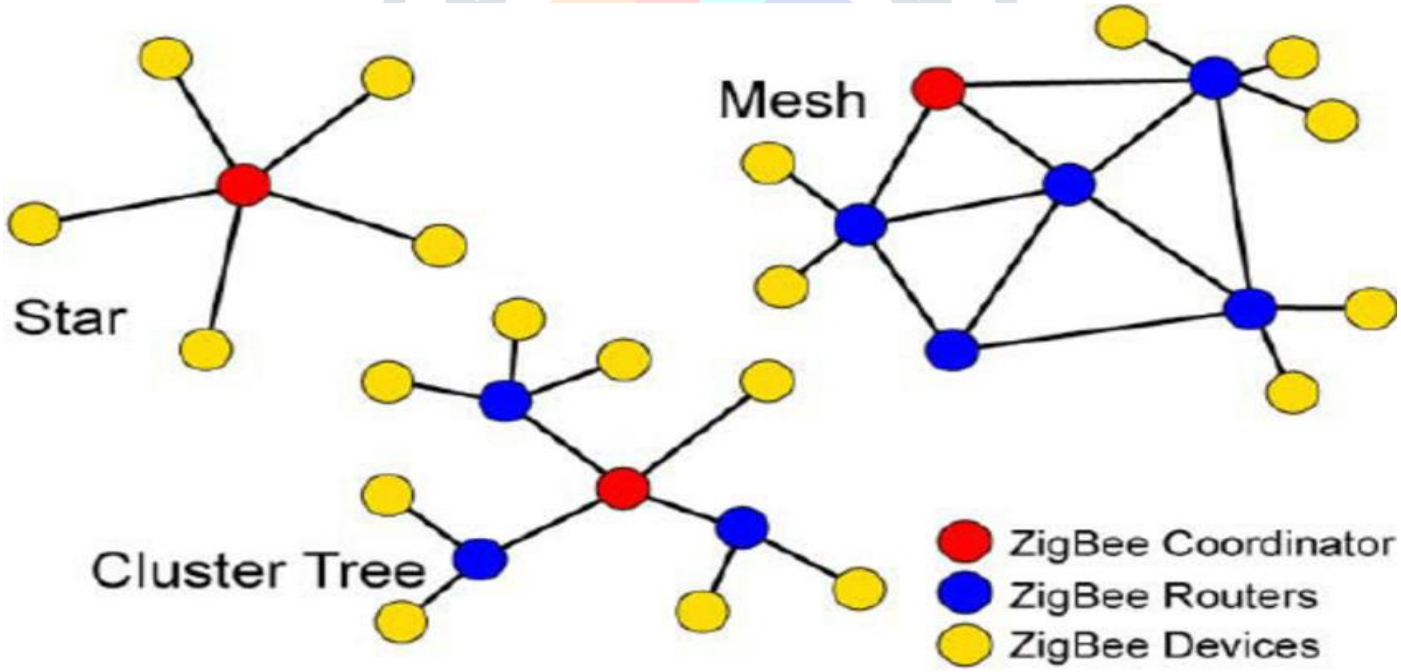

Figure: 4 IEEE 802.15.4 Network Topologies

V. FRAMEFORMATANDOTHER TECHNOLOGIES

The maximum frame size is calculated as the 127octets, 127bytes.The maximum frame header is calculated as the 25octets. A type of frame and different fields are use to control a frame fields. The fields are described as the PAN Field, app request, frame pending, address mode of destination source etc. The format of a frame is calculated to the field of frame control [7]. If any error is occurring in the field protect it then check a frame sequence. At the lower layers ZigBee and 6LoWPAN devices are used by the standard frame format of IEEE 802.15.4.

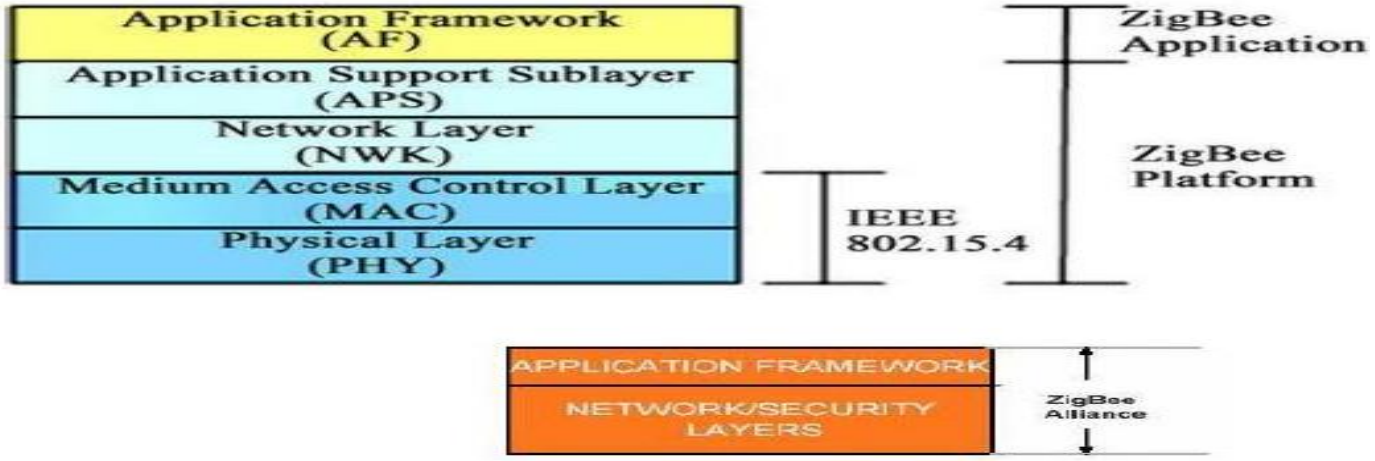

Figure: 5 ZigBee Layered Architecture

5.1 ZigBee

The upper layers of ZigBee alliance and ZigBee ads are supported. Establish in the IEEE.802.15.4 protocol are used in the layer of application, ZigBee network, medium access control and the physical layers. The service operation of the different type is provided by the ZigBee in the upper layers. In the network environment ZigBee works in the correct way. To form an IOT or a wireless sensor network connection are used by ZigBee. A star, mesh, cluster tree are included in the ZigBee network topology. The basic common topology is form by the star network. High reliability is formed by the Mesh or P2P networks. Multiple routes nodes are supported. A combination of star and P2P topologies are the cluster tree network. The IEEE 802.15.4 protocol is provided by the network connectivity and it is dependent to the network topologies of ZigBee.

5.2 6LoWPAN

A Low power wireless personal area network is called as the 6LoWPAN. The IEEE 802.15.4 wireless personal area network is supported by the IPV6 packets. IOT devices are operated a low power design and includes a good battery. The battery life is extending by the low power consumption. An Internet Engineering Task Force (IETF) standard is called as the 6LoWPAN. The IETF and the IREF are two task forces. Two basic layer operations are used in the process and it is used a technology of wireless PAN of 6LoWPAN standard the IEEE 802.15.4. IPv6 Internet is containing the wireless PAN direct connection it is provided by the 6LoWPAN.It is efficient and benefit then it is support a wireless personal networks and includes a features of IPv6.The functions utilized effectively such as security, naming, addressing, translation, lookup, and discovery are the feature of IPv6.

The largest heterogeneous network and infrastructure is called as the Internet. The fast growing heterogeneous network is the Internet of Things (IOT).It is connecting to the sensor and attaches to the different objects. IOT is the progress of communication and connectivity to drive a technology. Connect low and smart network technologies with the use of wireless transmission of reliable internet [8].

The IOT is investigating wireless technologies. It is analyze the IEEE 802.15.4, low energy Bluetooth, and Wi-Fi. In long-range and low-power WAN are consist of a latest technologies of LoRaWAN and IEEE 802.11ah.The devices of low power cost is described. Key requirements of the IOT is includes the communication of bi-directional, mobility and service localization. In the market low cost power is define by the IEEE 802.11ah. Other technologies are described as the LoRa, and ZigBee.

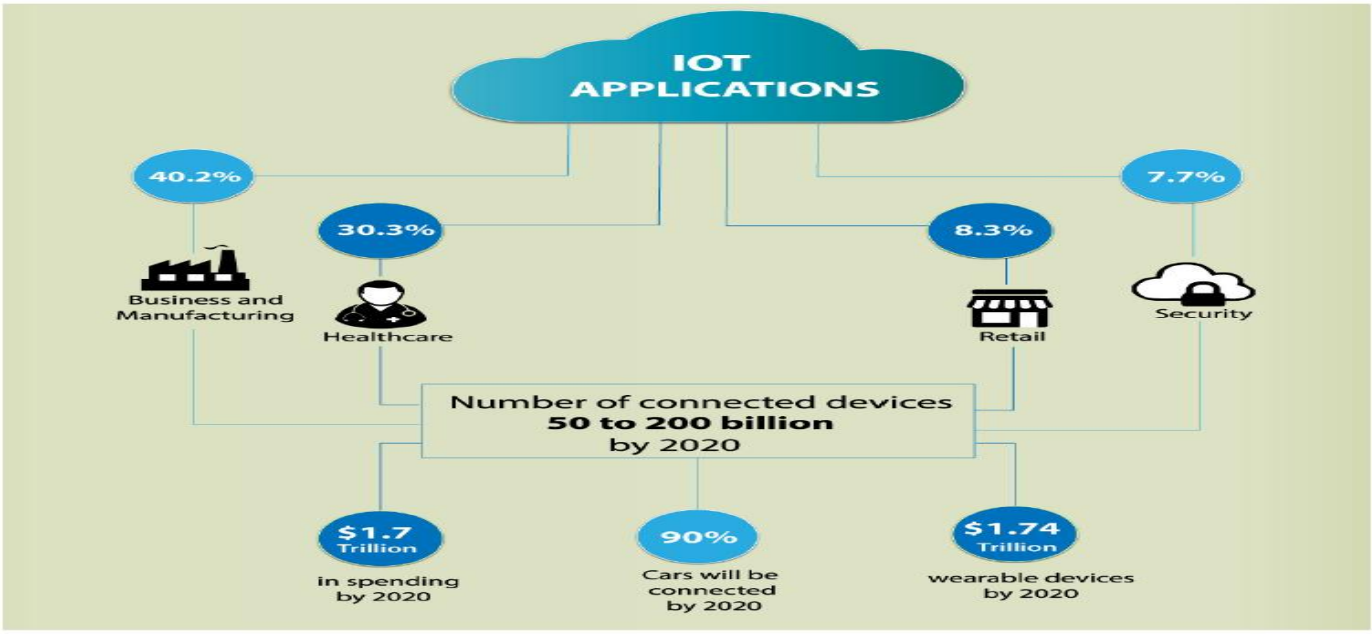

Figure: 6 IOT Growths by 2020

VI. WIRELESS LOW-POWER TECHNOLOGIES FOR THE IOT

Applications of broad range and devices are covered by the IOT. An IOT applications technology is includes the hardware devices, requirements of low power consumption, and the cost. When connecting to the Internet the IOT devices are requiring a wireless technology of the low-cost and low-power. Many wireless sensor network applications are includes the energy consumption. An essential requirement is the growth of IOT and the power consumption of low.

Multiple networking protocols are combined in the different devices, sources of data and wireless techniques. The light weight device is called as the communication and the batteries are operating by the sensors. The effective function of wireless technology is requiring a low-power [9].

To improve a way an IOT device is consist of the low-power wireless technologies and it is connect to the internet and operate an IOT application. An operation and contextual parameters is monitor a low cost network and light weight IOT. Many automated tasks are performed by the IOT and it is allowed to collect a different data. In the various locations the ambiance temperatures are reported by the wireless sensors of IOT. Simple sensor devices and the small bandwidth are requiring a low power and it is form in the IOT. Critical infrastructure or sensitive information is monitor by the use of sensor devices.

6.1 Analysis of IEEE 802.11 WLANs for IOT Communications

Indoor broadband wireless access is used the dominant technology of the Wireless Local Area Networks (WLANs). A higher degree of mobility is increasing the wireless devices. The IEEE 802.11 standard and the European HIPER are the standard of two common WLAN. Two types of configurations, are used in the IEEE 802.11.They are Infrastructure Basic Service Set (iBSS) and Independent BSS (IBSS).The functionality coordination is the central entity and it is includes a coverage area. The wireless network and the wired infrastructure are used in the AP. mobile devices interface of the IEEE 802.11 wireless network is access in the station. The shared wireless medium is includes a data and it is associates to the station. The wired infrastructure is helping to data transmit and receive. To refer an AP and stations are used by the Basic Service Set (BSS). An Extended Service Set (ESS) is setup the BSSs. The wired infrastructure is connecting the DS and the AP is used to allow the station service access.

A star topology is form by the use of WIFI and it is act in the gateway of internet. Local area network wireless technologies are lower to compare of the WIFI output. Wi-Fi networks are connecting to the internet full coverage. The 2.4 and 5 GHz bands are operated by the WIFI. The channels are used then data rates are provide high. The multiple input and multiple output methods are improved by the IEEE 802.11n. A wider RF bandwidth is calculated as the 160 MHz. A bandwidth ranging limitation is calculated as 100Kbps to 40Mbps. Bluetooth and ZigBee protocols are used to the sensor technology.

6.2 IEEE 802.11ah, ZigBee IP and Bluetooth Low Energy

The low-power consumption is an important requirement and it is use a Wi-Fi, with its 802.11 a/b/g/n/ac variants. Some IOT application is not accept these variants. At a short distance Wi-Fi is designed a limited number of devices and it is highly offer then it is indoor located. The IEEE 802 LAN/MAN Standards Committee is formed by the requirements of IOT low-power. In the same area design an energy efficient protocol and it is work the indoor and outdoor devices. IEEE 802.11ah support range is 150 Kbps up to 40 Mbps. The unlicensed sub-1GHz bands are operated by the IEEE 802.11ah. The power saving mechanisms is used for the one-hop network topology. The IOT requirements are satisfied by the IEEE 802.11ah technology.

A new PHY and MAC layers grouping devices are consist of a small units and communication of machine to machine (M2M) in the IEEE 802.11ah standard. Wireless sensors are used in many devices with 900 MHz .The frequency bands are

different from these MHz. The IEEE 802.11af is described as the Super WiFi or White-Fi. It is operating in the TV spectrum. The frequency bands are calculated as the 54MHz and 790MHz. The IOT devices and bandwidth sensors are provided by this application of 802.11ah.

The classic Bluetooth protocol is enhanced by the Bluetooth Low Energy (BLE) 4 in the process. Many devices are consisting of the BLE protocol connectivity, monitoring, and information sharing in the low-power consumption. A minimal consumption of energy is includes in the appliances of home and devices of wearable. A number of IOT applications are created by the BLE protocol. In smart grid applications are used the automation systems and health monitor devices. This gateway and the IOT devices are provide a communication medium. The air data rate of 1 Mbps it is designed in the BLE protocol. ZigBee is consist of a data rate and it is includes at ranges of 20 to 250 kbps. Wireless technologies are operating unlicensed 2.4 GHz band. A scalable architecture is provided by the ZigBee-IP and it is includes IPv6 then support a network of end to end [10].

6.3 LoRaWAN

Industrial IOT applications are required a data transmitted. Low bandwidth communication indoors and outdoors areas are includes the application of IOT Sensors and actuators in industrial. Low power technologies are consisting of short-range limitations. Using meshing technologies eliminate the low-power, wide-area network (LPWAN).

In several IOT applications provide a numerous devices connectivity in LPWANs. LPWAN wireless technology is called as the LoRa. To support low-power communications and develop the technology are in the wide area network. High data are support by this technology. IOT devices and M2M applications are designed by the LoRa. LoRa network consist the following information.

6.3.1 LoRa end devices:

The sensing or actuation is used in the IOT devices of end point.

6.3.2 LoRa gateways:

A gateway of IEEE 80211ah or ZigBee/6lowpna coordinator is similar to it. LoRa end devices are giving a communication and it is includes a functionality of internet. The cellular base stations are used the LoRa gateway.

6.3.3 LoRa server:

The LoRa network is includes the filtration of packet manages, adaptation of data rate, management of network control.

6.3.4 LoRa remote computer/cloud system:

A high level application services are provided then a data process is collected an end devices, analysis a data and IOT application run.

A star network topology is implemented by the Lora WAN. The data rates rang is calculated as the end-point communication of 0.3 kbps to 50 kbpsb. The individual nodes of the data rate and RF output are managed by the LoRa server. The application is require LoRa end devices and it is includes the battery consumptions. The Aloha method is used to the data transmit of LoRaWAN network nodes [11].

VII. ON THE ADOPTION OF WIRELESS TECHNOLOGIES IN THE IOT

The design of new technologies Bluetooth classic to Bluetooth smart, ZigBee classic to ZigBee-IP are growing based on the existing technologies. IOT wireless key address technology is used the low-power consumption and an operational cost in the wide range coverage. A various wireless sensor network applications are used the 6Lowpan and ZigBee technologies.

The IEEE 802.11ah range is use a bandwidth lost. Various communication technologies are used then information's are shared and exchanged. Simple peer-to-peer applications are formed. A wide array of technologies, are used and communicate a heterogeneous devices. Several communication technologies are used to operate devices.

7.1 WLANs: Capacity vs. IOT Requirements

The wireless technologies are used the highest data rate in the IEEE 802.11ac. A data transfer speed is maximum and it is provide by the IEEE 802.11ac. A transfer speed is calculated up to 1.3Gbps. A wireless technology distance coverage is includes a low power consumption, space, rate, Low Energy of Bluetooth. The highest data rate is described as the 2.1 Mbps. The IEEE802.15.4 is support a technologies of ZigBee and 6Lowpan.The frequency band of data rate is calculate as the 250 Kbps.

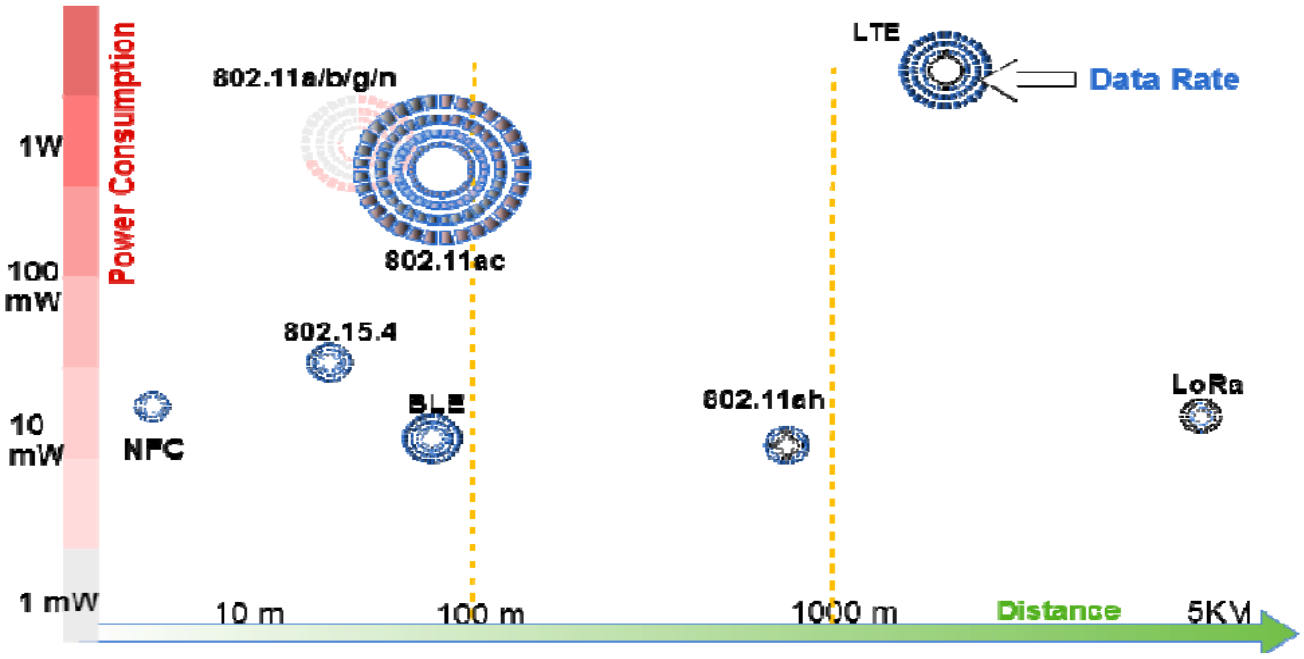

Figure: 7- A Comparative Study of Power Consumption, Distance Coverage in Meters, and Data rate

The lowest data rate is targeted by the IEEE802.11ah. Other WiFi technologies are compared and it is cover a larger area and it is maximum range is calculated as the 100 m. Wireless technologies low power range is used BLE technologies. The 802.11 protocols are out performing and it is support the mesh networking. Through several nodes on a network is used to rout a message and reach a destination. A mesh formation uses a network range of the ZigBee easily. A mesh of nodes is around by the hops of ZigBee network. To coverage a ZigBee network with the use of a high density of nodes.

The data rate and range requirements are used the application of IOT. A larger number of nodes use a IOT application. A larger coverage area is used the meshing technique and includes the 802.11 Wi-Fi technologies. The data rate and range parameters are measures IOT wireless technologies [12].

7.2 Network Size Capabilities for IOT Networks

In the network a maximum of eight nodes are supported by the BLE protocol. In the star topology used the 65,000 nodes in the Zigbee. A cluster tree or mesh network are used by the extended in Zigbee. A scatter net network is used to extend by a BLE. A scatter net is referred by the Bluetooth devices. Two piconets are used to connect the process. In the network a number of devices are used in the IEEE 802.11. A unique value assigned by the Association Identifier (AID).An addressing traffic group is reserved by the AID of value of 0. The numbers of stations are associates with AID design. The mechanisms of power management is used the bitmap of Traffic Indication Map (TIM).The AP is received a buffered frame. The maximal length of the TIM bitmap is increase by the IEEE 802.11ah. The network size requirements are used in the classic 802.11a/ac protocol [13].

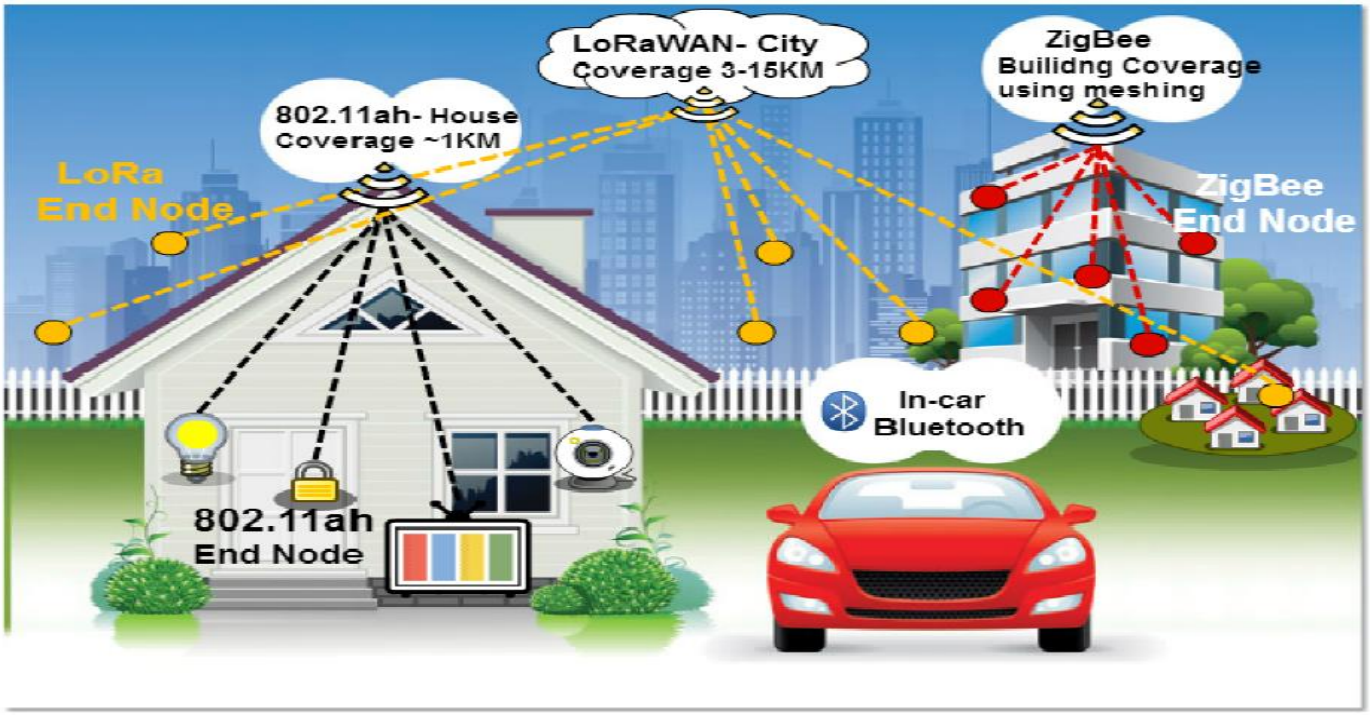

Figure: 8 Influence of Wireless Technologies Ranges on their Applications in the IOT

Table: 2. Network Size Comparisons

Technology	Network Size
ZigBee	Approximately up to 65,000 nodes
Bluetooth	Eight nodes per network/piconet
Wi-Fi (802.11a/ac)	2007 associated with an AP
Wi-Fi 802.11ah	Approximately 8000 nodes
LoRa	LoRa gateway must have a very high capacity or capability to receive messages from a very high volume of End nodes

An enormous network size is consisting of the cellular technologies. Mobile provider is includes in the cellular connectivity. A larger number of devices, the costs are used in the cellular technology and it is associated by the other technologies. A large volume of devices are support in the ZigBee. The ZigBee, BLE, Wi-Fi, and LoRa network size is provided in the above table [14].

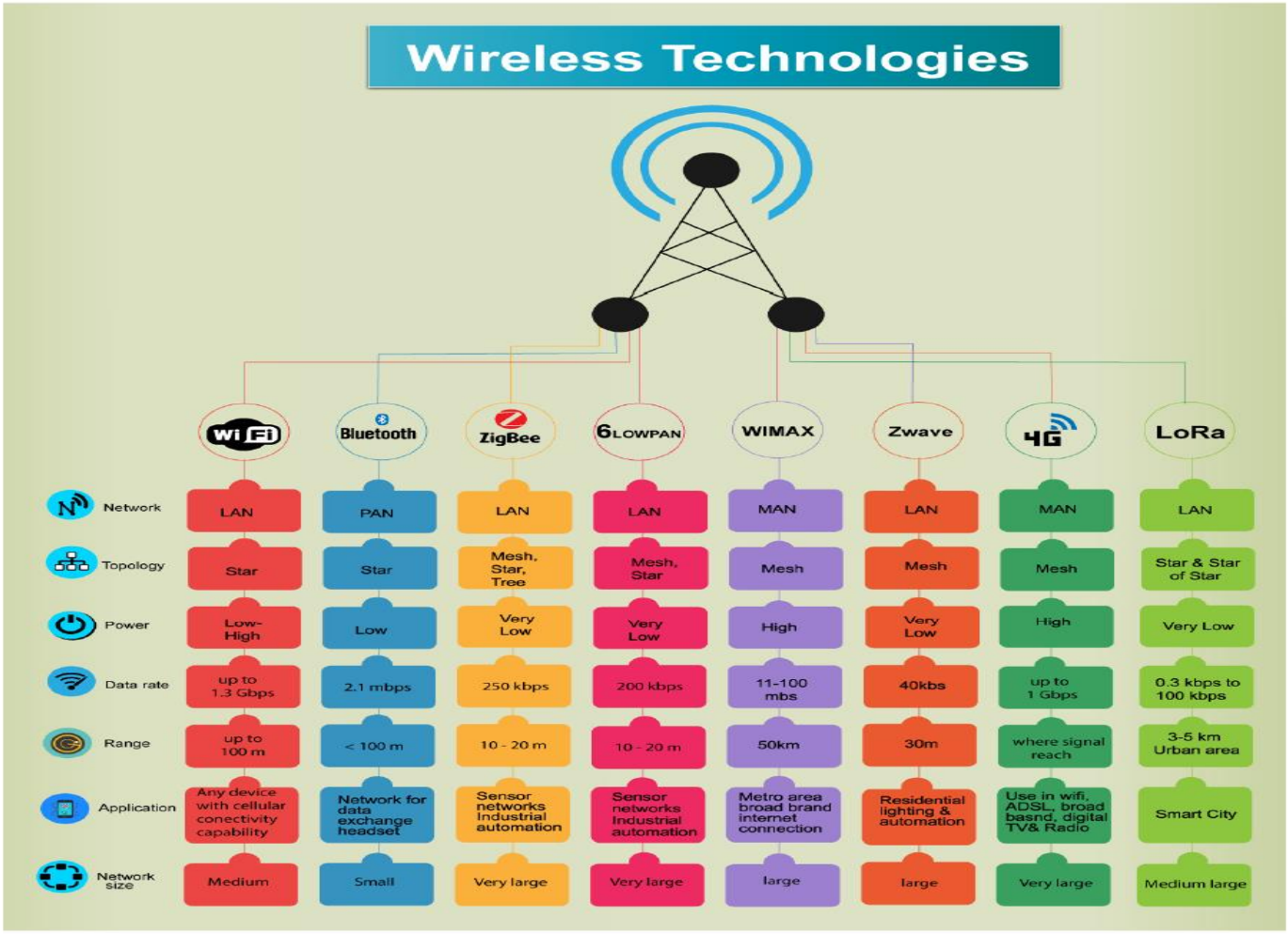

Figure: 9. Wireless Technologies Comparison

7.3 Transmission Power Evaluation

The BLE, LoRa, and 802.11ah are the low power consumption and it is used the 802.15.4 technologies. The BLE ranges are calculated as the 1 to 10 mW in the power transmission [15].

Table: 3. Low-Power Wireless Technologies Comparison

	Security	Location Detection	Low Cost	Ease of use	Ecosystem	Range	Remote control	Antenna size	Networking size
802.15.4	✓	✓	✓	✓	✓	✓(✓)	✓	✓	✓
BLE	✓	x	✓	✓	✓	x	✓	✓	x
802.11ah	✓	✓	✓	✓	✓	✓	✓	✓	✓(✓)
LoRa	✓	✓	✓	✓	✓	✓	✓	✓	✓

Low estimated power transmission is defined by the ZigBee. A small number of nodes are including in the IEEE 802.15.4 energy consumption. The successful transmission of a packet is used in the low traffic scenario of IEEE 802.11ah. The energy consumption is higher than IEEE 802.11ah in the dense network.

VII. CONCLUSION

The different LPWAN (Low Power Wide Area Network) technologies are used in the IOT. The LoRaWAN, SigFox, RPMA and NB-IOT technologies are compared and include the features, applications, range, and bandwidth. The IOT related applications are provide a solution for IOT. Low energy networks are integrated by the IOT. The IOT networks are used to develop energy and reduce power consumption. The star, mesh-p2p and cluster tree topologies are implementing by the IOT.A variety of wireless and mobile technologies are used to support the internet connecting. The low-power IEEE 802.11ah protocol is used a wireless technology of ZigBee, 6LoWPAN, BLE, LoRa and Wi- Fi. The wireless low power technologies are used a unique characteristics and it is includes the security, and privacy-preserving methods. Heterogeneous networks are used a large number of connected things. Various technologies are used a secure and interoperable communication.

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