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A REVIEW ON ZIGBEE TECHNOLOGY IN INTERNET OF THINGS (IOT) AND ITS APPLICATIONS

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Abstract: - In this paper we have discussed about the Zigbee is a low-power, low-data rate, and proximity PAN (i.e., personal area networks) wireless ad hoc network technology. This was developed as an open global standard to address the unique needs of low-cost, low-power wireless IoT networks. It is based on IEEE 802.15.4 specification for a suite of high-level communication protocols.

Keywords: Zigbee, PAN, IEEE 802.15.4, IoT

I. INTRODUCTION

Zigbee is a protocol used to link smart devices like lights, plugs, and smart locks to a home network. It's a networking standard for connecting sensors and control systems, just like how IoT works. The specification is a packet-based radio protocol intended for low-cost, battery-operated devices. The protocol allows devices to communicate in a variety of network topologies and can have battery life lasting several years.

The Zigbee standard operates on the IEEE 802.15.4 physical radio specification and operates in unlicensed bands including 2.4GHz, 900MHz, and 868MHz. The 802.15.4 specification upon which the Zigbee stack operates gained ratification by the IEEE in 2003. Zigbee is a specification that has been around for more than a decade, and it's widely considered an alternative to Wi-Fi and Bluetooth for some applications. The technology defined by the Zigbee specification is intended to be simpler and less expensive than other (WPANs), such as Bluetooth or more general wireless networking such as Wi-Fi.

The Zigbee protocol has been created and ratified by member companies of the Zigbee Alliance. The Zigbee Alliance works on wireless devices and Zigbee is a very prominent application of Internet of Things.

The Zigbee protocol was designed to provide an easy-to-use wireless data solution characterized by secure, device-to-device communication, reliable wireless network architectures. Its lower power consumption limits transmission distances to 10-100 meters depending on power output and environmental characteristics. Zigbee devices can transmit data over long distances by passing data

through a mesh network of intermediate devices to reach more distant ones. Zigbee is typically used in low data rate applications that require long battery life and secure networking. They are secured by 128-bit symmetric encryption keys.

The name 'Zigbee' is derived from the zig-zag dance of the honeybees. When bees find a rich source of pollen or nectar, they communicate to the other bees in the hive the location of the food source. They communicate by performing a "waggle-dance": a dance that uses a zig-zag motion.

II.LITERATURE REVIEW

Zigbee and IEEE 802.15.4 are not the same. IEEE 802.15.4 is a technical standard, defined and maintained by IEEE (IEEE 802.15 Working Group, to be specific) that defines the operations of low data rate WPANs (Wireless Personal Area Networks).

Contrastingly, Zigbee is a network protocol which is designed, maintained and developed exclusively by the Zigbee Alliance. Zigbee uses the MAC and physical layers of IEEE 802.15.4. Like Zigbee, MiWi, SNAP, Wireless HART, and many more are different network protocols which are also based on IEEE 802.15.4.

This standard is a communication layer defined at level 3 and uppers in the OSI (open system interconnection) model. The main purpose of this standard is to create a network topology that lets many devices communicate among themselves and sets extra communication features for instance encryption, authentication and association in the upper layer application services.

Is Zigbee a mesh network?

A mesh network is primarily a network where several devices in the network act as router or repeater. Instead of only sending signals back to the originator, it repeats the signals and forwards to the other network devices in the vicinity. Sequentially, it can relay the signals further. This 'signal-hopping' gives mesh networks a wide range and better consistency than the traditional 'star networks' .

To understand this better, let us first see how Zigbee network works.

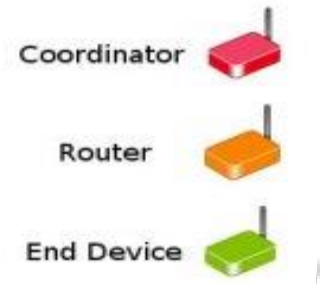


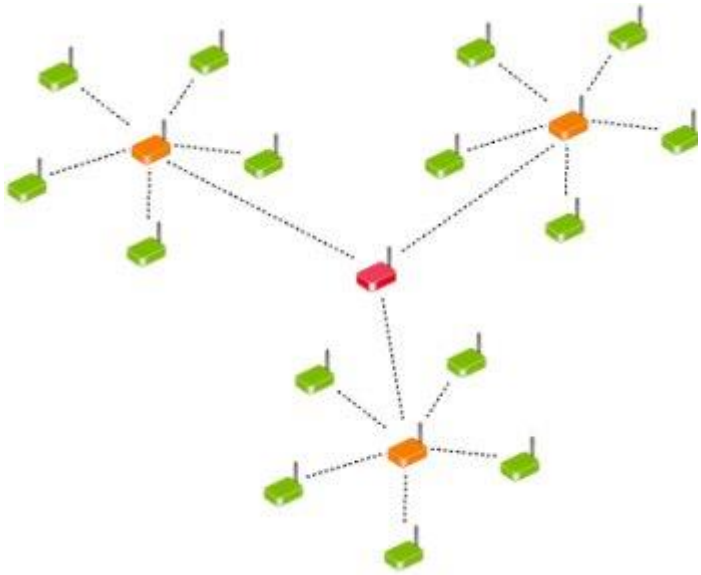
Fig (1): Types of ZigBee

There are three kinds of nodes in a ZigBee network:

- Coordinator: is the "master" device, it directs all the network
- Routers: they route the information which sent by the end devices
- End device: (the motes): they are the sensor nodes, the ones which take the information from the environment.

The Coordinator and the Routers cannot be battery operated whereas the End device can be battery powered. ZigBee creates star topologies; however, there are some basic rules:

- The end devices should be connected to a router or a coordinator.
- The routers can connect among them and with the coordinator.
- The routers and coordinators cannot sleep. They have to save in their buffer the packets which go to the end devices.
- The end devices can sleep.



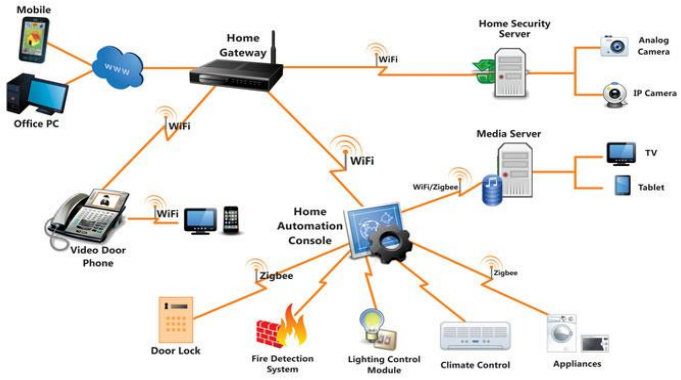
Fig(2) : Mesh Network

The concept "Mesh Network" transmits in the Ad hoc communications, also called peer to peer (P2P). In this ad hoc communication, all the devices in the network can communicate directly with each other. They must be able to identify each other and send broadcast messages to all their mates. (*"hello! is there anybody out there?"*). They have to be able to create networks like the one represented in the image above.

Zigbee does not create mesh network, they create star network topologies. In order to create a mesh network like the one shown above, all the nodes need to have the same role, all of them should be "end devices + routers". From this they can route their mates' information and sleep when no action is necessary, thus saving energy. The Digi Mesh protocol (over 802.15.4) sets a completely distributed network where all the nodes talk among them using p2p (equal to equal) datagrams.

How Zigbee Works?

Zigbee uses the digital radios to permit devices to communicate with each other. A characteristic Zigbee network consists of multiple types of devices. A network coordinator is a device that establishes the network, is aware of all the nodes within its network, and directs the information about each node as well as the information that is being transmitted/received within the network. It is necessary that every Zigbee network must have a network coordinator. Additional Full Function Devices (FFD's) might be present in the network, which support all of 802.15.4 functions. These FFD's can serve as a network coordinator, network routers, or as devices which interact with the physical world. The final device found in the networks is the Reduced Function Device (RFD), which generally only assist as devices that interact with the physical world. As mentioned earlier several topologies are supported by Zigbee, including star, mesh, and cluster tree. Among these, star topology is most useful when several end devices that are set close together so that they can communicate with a single router node. That node can then be a part of a larger mesh network which eventually communicates with the network coordinator. The mesh networking allows for dismissal in node links, so that if one node collapse, the devices will find alternate path to communicate with one another.



How Zigbee is unlicensed?

Based on IEEE 802.15.4, Zigbee defines operation in three license-free industrial scientific medical (ISM) frequency bands—915 MHz and 2.4 GHz. The 2.4 GHz ISM band usage ensures license-free product arrangement globally. Zigbee products have access to 16 separate 5 MHz channels in this band and this helps in providing clear communication ways regardless of the geographic region.

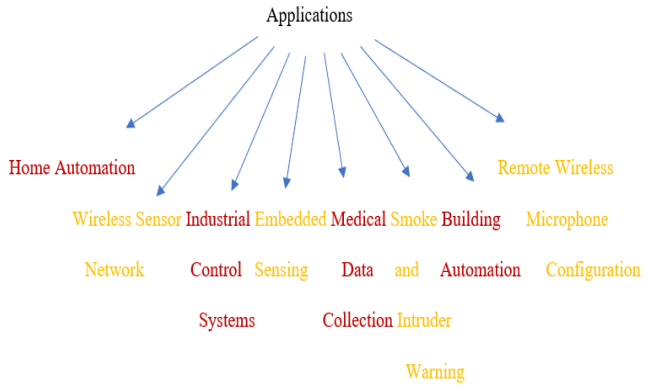
Zigbee in security— how secure is Zigbee?

Zigbee claims to provides one of the most secure IoT wireless devices. Security is one of Zigbee's strength. The security is based on symmetric-key cryptography, where two parties must share the same keys to communicate. Zigbee uses the highly secure 128-bit AES- based encryption system (advanced encryption standard). Being a low-cost protocol, Zigbee has an 'open trust' model where the protocol stack layers trust one another. So, cryptographic protection only prevails between devices, but not between different layers in a device. This permits the keys to reuse among layers of the same device. To make the interoperability of devices simple, Zigbee uses the same security level for all devices on a given network and all layers of a device. Besides, Zigbee command includes a frame counter which stops

replay attacks i.e., where an attacker can record and replay a command message. The receiving end point always ensures the frame counter and ignores duplicate messages. Zigbee supports frequency agility as well, so in case of a jamming attack, its network gets relocated.

III. APPLICATIONS OF ZIGBEE TECHNOLOGY

Zigbee has covered applications ranging from industrial to business to home, which has led to the development of separate service standards.



- Zigbee in Home Automation—

Zigbee works in a mesh network within the range of 10-100 meters of each other. It is perfect for home environment. As for now, the Zigbee Alliance website lists about 400 devices for home automation. You can buy a wholly new Home Automation Zigbee device, and it will connect to the existing meh network. The Home Automation Zigbee Devices are common IoT Home Devices for instance light bulbs, locks, switches motion sensors, and thermostats.

The major companies which use Zigbee products are Samsung, Bosch, Texas Instruments, Honeywell and Amazon. The Amazon Echo Plus comes with a built-in Zigbee hub to control Zigbee devices. Samsung's SmartThings devices also uses Zigbee to communicate supporting Z-wave.

- Zigbee in Medicine

Another application of Zigbee Technology is its application medicine. It is used in the in-home patient monitoring, in which the patient will have to wear a Zigbee device which will periodically collect the information like heart rate and blood pressure.

- Zigbee in Wireless Sensor Networks (WSN)—

The main category the Zigbee Technology has focused on is the Wireless Sensor Network even though it has many applications in home automation and military.

It is also used in the building's structural health monitoring. This application is very useful and helpful in earthquake prone areas. There are several Zigbee based wireless sensors like accelerometers which are installed throughout the build. These wireless sensors collect information that can be used in detecting signs of damage and assessing whether the building is safe for people or not.

- Zigbee in Industrial Automation—

Zigbee Mesh Technology is supported by one of IoT's industrial devices in eModGATE from TECHBASE. Economical, ESP32-based solution serves as an end-point in any installation or works well as a gateway, gathering data from scattered sensor mesh across the installation.

Research Method:

Research was done by collecting data from primary and secondary resources.

Primary research –

Data about awareness of Zigbee Technology was collected through random sampling.

The questionnaire was designed and circulated to various potential respondents.

The sample size was 67 and the respondents were of different age groups, occupations and educational level.

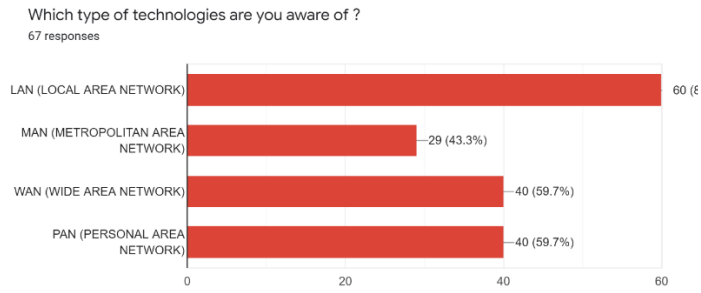
The tool used was Google Forms.

Secondary research—

The data regarding Zigbee Technology and its application in various fields were collected from secondary resources like published research papers and google search engine.

Data Analysis:

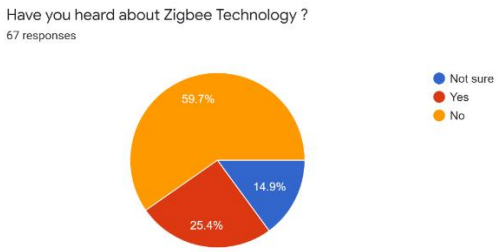
Here are some graphs of questions asked in a survey—



This graph represents that most of the people are aware of LAN as compared PAN and WAN; whereas MAN is the least known.

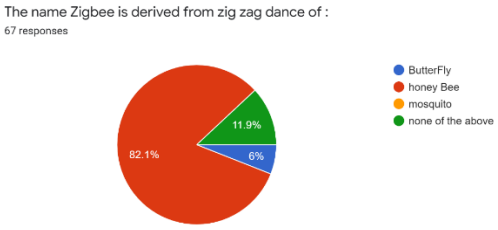
PAN allows you to deal with information devices interconnected with a single user environment as compared to others.

This chart shows that not many people are aware of new technologies other than Wi-Fi and Bluetooth.



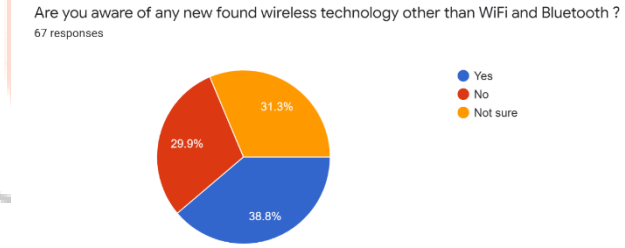
Analysing this chart, we understand that almost 60 % people don't know about Zigbee technology and the awareness level is low around 25%.

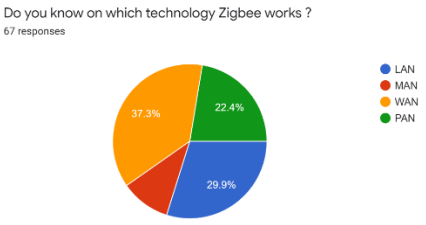
Zigbee Technology is a wireless technology based on PAN.



More than 80% people logically figured out that the name Zigbee could be derived from honeybees; yet a small amount opted for none of the options.

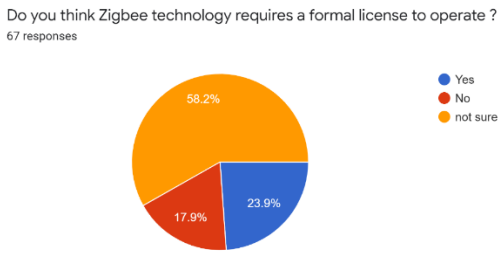
Zigbee is derived from the waggle-dance of honeybees. They do this dance to notify their fellow mates about nectar found and communicate via this dance. Just like that Zigbee also works and communicates in a mesh network technology.





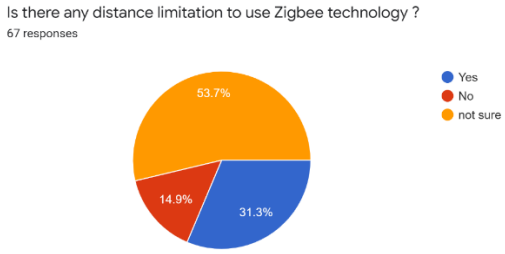
This pie-chart tells that people assume that Zigbee is based on wide area network or local area network.

However, around 22 % people know exactly that Zigbee is based on personal area network.



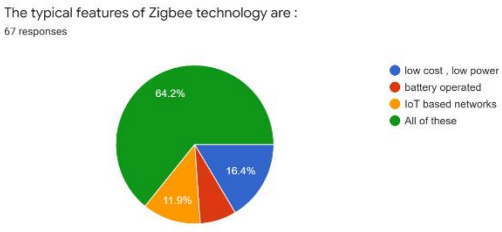
Maximum people are not sure about the license operation. Only a few people around 18% were sure that it doesn't require a formal license to operate.

Zigbee Technology operates on unlicensed bands.



Maximum responses were not sure about the distance limitation, still approx. 32% knew about the limitation.

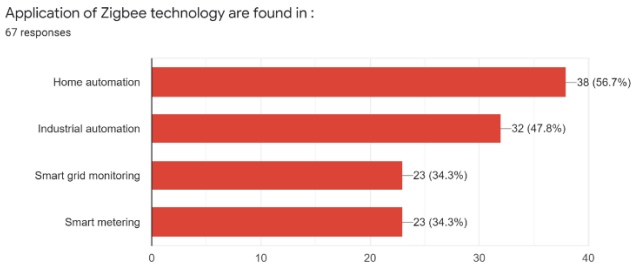
Since Zigbee is a personal area network system, it has a distance limitation, it can be of 10-100 meters.



Majority of the people responded around 65% with all of these as the features of Zigbee.

Since in the above chart, we observed that not many people knew about Zigbee Technology, they have assumed that Zigbee would be different yet quite similar to Wi-Fi and Bluetooth and would possibly have all these features.

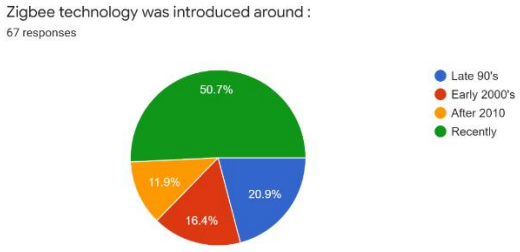
Zigbee is indeed a low-cost, low-power network and it has a long battery life and is an application of Internet of Things.



As we can see people think that Zigbee Technology is for home and industrial automation basically.

1/3rd people are aware of Zigbee's application in smart grid monitoring and smart metering.

Zigbee Technology is widely used in home automation and industrial automation.



This question was asked to check whether people are aware about these technologies and we analysed that half of them think that Zigbee is one of the recent technologies because it hasn't been fully applicable in the society but it is going to be in the near future.

Zigbee Technology was actually introduced in 1998 by the Zigbee Alliance and developed by IEEE and approved in 2006.

IV. CONCLUSION

Zigbee Technology is a newfound wireless protocol which has a huge success as an application of Internet of Things. The most important and well-known application of Zigbee is in Home Automation. Renown brands like Samsung, Amazon, Bosch have started using Zigbee hubs which would connect directly to the mesh networks and all these Zigbee enabled devices would work together and communicate with each other accordingly.

Zigbee is although not very popular for now but soon it has a chance to become one of the best applications of Internet of Things.

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