SEMINAR REPORT

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SUBMITTED BY

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DEPARTMENT OF COMPUTER APPLICATIONS

(2020-2023)

M.E.S. COLLEGE MARAMPALLY

ALUVA-7

CERTIFICATE

this is to certify that ***khadeeja beevi c n*** has taken a seminar entitled ***zigbee technology*** which is a bonafide work, carried out her in partial fulfillment of the requirements for the award of the degree of bachelor of computer applications during the period of 2020-2023

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PROFORMA FOR THE APPROVAL OF BCA SEMINAR (2019-2022)

1. Roll Number : 200139
2. Name of Student : KHADEEJA BEEVI C N
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4. Date Of Submission :

Signature of the student

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Suggestions for reformulating the seminar if any:

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I thank God almighty for giving the favour to complete this seminar to extend my knowledge and capabilities. I like this opportunity to express my sincere thanks and gratitude to Dr. Ajims P Mohammed, Principal of MES College, Marampally for the guidance and encouragement given during the course of the study. I would like to thank Mrs. Leena C Sekhar, Head of the Department of computer applications MES College, Marampally is inspiring and commendable support throughout the course and seminar. I would like to extend my sincere feeling of gratitude to Ms Dr Julie M David, Seminar Guide, for all the necessary facilities to complete my project work successfully and their single minded devotion to obtain maximum effort. I would like to thank all staff members of Computer Applications Department for their valuable suggestions and help during the course of study. I express my sincere thanks to my parents and friends those who had provide all the support both directly and indirectly.

KHADEEJA BEEVI C.N

CONTENT

1. INTRODUCTION

1.1 Introduction

Zigbee is a low-power wireless mesh network standard targeted at battery-powered devices in wireless control and monitoring applications. Zigbee delivers low-latency communication. Zigbee chips are typically integrated with radios and with microcontrollers. Zigbee operates in the industrial, scientific and medical (ISM) radio bands: 2.4 GHz in most jurisdictions worldwide; though some devices also use 784 MHz in China, 868 MHz in Europe and 915 MHz in the US and Australia, however even those regions and countries still use 2.4 GHz for most commercial Zigbee devices for home use. Data rates vary from 20 kbit/s (868 MHz band) to 250 kbit/s (2.4 GHz band).

Compared to other wireless protocols, the ZigBee wireless protocol offers low complexity, reduced resource requirements and most importantly, a standard set of specifications. It also offers three frequency bands of operation along with a number of network configurations and optional security capability. If you are currently exploring alternatives to your existing control network technologies, such as RS-422, RS-485 or proprietary wireless protocol, the ZigBee protocol could be the solution you need. This application note is specifically designed to assist you in adopting the ZigBee protocol for your application. You can use the Microchip Stack for the ZigBee protocol provided in this application note to quickly build your application. To illustrate the usage of the Stack, several working demo applications are included. You can use these demo applications as a reference or simply modify and adopt them to your requirements.

Zigbee builds on the physical layer and media access control defined in IEEE standard 802.15.4 for low-rate wireless personal area networks (WPANs). The specification includes four additional key components: network layer, application layer, *Zigbee Device Objects* (ZDOs) and manufacturer-defined application objects. ZDOs are responsible for some tasks, including keeping track of device roles, managing requests to join a network, as well as device discovery and security.

The Zigbee network layer natively supports both star and tree networks, and generic mesh networking. Every network must have one coordinator device. Within star networks, the coordinator must be the central node. Both trees and meshes allow the use of Zigbee routers to extend communication at the network level. Another defining feature of Zigbee is facilities for carrying out secure communications, protecting establishment and

transport of cryptographic keys, ciphering frames, and controlling device. It builds on the basic security framework defined in IEEE 802.15.4.

1.2 Abstract

This abstract tells about a Wireless Technological Device which is popular for extremely Low Power, and Low Bit Rate Wireless PAN Technology called ZigBee.
ZigBee is designed for wireless Automation and other lower data tasks, such as smart home automation and remote monitoring. ?ZigBee is a low-cost, low-power, wireless mesh networking standard. ?The low cost allows the technology to be widely deployed in wireless control and monitoring applications, the low power usage allows longer life with smaller batteries, and the mesh networking provides high reliability and larger range. Due to the low-cost and low-power usage this wireless technology is widely used in Home Automation, Smart Energy, Telecommunication Applications, Personal Home, Hospital Care. ?ZigBee enables new opportunities for wireless sensors and control networks. ZigBee is standard based,low cost, can be used globally, reliable and self healing, supports large number of nodes, easy to deploy ,very long battery life and secure.

2. CONTENTS

2.1 Features

•Low duty cycle - provides long battery life

• Low latency

• Support for multiple network topologies: static, dynamic, star and mesh

• Direct Sequence Spread Spectrum (DSSS)

• Up to 65,000 nodes on a network

• 128-bit AES (Advanced Encryption Standard) - provides secure connections between devices

• Collision avoidance

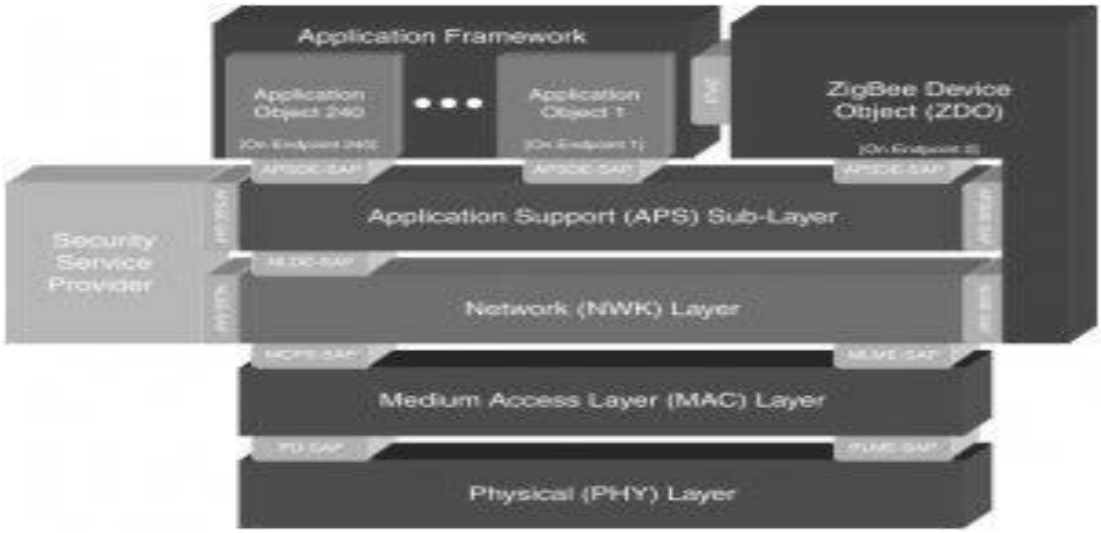
• Link quality indication

• Clear channel assessment

• Retries and acknowledgements

• Support for guaranteed time slots and packet freshness.

2.2 ZIGBEE ARCHITECTURE



The ZigBee protocol was engineered by the ZigBee Alliance, a non-profit consortium of leading semiconductor manufacturers, technology providers, OEMs and end-users

worldwide. The ZigBee protocol carries all the benefits of the 802.15.4 protocol with added networking functionality. The 802.15.4 specification was developed at the Institute of Electrical and Electronics Engineers (IEEE). The specification is a packet-based radio protocol that meets the needs of low-cost, battery-operated devices. The protocol allows devices to intercommunicate and be powered by batteries that last years instead of hours.

ZigBee can be implemented in mesh networks larger than is possible with Bluetooth. ZigBee compliant wireless devices are expected to transmit 10-75 meters, depending on the RF environment and the power output consumption required for a given application, and will operate in the unlicensed RF worldwide (2.4GHz global, 915MHz Americas or 868 MHz Europe). The data rate is 250kbps at 2.4GHz, 40kbps at 915MHz and 20kbps at 868MHz. IEEE and ZigBee Alliance have been working closely to specify the entire protocol stack. IEEE 802.15.4 focuses on the specification of the lower two layers of the protocol (physical and data link layer). On the other hand, ZigBee Alliance aims to provide the upper layers of the protocol stack (from network to the application layer) for interoperable data networking, security services and a range of wireless home and building control solutions, provide interoperability compliance testing, marketing of the standard, advanced engineering for the evolution of the standard.

Zigbee system structure consists of three different types of devices as Zigbee Coordinator, Router, and End device. Every Zigbee network must consist of at least one coordinator which acts as a root and bridge of the network. The coordinator is responsible for handling and storing the information while performing receiving and transmitting data operations.

Zigbee routers act as intermediary devices that permit data to pass to and fro through them to other devices. End devices have limited functionality to communicate with the parent nodes such that the battery power is saved as shown in the figure. The number of routers, coordinators, and end devices depends on the type of networks such as star, tree, and mesh networks.

Zigbee protocol architecture consists of a stack of various layers where IEEE 802.15.4 is defined by physical and MAC layers while this protocol is completed by accumulating Zigbee's own network and application layers.

Physical Layer: This layer does modulation and demodulation operations upon transmitting and receiving signals respectively. This layer's frequency, data rate, and a number of channels are given below.

MAC Layer: This layer is responsible for reliable transmission of data by accessing different networks with the carrier sense multiple access collision avoidances (CSMA). This also transmits the beacon frames for synchronizing communication.

Network Layer: This layer takes care of all network-related operations such as network setup, end device connection, and disconnection to network, routing, device configurations, etc.

Application Support Sub-Layer: This layer enables the services necessary for Zigbee device objects and application objects to interface with the network layers for data managing services. This layer is responsible for matching two devices according to their services and needs.

Application Framework: It provides two types of data services as key-value pair and generic message services. The generic message is a developer-defined structure, whereas the key-value pair is used for getting attributes within the application objects. ZDO provides an interface between application objects and the APS layer in Zigbee devices. It is responsible for detecting, initiating, and binding other devices to the network.

2.3 How does Zigbee Technology Work?

Zigbee technology works with digital radios by allowing different devices to converse through one another. The devices used in this network are a router, coordinator as well as end devices. The main function of these devices is to deliver the instructions and messages from the coordinator to the single end devices such as a light bulb.

In this network, the coordinator is the most essential device which is placed at the origin of the system. For each network, there is simply one coordinator, used to perform different tasks. They choose a suitable channel to scan a channel as well as to find the most appropriate one through the minimum of interference, allocate an exclusive ID as well as an address to every device within the network so that messages otherwise instructions can be transferred in the network.

Routers are arranged among the coordinator as well as end devices which are accountable for messages routing among the various nodes. Routers get messages from the coordinator

and stored them until their end devices are in a situation to get them. These can also permit other end devices as well as routers to connect the network;

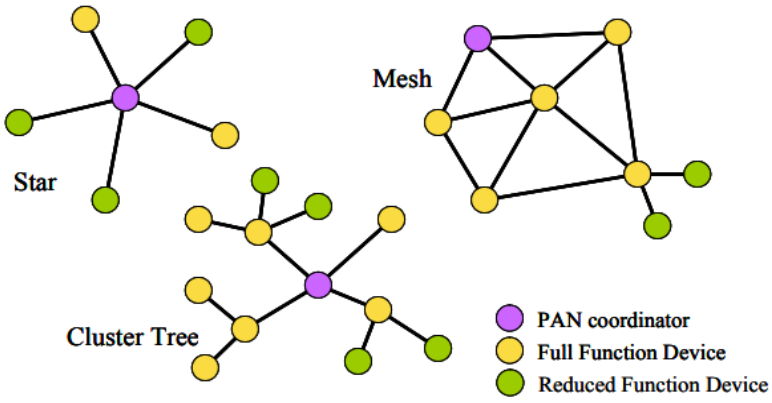
In this network, the small information can be controlled by end devices by communicating with the parent node like a router or the coordinator based on the Zigbee network type. End devices don’t converse directly through each other. First, all traffic can be routed toward the parent node like the router, which holds this data until the device’s receiving end is in a situation to get it through being aware. End devices are used to request any messages that are waiting from the parent.

2.4 ZIGBEE VS BLUETOOTH

ZigBee is broadly categorized as a low rate WPAN, and its closest technology is Bluetooth. A good bit of energy has been spent in analyzing whether ZigBee and Bluetooth are complementary or competing technologies, but after a quick look at the two, it can be seen that they fall a lot farther down the complementary side of the spectrum. They are two different technologies with very different areas of application and different means of designing for those applications. While ZigBee is focused on control and automation, Bluetooth is focused on connectivity between laptops, PDA’s, and the like, as well as more general cable replacement. ZigBee uses low data rate, low power consumption, and works with small packet devices; Bluetooth uses a higher data rate, higher power consumption, and works with large packet devices. ZigBee networks can support a larger number of devices and a longer range between devices than Bluetooth. Because of these differences, the technologies are not only geared toward different applications, they don't have the capability to extend out to other applications. As an example, for its applications, Bluetooth must rely on fairly frequent battery recharging, while the whole goal of ZigBee is for a user to be able to put a couple of batteries in the devices and forget about them for months to years. In timing critical applications, ZigBee is designed to respond quickly, while Bluetooth takes much longer and could be detrimental to the application. Thus, a user could easily use both technologies as a wireless solution in a PAN to suit all types of applications within that network.

2.5 ZIGBEE NETWORK CONSIDERATIONS

In the interest of brevity, many network specific features of the IEEE 802.15.4 standard are not covered in detail in this paper. However, these are necessary for the efficient operation of ZigBee networks. These features of the PHY include receiver energy detection, link quality indication and clear channel assessment. Both contention-based and contention-free channel access methods are supported with a maximum packet size of 128 bytes, which includes a variable payload up to 104 bytes. Also employed are 64-bit IEEE and 16-bit short addressing, supporting over 65,000 nodes per network. The MAC provides network association and disassociation, has an optional superframe structure with beacons for time synchronization, and a guaranteed time slot (GTS) mechanism for high priority communications. The channel access method is carrier sense multiple access with collision avoidance (CSMA-CA). ZigBee defines the network, security, and application framework profile layers for an IEEE 802.15.4-based system. ZigBee's network layer supports three networking topologies; star, mesh, and cluster tree as shown in Figure 3. Star networks are common and provide for very long battery life operation. Mesh, or peer-to-peer, networks enable high levels of reliability and scalability by providing more than one path through the network. Cluster-tree networks utilize a hybrid star/mesh topology that combines the benefits of both for high levels of reliability and support for battery-powered nodes.



2.6 DEVICE TYPES AND OPERATION MODES

There are three classes of Zigbee devices:

- **Zigbee Coordinator (ZC)**: The most capable device, the coordinator forms the root of the network tree and may bridge to other networks. There is precisely one Zigbee coordinator in each network since it is the device that started the network originally (the Zigbee LightLink specification also allows operation without a Zigbee coordinator, making it more usable for off-the-shelf home products). It stores information about the network, including acting as the trust center and repository for security keys.[23][24]
- **Zigbee Router (ZR)**: As well as running an application function, router devices can act as intermediate routers, passing data on to other devices. These types of Zigbee products are typically mains-powered so they are always available on the network. Zigbee Router devices are sometimes called Zigbee repeaters or Zigbee range extenders.
- **Zigbee End Device (ZED)**: Contains just enough functionality to talk to the parent node (either the coordinator or a router); it cannot relay data from other devices. This relationship allows the node to be asleep a significant amount of the time thereby giving long battery life. These types of Zigbee device products are often battery-powered. A ZED requires the least amount of memory and thus can be less expensive to manufacture than a ZR or ZC.

The current Zigbee protocols support beacon-enabled and non-beacon-enabled networks. In non-beacon-enabled networks, an unslotted CSMA/CA channel access mechanism is used. In this type of network, Zigbee routers typically have their receivers continuously active, requiring additional power.[25] However, this allows for heterogeneous networks in which some devices receive continuously while others transmit when necessary. The typical example of a heterogeneous network is a wireless light switch: The Zigbee node at the lamp may constantly receive since it is reliably powered by the mains supply to the lamp, while a battery-powered light switch would remain asleep until the switch is thrown. In which case, the switch wakes up, sends a command to the lamp, receives an acknowledgment, and returns to sleep. In such a network the lamp node will be at least a Zigbee router, if not the Zigbee coordinator; the switch node is typically a Zigbee end

device. In beacon-enabled networks, Zigbee routers transmit periodic beacons to confirm their presence to other network nodes. Nodes may sleep between beacons, thus extending their battery life. Beacon intervals depend on data rate; they may range from 15.36 milliseconds to 251.65824 seconds at 250 kbit/s, from 24 milliseconds to 393.216 seconds at 40 kbit/s and from 48 milliseconds to 786.432 seconds at 20 kbit/s. Long beacon intervals require precise timing, which can be expensive to implement in low-cost products.

In general, the Zigbee protocols minimize the time the radio is on, so as to reduce power use. In beaconing networks, nodes only need to be active while a beacon is being transmitted. In non-beacon-enabled networks, power consumption is decidedly asymmetrical: Some devices are always active while others spend most of their time sleeping.

Except for Smart Energy Profile 2.0, Zigbee devices are required to conform to the IEEE 802.15.4-2003 Low-rate Wireless Personal Area Network (LR-WPAN) standard. The standard specifies the lower protocol layers—the physical layer (PHY), and the media access control portion of the data link layer. The basic channel access mode is carrier-sense multiple access with collision avoidance (CSMA/CA). That is, the nodes communicate in a way somewhat analogous to how humans converse: a node briefly checks to see that other nodes are not talking before it starts. CSMA/CA is not used in three notable exceptions:

- Message acknowledgments
- Beacons are sent on a fixed-timing schedule.
- Devices in beacon-enabled networks that have low-latency, real-time requirements may also use guaranteed time slots.

Network layer

The main functions of the network layer are to ensure correct use of the MAC sublayer and provide a suitable interface for use by the next upper layer, namely the application layer. The network layer deals with network functions such as connecting, disconnecting, and setting up networks. It can establish a network, allocate addresses, and add and remove devices. This layer makes use of star, mesh and tree topologies.

The data entity of the transport layer creates and manages protocol data units at the direction of the application layer and performs routing according to the current topology. The control entity handles the configuration of new devices and establishes new networks. It can determine whether a neighboring device belongs to the network and discovers new neighbors and routers.

The routing protocol used by the network layer is AODV. To find a destination device, AODV is used to broadcast a route request to all of its neighbors. The neighbors then broadcast the request to their neighbors and onward until the destination is reached. Once the destination is reached, a route reply is sent via unicast transmission following the lowest cost path back to the source. Once the source receives the reply, it updates its routing table with the destination address of the next hop in the path and the associated path cost.

Application layer

The application layer is the highest-level layer defined by the specification and is the effective interface of the Zigbee system to its end users. It comprises the majority of components added by the Zigbee specification: both ZDO (Zigbee device object) and its management procedures, together with application objects defined by the manufacturer, are considered part of this layer. This layer binds tables, sends messages between bound devices, manages group addresses, reassembles packets and also transports data. It is responsible for providing service to Zigbee device profiles.

Main components

The ZDO (Zigbee device object), a protocol in the Zigbee protocol stack, is responsible for overall device management, security keys, and policies. It is responsible for defining the role of a device as either coordinator or end device, as mentioned above, but also for the discovery of new devices on the network and the identification of their offered services. It may then go on to establish secure links with external devices and reply to binding requests accordingly.

The application support sublayer (APS) is the other main standard component of the stack, and as such it offers a well-defined interface and control services. It works as a bridge between the network layer and the other elements of the application layer: it keeps up-to-date binding tables in the form of a database, which can be used to find appropriate devices depending on the services that are needed and those the different devices offer. As

the union between both specified layers, it also routes messages across the layers of the protocol stack.

2.7 GENERAL OPERATION FRAMEWORK

The General Operation Framework (GOF) is a glue layer between applications and rest of the protocol stack. The GOF currently covers various elements that are common for all devices. It includes subaddressing and addressing modes and device descriptions, such as type of device, power source, sleep modes, and coordinators. Using an object model, the GOF specifies methods, events, and data formats that are used by application profiles to construct set/get commands and their responses. Actual application profiles are defined in the individual profiles of the IEEE's working groups. Each ZigBee device can support up to 30 different profiles. Currently, only one profile, Commercial and Residential Lighting, is defined. It includes switching and dimming load controllers, corresponding remote-control devices, and occupancy and light sensors.

The ZigBee stack is small in comparison to other wireless standards. For network-edge devices with limited capabilities, the stack requires about 4Kb of the memory. Full implementation of the protocol stack takes less than 32Kb of memory. The network coordinator may require extra RAM for a node devices database and for transaction and pairing tables. The 802.15.4 standard defines 26 primitives for the PHY and MAC layers; probably another dozen will be added after finalizing the NWK layer specification. Those numbers are still modest compared to 131 primitives defined for Bluetooth. Such a compact footprint enables you to run Zigbee on a simple 8-bit microcontroller such as an HC08- or 8051-based processor core.

A typical ZigBee-enabled device includes a radio frequency integrated circuit (RF IC) with a partially implemented PHY layer connected to a low-power, low-voltage 8-bit microcontroller with peripherals, connected to an application sensor or actuators. The protocol stack and application firmware reside in on-chip flash memory. The entire ZigBee device can be compact and cost efficient. The focus of network applications under the ZigBee standard include the features of low power consumption, needed for only two major modes (Tx/Rx or Sleep), high density of nodes per network, low costs and simple implementation.

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Transmission Range : ZigBee relies on the basic 802.15.4 standard to establish radio performance. As a short-range wireless standard, 802.15.4 doesn't try to compete with high-powered transmitters but instead excels in the ultra-long battery life and low transmitter power. The standard specifies transmitter output power at a nominal 3 dBm (0.5 mW), with the upper limit controlled by the regulatory agencies of the region in which the sensor is used. At 3 dBm output, single-hop ranges of 10 to more than 100 m are reasonable, depending on the environment, antenna, and operating frequency band.

Data Rate : When the sensor is transmitting only a few bits or bytes, the system can be more efficient if it transmits and receives the data quickly. For any given quantity of data, transmitting at a higher data rate allows the system to shut down the transmitter and receiver more quickly, saving significant power. Data Latency: Sensor systems have a broad range of data-latency requirements. If sensor data are needed within tens of milliseconds, as opposed to dozens of seconds, the requirement places different demands on the type and extent of the intervening network. For many sensor applications, data latency is less critical than battery life or data reliability. For simple star networks (many clients, one network coordinator), ZigBee can provide latencies as low as ~16 ms in a beacon-centric network, using guaranteed time slots to prevent interference from other sensors. You can further reduce latencies to several milliseconds and it has risk potential interference from accidental data collision with other sensors on the network. If you relax data-latency requirements, you can assume that the battery life of the client nodes will increase. This is even truer of network hubs, which are required to coordinate and supervise the network.

Size : As silicon processes and radio technology progress, transceiver systems shrink in physical size. A transceiver might easily fit inside a thimble. In the case of ZigBee systems, the radio transceiver has become a single piece of silicon, with a few passive components and a relatively noncritical board design. Microcontrollers that have native

ability to interface with sensors have eclipsed even the radios rapid reduction in size. Today, the 8-bit MCU that hosts the application may already include dozens of kilobytes of flash memory, RAM, and various hardware-based timer functions, along with the ability to interface directly to the radio transceiver IC. The MCU requires only a few external passive components to be fully functional.

Data Security : It's important to provide your sensor network with adequate security. IEEE 802.15.4 provides authentication, encryption, and integrity services for wireless systems that allow systems developers to apply security levels as required. These include no security, access control lists, and 32-bit to 128-bit AES encryption with authentication. This security suite lets the developer pick and choose the security necessary for the application, providing a manageable tradeoff against data volume, battery life, and system processing power requirements. The IEEE 802.15.4 standard doesn't provide a mechanism for moving security keys around a network; this is where ZigBee comes in. The ZigBee security toolbox consists of key management features that let you safely manage a network remotely. For those systems where data security is not critical (e.g., a set of sensors monitoring microclimates in a forest), you may decide not to implement security features but instead optimize battery life and reduce system cost. For the developer of an industrial or military perimeter security sensor system, data security and more importantly the ability to defend against sensor masking or spoofing may have the higher priority. In many ZigBeeapproved applications, security will already be a seamless part of the overall system.

2.8 IEEE 802.15.4 AND ZIGBEE

There are many standards for short-range wireless technologies, but this variety often perplexes designers who want to select a standard for an application. The popular IEEE 802.15.4 standard and its relative ZigBee often are confused. They aren't the same thing.

Short-Range Wireless Choices

A designer of wireless applications has multiple choices of standards and protocols ranging from the simple to the amazingly complex. The most familiar choices are Bluetooth and Wi-Fi. Bluetooth has found a niche in the audio space with billions of cell-phone headset connections, automotive hands-free connections, and wireless speakers. Its newer low-energy versions are finding many applications in the medical and sports/fitness world to monitor an individual's physical status.

Wi-Fi is the premier local-area network (LAN) technology for high-speed Internet access for laptops, smart phones, and tablets. New faster versions are used in smart TV sets for video transfer. In a stripped down form, it can also be used in data acquisition applications. Low-power versions are now available. Many versions and supplement use the 2.4-, 5-, and 60-GHz industrial, scientific, and medical (ISM) bands.

The proprietary Z-Wave standard has found a niche in the home monitoring and control market. There are other proprietary standards for specific applications, such as WirelessHD for 60-GHz video transfer. Many of these proprietary variations use the ISM bands below 1 GHz, including garage door openers at 315 MHz, remote temperature monitors at 433 MHz, and data acquisition at 915 MHz. A growing category is cellular connectivity for machine-to-machine (M2M) and Internet of Things (IoT) applications.

Most of the rest of the standards use some variation of the 802.15.4 standard.

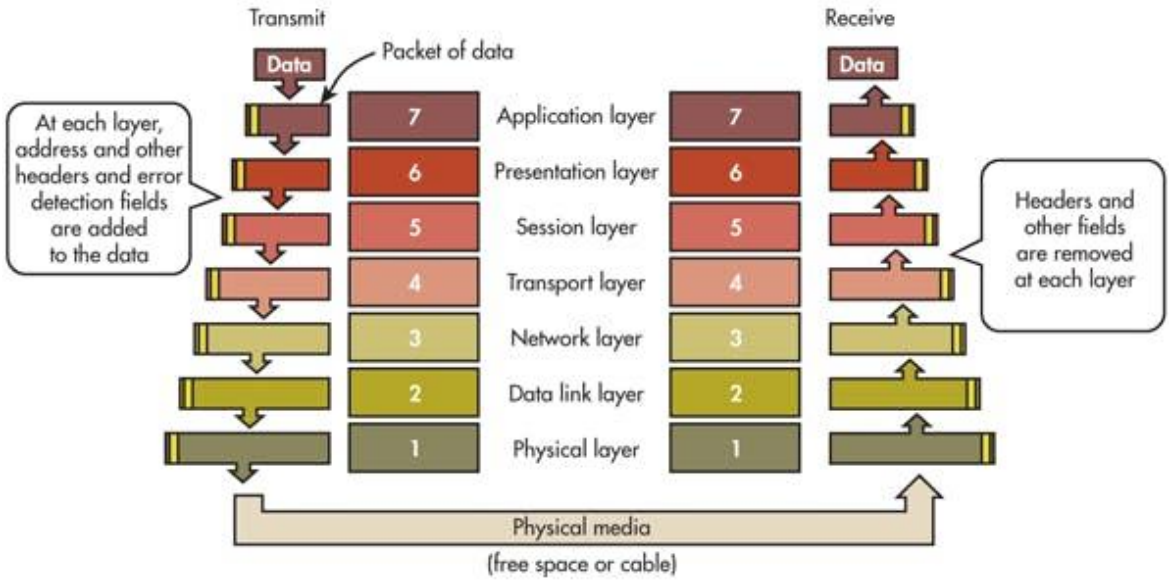
IEEE 802.15.4

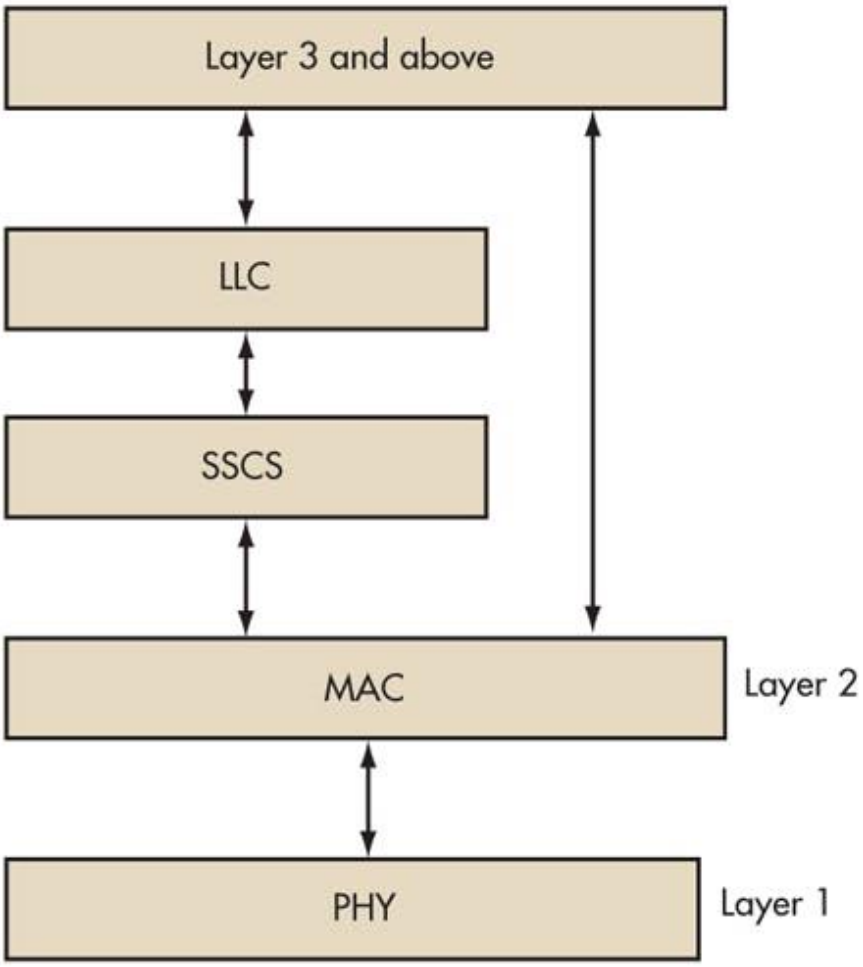
The Institute of Electrical and Electronics Engineers (IEEE) supports many working groups to develop and maintain wireless and wired communications standards. For example, 802.3 is wired Ethernet and 802.11 is for wireless LANs (WLANs), also known as Wi-Fi. The 802.15 group of standards specifies a variety of wireless personal area

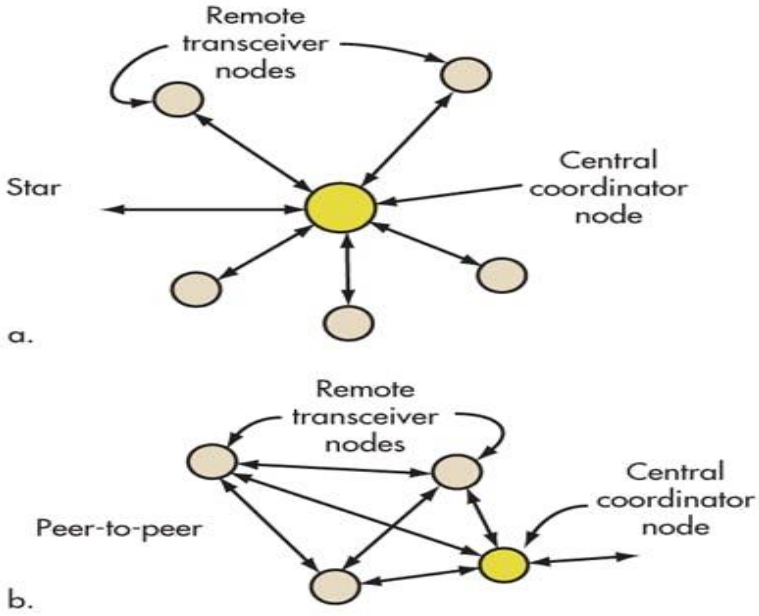
networks (WPANs) for different applications. For instance, 802.15.1 is Bluetooth, 802.15.3 is a high-data-rate category for ultra-wideband (UWB) technologies, and 802.15.6 is for body area networks (BAN). There are several others.

The 802.15.4 category is probably the largest standard for low-data-rate WPANs. It has many subcategories. The 802.15.4 category was developed for low-data-rate monitor and control applications and extended-life low-power-consumption uses. The basic standard with the most recent updates and enhancements is 802.15.4a/b, with 802.15.4c for China, 802.15.4d for Japan, 802.15.4e for industrial applications, 802.15.4f for active (battery powered) radio-frequency identification (RFID) uses, and 802.15.4g for smart utility networks (SUNs) for monitoring the Smart Grid. All of these special versions use the same base radio technology and protocol as defined in 802.15.4a/b.

The 802.15.4 standard defines the physical layer (PHY) and media access control (MAC) layer of the Open Systems Interconnection (OSI) model of network operation *(Fig. 1)*. The PHY defines frequency, power, modulation, and other wireless conditions of the link. The MAC defines the format of the data handling. The remaining layers define other measures for handing the data and related protocol enhancements including the final application.




Layer 3 and above
LLC
SSCS
MAC
Layer 2
PHY
Layer 1


Remote transceiver nodes
Star
Central coordinator node
a.
Remote transceiver nodes
Central coordinator node
Peer-to-peer
b.

The goal of the standard is to provide a base format to which other protocols and features could be added by way of the upper layers (layers 3 through 7). While three frequency assignments are available, the 2.4-GHz band is by far the most widely used Most available chips and modules use this popular ISM band. The standard uses direct sequence spread spectrum (DSSS) modulation. It is highly tolerant of noise and interference and offers coding gain to improve link reliability. Standard binary phase-shift keying (BPSK) is used in the two low-speed versions, while offset-quadrature phase-shift keying (O-QPSK) is used for the higher-data-rate version. O-QPSK has a constant wave envelope meaning that more efficient non-linear power amplification techniques can be used to minimize power consumption.

With regard to channel access, 802.15.4 uses carrier sense multiple access with collision avoidance (CSMA-CA). This multiplexing approach lets multiple users or nodes access the same channel at different times without interference. Most transmissions are short packets that occur infrequently for a very low duty cycle (<1 %), minimizing power consumption. The minimum power level defined is –3 dBm or 0.5 mW. Most modules use 0 dBm or 1 mW. However, some 20-dBm or 100-mW modules are available.

Transmission range varies considerably depending on the nature of the path that must for the most part be line of sight (LOS). Transmit power level and receiver sensitivity are also factors. Under the best conditions the range can be as great as 1000 meters with a clear outdoor path. Most applications cover a shorter range of 10 to 75 meters.

With regard to networking capability, 802.15.4 defines two topologies. One of them is a basic star All communications between nodes must pass through the central coordinator node. A basic peer-to-peer (P2P) topology is also defined Any device may then talk to any other device. This basic topology may be expanded into other topologies in the upper network layers, such as the popular mesh topology.

ZigBee

The most widely deployed enhancement to the 802.15.4 standard is ZigBee, which is a standard of the ZigBee Alliance. The organization maintains, supports, and develops more sophisticated protocols for advanced applications. It uses layers 3 and 4 to define additional communications features These enhancements include authentication with

valid nodes, encryption for security, and a data routing and forwarding capability that enables mesh networking. The most popular use of ZigBee is wireless sensor networks using the mesh topology.

The main benefit of the mesh topology is that any node can communicate with any other node, if not directly if within range, but indirectly by relaying the transmission through multiple additional nodes . The network then can spread out over a larger area. Furthermore, it increases network reliability as it still functions even if one node is disabled. There are usually alternate paths through the network to sustain a connection. For example, if node A wishes to communicate with node G, it can relay data through nodes C and E. If node C fails, another path is via nodes B, D, and F. ZigBee mesh networks are self-configuring and self-healing.

ZigBee is also available in a version that supports energy harvesting where no battery or ac mains power is available. And, one of the key benefits of ZigBee is the availability of pre-developed applications.

2.9 APPLICATIONS

ZigBee networks consist of multiple traffic types with their own unique characteristics, including periodic data, intermittent data, and repetitive low latency data. The characteristics of each are as follows: • Periodic data – usually defined by the application such as a wireless sensor or meter. Data typically is handled using a beaconing system whereby the sensor wakes up at a set time and checks for the beacon, exchanges data, and goes to sleep. • Intermittent data – either application or external stimulus defined such as a wireless light switch. Data can be handled in a beaconless system or disconnected. In disconnected operation, the device will only attach to the network when communications is required, saving significant energy. • Repetitive low latency data – uses time slot allocations such as a security system. These applications may use the guaranteed time slot (GTS) capability. GTS is a method of QoS that allows each device a specific duration of time as defined by the PAN coordinator in the Superframe to do whatever it requires without contention or latency.

Industrial Purposes : In industrial sector, ZigBee technology helps improve Automated Meter Reading (AMR) for utility and energy management, logistics and inventory

tracking, and security and access control. Other systems can be tracked for preventive maintenance & performance monitoring. Seismic detectors, inclinometers, robotics and security systems are just a few examples. Fingerprint Keypad Lock : If you're like most people, you're probably frustrated when fumbling with multiple keys late at night, or when you're juggling grocery bags. The Fingerprint Keypad Lock combines a conventional cylinder lockset with state-of-the-art fingerprint-reading circuitry and a digital keypad. You'll be able to keep your keys in your pocket and open the door by simply pressing the sensor with your registered fingerprint, or you can key in your PIN on the keypad. Electronic access is also great for housekeepers and guests anyone you'd rather not have a key.With a single latch mortise, installation of this fingerprint door lock is both simple and quick. This Lock can store upto 120 different fingerprints to allow access for family members, cleaning staff, friends, and more. A super integrated circuit chip easily allows a full-function program of enrolling and erasing fingerprints

Butterfly Indoor Flyer : The Butterfly Indoor Flyer is the smallest and lightest ready-to-fly RC airplane available. At 3.6 grams, this delicate plane is small and light enough to maneuver around your living room. The included four-channel transmitter provides precise control for tight turns and slow flying. Your airspace needs only to be 12 feet by 16 feet. This tiny remote-control plane is powered by the included lithium-polymer battery. The receiver is powered by four AA batteries (sold separately). The Butterfly Indoor Flyer remotecontrol airplane has a beautifully constructed delicate airframe along with a carbon-fiber propeller, a Swiss-engineered gearbox, and a tiny 4mm coreless motor. Control the RC airplane with the transmitter's two joysticks. The transmitter also includes a built-in portable charger for the remote-control plane's lithium polymer battery.

Motion and Heat-sensing solar Floodlight : Want to install a motion- and heat-sensing solar floodlight without having to hire an electrician to wire it? Install this solar powered security light anywhere around your home without wiring hassles or expensive battery replacement! This maintenance-free security light uses solar energy to power the long lasting, bright, energy-efficient halogen bulb, so you won't be left in the dark. Install a Solar Floodlight with Heat & Motion Sensor near each of your entryways and you can be sure that your family can enter and exit your home safely, www.jntuworld.com even when there's a power outage. The Solar Floodlight is powered by a rechargeable lead acid battery, which is included. Don't worry about cloudy skies, because the Solar Floodlight

works for approximately 2 weeks without ANY sunlight (at an average of eight 30- second light intervals each night)! A built-in motion and heat sensor turns the light on for people, but not for swaying tree branches. You can adjust the sensitivity of the sensor to pick up a full 90° horizontally, at a distance of up to 30 feet. Set the darkness level to keep the light from coming on too early in the evening or too late at night. Choose either a 30- or 60-second duration for the light to remain on after the last motion detected. A 14-foot cable between the solar panel and the light lets you place the security light where you need it, while allowing the solar panel to be installed facing the sun

Wireless Personal Area Networking (WPAN) : Whereas RFID is a method of remotely storing and retrieving data using RFID tags and readers, Zigbee goes much further. It is a full- blown telemetry system in its own right, with the ability to provide wireless personal area networking (WPAN) i.e. digital radio connections between computers and related devices, such as sensors. This kind of network eliminates the use of physical data buses such as USB and Ethernet cables. As such, Zigbee it is the ideal system to provide the copper-less warehouse or factory. When used in a tracking application, Zigbee does not require the read portals or the associated management software Zigbee builds on the global communication protocol standards developed by the 802.15 Working Group. The fourth in the series of these protocols, WPAN Low rate Zigbee is designed primarily for telemetry applications.However, its strength is that it can be incorporated into small chips that consume little power and are relatively inexpensive. These chips can then be integrated into low-cost, low -power devices that can "sleep" for 99% of the time until awakened by a beacon signal. The technology provides high reliability, selfhealing, self-joining networks, with network protocol security encryption, and is designed to operate in electrically noisy industrial environments.

in wind turbines : One of the first uses planned by IDC for Zigbee is in the area of offshore safety; in particular, offshore manpower tracking in wind turbines. Tracking is required in these structures for a number of reasons.First, because the weather often turns bad very quickly, and there is a need to get people back on shore within 60 minutes. Second, there is the safety issue of personnel working in isolation, remotely. Third, security and access restrictions apply to the turbines. Fourth, management need to know who is working where, and how efficiently. Fifth, access to maintenance logs is restricted. Finally, details of personnel medical records can be held on the Zigbee chip, for fast

retrieval of personnel medical details in the event of an accident. The building blocks of this system using ZigBee technology start with a simple configuration employing a single wireless sensor in each turbine to log when a person enters and leaves. Complementing this will be basic central software for real time tracking and logging. ZigBee for Business Building control and automation, wireless lighting, security and access control and asset and inventory management are ideal applications for ZigBee technology in commercial systems. Wireless inventory management is becoming especially important with the advent of asset tags that track everything from individual equipment and products to pallets in a warehouse. A ZigBee wireless system can bring a new level of control to security systems that connect components such as motion-control sensors, cameras and employee badges.

EmbedSenseTM

MicroStrain, Inc. announces the availability of the miniature EmbedSense™ wireless sensor. EmbedSense™ is a tiny wireless sensor and data acquisition system that is small enough to be embedded in a product, enabling the creation of smart structures, smart materials and smart machines EmbedSense™ nodes can be placed within implants, on spinning machinery and within composite materials. Because they can tolerate extreme G levels and high temperatures, sensor measurements can be made in applications where previously no data could be obtained. Batteries are completely eliminated which means that the embedded sensors and EmbedSense™ node can be queried for the life of the structure. EmbedSense™ uses an inductive link to receive power from an external coil and to return digital strain, temperature and unique ID information. Applications range from monitoring the healing of the spine, to testing strains and temperatures on jet turbine engines. . EmbedSense™ tags can read data from multiple types of sensors, including semiconductor temperature sensors, thermocouples, strain gauges, pressure sensors, and load cells.

• Building automation for commercial monitoring and control of facilities

• Remote control (RF4CE or RF for consumer electronics)

• Smart energy for home energy monitoring

• Health care for medical and fitness monitoring

• Home automation for control of smart homes

• Input devices for keyboards, mice, touch pads, wands, etc.

• Light Link for control of LED lighting

• Retail services for shopping related uses

• Telecom services

• Network services related to large mesh networks

Industrial Automation:

In manufacturing and production industries, a communication link continually monitors various parameters and critical equipment. Hence Zigbee considerably reduces this communication cost as well as optimizes the control process for greater reliability.

Home Automation:

Zigbee is perfectly suited for controlling home appliances remotely as a lighting system control, appliance control, heating, and cooling system control, safety equipment operations and control, surveillance, and so on.

Smart Metering:

Zigbee remote operations in smart metering include energy consumption response, pricing support, security over power theft, etc.

Smart Grid monitoring

: Zigbee operations in this smart grid involve remote temperature monitoring, fault locating, reactive power management, and so on.

ZigBee technology is used to build engineering projects like wireless fingerprint attendance system and home automation.

This is all about a brief description of Zigbee technology's architecture, operations modes, configurations, and applications. We hope that we have given you enough content on this title, for you to understand it better. Thus, this is all about an overview of Zigbee technology and it is based on IEEE 802.15.4 network. The designing of this technology can be done extremely strong so it operates in all kinds of environments.

It provides flexibility as well as security for different environments. Zigbee technology has gained so much popularity in the market because it provides consistent mesh networking by enabling a network to control over an extensive region, and also it provides low-power communications. So this is a perfect IoT technology.

2.10 ADVANTAGES OF ZIGBEE TECHNOLOGY

- This network has a flexible network structure
- Battery life is good.
- Power consumption is less
- Very simple to fix.
- It supports approximately 6500 nodes.
- Less cost.
- It is self-healing as well as more reliable.
- Network setting is very easy as well as simple.
- Loads are evenly distributed across the network because it doesn't include a central controller
- Home appliances monitoring as well controlling is extremely simple using remote
- The network is scalable and it is easy to add/remote ZigBee end device to the network.

2.11 DISADVANTAGES OF ZIGBEE TECHNOLOGY

- It needs the system information to control Zigbee based devices for the owner.
- As compared with WiFi, it is not secure.
- The high replacement cost once any issue happens within Zigbee based home appliances
- The transmission rate of the Zigbee is less
- It does not include several end devices.
- It is so highly risky to be used for official private information.
- It is not used as an outdoor wireless communication system because it has less coverage limit.
- Similar to other types of wireless systems, this ZigBee communication system is prone to bother from unauthorized people.

3. CONCLUSION

The advantage of ZigBee technology promotes theapplication of wireless communication network inintelligent community which makes it become the mainmodel of replacing integrated wiring communityintelligent network. Aiming at ZigBee's characteristic andwith combination of architectural market, the system doesthe reformation and innovation of intelligent architectureof intelligent community. It is believed that by virtue of itsmain technological advantage, wireless network usingZigBee technology will become the main networkingform of intelligent community

We know that Zigbee is one kind of communication technology similar to Bluetooth as well as WiFi, however, there are also numerous new rising networking alternatives like Thread which is an option for the applications of home automation. In major cities, the Whitespace technologies were implemented for IoT-based wider region use cases.

ZigBee is a low-power WLAN (wireless local area network) specification. It provides fewer data using less power by frequently connected devices to turn off a battery. Due to this, the open standard has been connected through M2M (machine-to-machine) communication as well as the industrial IoT (internet of things).

Zigbee has become an IoT protocol that is accepted globally. It is already competing with Bluetooth, WiFi, and Thread.

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