VISHVESHWARAIAH TECHNOLOGICAL UNIVERSITY
BELGAUM-10

S.D.M COLLEGE OF ENGINEERING AND TECHNOLOGY
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A seminar report on
"ZIGBEE WIRELESS SYSTEM "

Submitted by

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CERTIFICATE

Certified that the seminar work entitled "ZIGBEE WIRELESS SYSTEM" is a bonafide work presented by MAHANTESH.B.BIKKANNAVAR bearing USN NO:2SD05CS033 in a partial fulfillment for the award of degree of Bachelor of Engineering in COMPUTER SCIENCE of the Vishveshwaraiah Technological University, Belgaum during the year 2009-10. The seminar report has been approved as it satisfies the academic requirements with respect to seminar work presented for the Bachelor of Engineering Degree.

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1. INTRODUCTION

●ZigBee is a wireless network protocol specifically designed for low data rate sensors and control networks.

●There are a number of applications that can benefit from the ZigBee protocol: building automation networks, home security systems, industrial control networks, remote metering and PC peripherals are some of the many possible applications.

●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.

●ZigBee is expected to provide low cost and low power connectivity for equipment that needs battery life as long as several months to several years but does not require data transfer rates as high as those enabled by Bluetooth. In addition, ZigBee can be implemented in mesh networks larger than is possible with Bluetooth.

2. FEATURES

●The Microchip Stack for the ZigBee protocol is designed to evolve with the ZigBee wireless protocol specification.

●At the time this document was published, the current ZigBee protocol specification version was v1.0. This document applies to Microchip Stack releases v1.0-3.5 and greater.

The Microchip Stack offers the following features:

• Based on version 1.0 of the ZigBee protocol specifications

• Support for 2.4 GHz frequency band

• Support for all ZigBee protocol device types (Coordinators, Routers and End devices)
• Implements nonvolatile storage for neighbor and binding tables

• RTOS and application independent

• Out-of-box support for Microchip MPLAB® C18 compiler

• Modular design and standard nomenclature aligns with the nomenclature used in the ZigBee protocol and IEEE 802.15.4 specifications.

3. ZIGBEE PROTOCOL OVERVIEW

●ZigBee is a standard wireless network protocol designed for low data rate control networks.

● It is layered on top of the IEEE 802.15.4 specification and provides a standard methodology for functions, including network formation, messaging and device discovery.

NETWORK CONFIGURATIONS

●A ZigBee protocol wireless network may assume many types of configurations. In all network configurations, there are at least two main components:

• Coordinator node
• End device

●The ZigBee protocol coordinator is a special variant of a Full Function Device (FFD) that implements a larger set of ZigBee protocol services. An end device may be an FFD or a Reduced Function Device (RFD).

●An RFD is the smallest and simplest ZigBee protocol node. It implements only a minimal set of ZigBee protocol services.

● A third and optional component, the ZigBee protocol router, is present in some network configurations.

Star Network Configuration

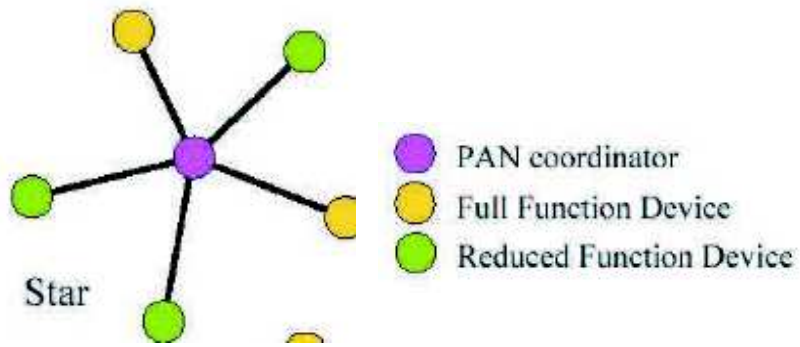
●In the star topology, the communication is established between devices and a single central controller ,called the PAN coordinator.

●The PAN coordinator may be mains powered while the devices will most likely be battery powered. Applications that benefit from this topology include home automation, personal computer (PC) peripherals, toys and games.

●After an FFD is activated for the first time, it may establish its own network and become the PAN coordinator.

●Each start network chooses a PAN identifier, which is not currently used by any other network within the radio sphere of influence.

●This allows each star network to operateindependently.



Cluster Tree Topology

●Cluster-tree network is a special case of a peer-to-peer network in which most devices are FFDs and an RFD may connect to a cluster-tree network as a leave node at the end of a branch.

●. Any of the FFD can act as a coordinator and provide synchronization services to other devices and coordinators.

●Only one of these coordinators however is the PAN coordinator.

●The PAN coordinator forms the first cluster by establishing itself as the cluster head (CLH) with a cluster identifier (CID) of zero, choosing an unused PAN identifier, and broadcasting beacon frames to neighboring devices.

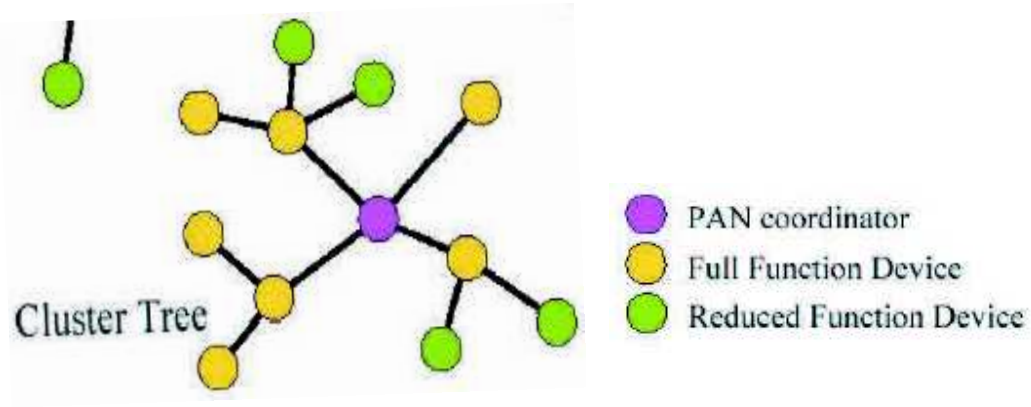
●A candidate device receiving a beacon frame may request to join the network at the CLH. If the PAN coordinator permits the device to join, it will add this new device as a child device in its neighbor list.

●The newly joined device will add the CLH as its parent in its neighbor list and begin transmitting periodic beacons such that other candidate devices may then join the network at that device.

●Once application or network requirements are met, the PAN coordinator may instruct a device to become the CLH of a new cluster adjacent to the first one.

● The advantage of this clustered structure is the increased coverage area at the cost of increased message latency.

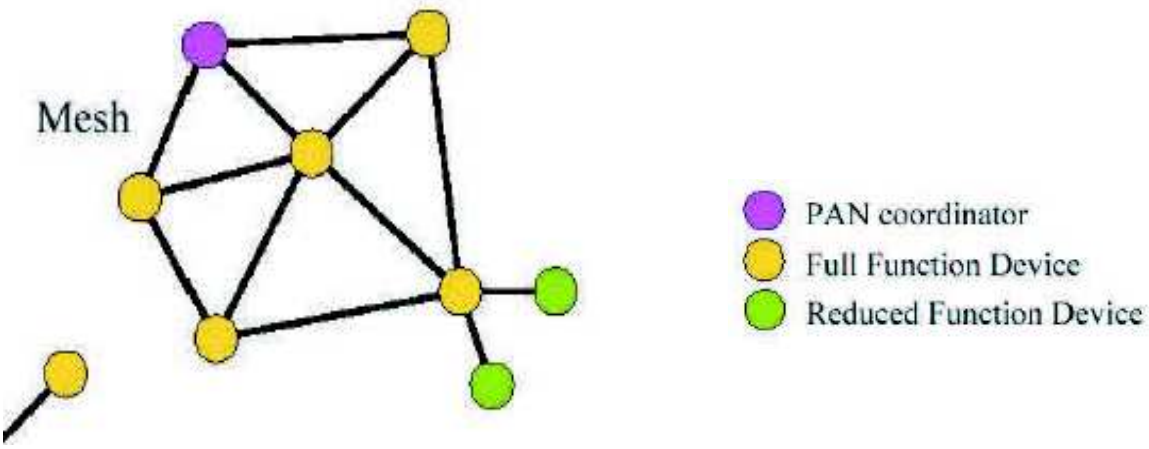
●The other is to extend the physical range of the network. With the addition of a router, an end device need not be in radio range of the coordinator. All messages in a cluster tree topology are routed along the tree.



Mesh Network

●A mesh network is similar to a cluster tree configuration, except that FFDs can route messages directly to other FFDs instead of following the tree structure.

●Messages to RFDs must still go through the RFD's parent. The advantages of this topology are that message latency can be reduced and reliability is increased.



●The cluster tree and mesh topologies are also known as multi-hop networks, due to their abilities to route packets through multiple devices, while the star topology is a single-hop network.

●A ZigBee protocol network is a multi-access network, meaning that all nodes in a network have equal access to the medium of communication.

●There are two types of multi-access mechanisms,beacon and non-beacon. In a non-beacon enabled network, all nodes in a network are allowed to transmit at any time as long as the channel is Idle.

● In a beacon enabled network, nodes are allowed to transmit in predefined time slots only.

●The coordinator periodically begins with a superframe identified as a beacon frame, and all nodes in the network are expected to synchronize to this frame.

●A superframe may also contain a common slot during which all nodes compete to access the channel.

●The current version of the Microchip Stack supports only non-beacon networks.

4. DEVICE TYPES

IEEE 802.15.4 defines two types of devices. These devices types are shown in Table 1. Listed in Table 2 are the three types of ZigBee protocol devices as they relate to the IEEE device

types

TABLE 1: IEEE 802.15.4 DEVICE TYPES

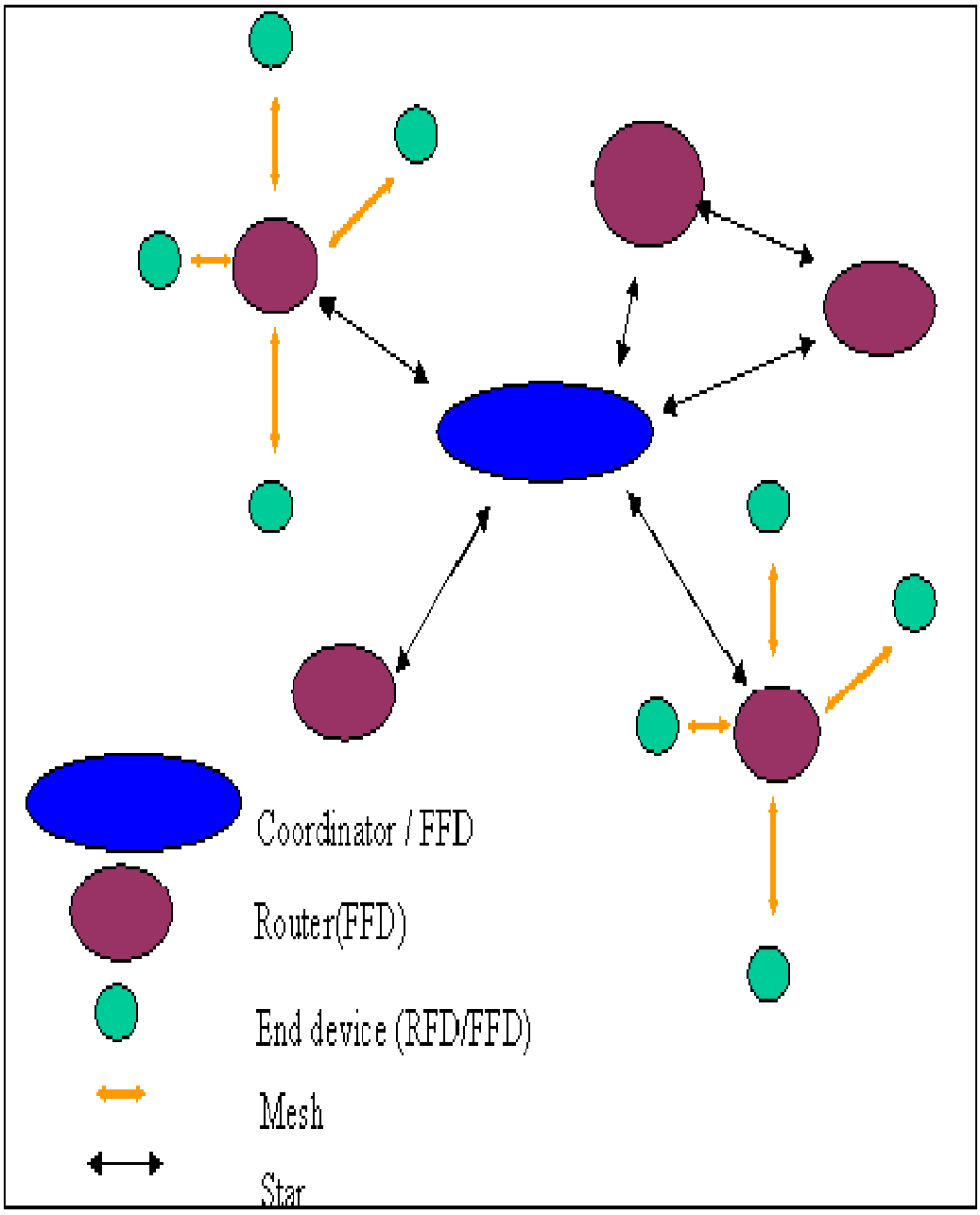
Device Type	Services Offered	Typical Power Source	Typical Receiver Configuration
Full Function Device (FFD)	Most or all	Mains	On when Idle
Reduced Function Device (RFD)	Limited	Battery	Off when Idle

TABLE 2: ZigBee™ PROTOCOL DEVICE TYPES

ZigBee Protocol Device	IEEE Device Type	Typical Function
Coordinator	FFD	One per network. Forms the network, allocates network addresses, holds binding table.
Router	FFD	Optional. Extends the physical range of the network. Allows more nodes to join the network. May also perform monitoring and/or control functions.
End	FFD or RFD	Performs monitoring and/or control functions.

These devices have 64-bit IEEE addresses, with option to enable shorter addresses to reduce packet size, and work in either of two addressing modes – star and peer-to-peer.

1. The ZigBee coordinator node : There is one, and only one, ZigBee coordinator in each network to act as the router to other networks, and can be likened to the root of a (network) tree. It is designed to store information about the network.
2. The full function device FFD : The FFD is an intermediary router transmitting data from other devices. It needs lesser memory than the ZigBee coordinator node, and entails lesser manufacturing costs. It can operate in all topologies and can act as a coordinator.
3. The reduced function device RFD : This device is just capable of talking in the network; it cannot relay data from other devices. Requiring even less memory, (no flash, very little ROM and RAM), an RFD will thus be cheaper than an FFD. This device talks only to a network coordinator and can be implemented very simply in star topology.


Coordinator / FFD
Router(FFD)
End device (RFD/FFD)
Mesh
Star

5. TRAFFIC TYPES

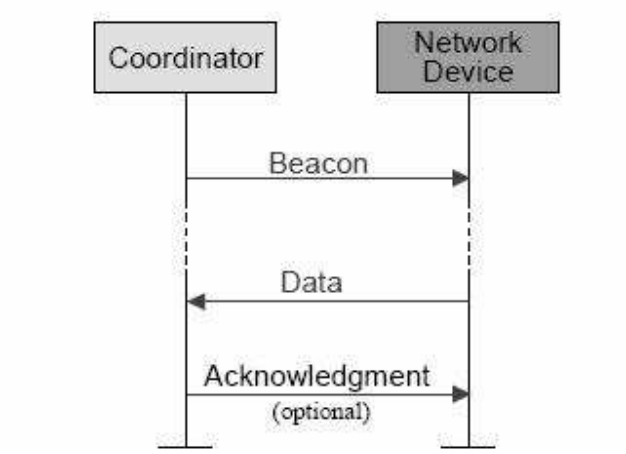
Beacon Generation

●Depending on the parameters of the MLME-START.request primitive, the FFD may either operate in a beaconless mode or may begin beacon transmissions either as the PAN coordinator or as a device on a previously established PAN.

●An FFD that is not the PAN coordinator shall begin transmitting beacon frames only when it has successfully associated with a PAN.

●This primitive also includes *macBeaconOrder* and *macSuperFrameOrder* parameters that determine the duration of the beacon interval and the duration of the active and inactive portions.

●The time of the transmission of the most recent beacon shall be recorded in *macBeaconTxTime* and shall be computed so that its value is taken at the same symbol boundary in each beacon frame, the location of which is implementation specific.



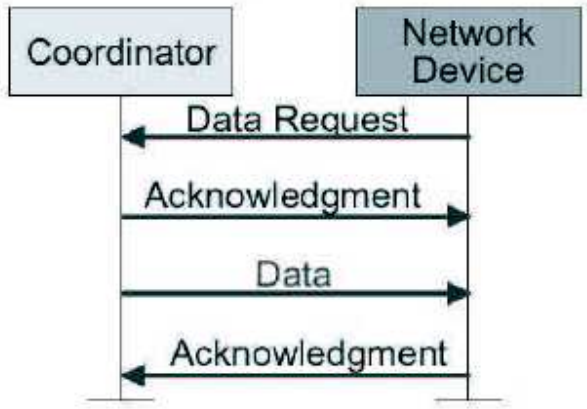
Non Beacon Generation

●An unassociated device shall initiate the association procedure by sending an associate request command to the coordinator of an existing PAN.

●If the association request command is received correctly, the coordinator shall send an acknowledgement. This acknowledgement however does not mean that the device has associated.

● The coordinator needs time to determine whether the current sources available on a PAN are sufficient to allow another device to associate.

●This decision should be made within *aResponseWaitTime* symbols. If already associated, remove all information. If sufficient resources are available, the coordinator shall allocate a short address to the device and generate an association response command containing the new address and a status indicating the successful association.



●If there are not enough resources, the coordinator shall generate an association response command containing a status indicating failure.

.● This response is sent to the device using indirect transmission (pending, request,...).
On the other side, the device, after getting the acknowledgement frame, waits for the response for *aResponseWaitTime* symbols.

●It either checks the beacons in the beacon-enabled network orextract the association response command from the coordinator after *aResponseWaitTime* symbols.

●On reception of association response command, the device shall send an Acknowledgement.

●If the association is successful, store the addressed of the coordinator with which it has associated.

●The association procedure is shown in Figure on the coordinator side and in Figure on the device side.

●When a coordinator wants one of its associated devices to leave the PAN, it shall send the disassociation notification command to the device using indirect transmission. Upon reception of the packet, the device should send the acknowledgement frame.

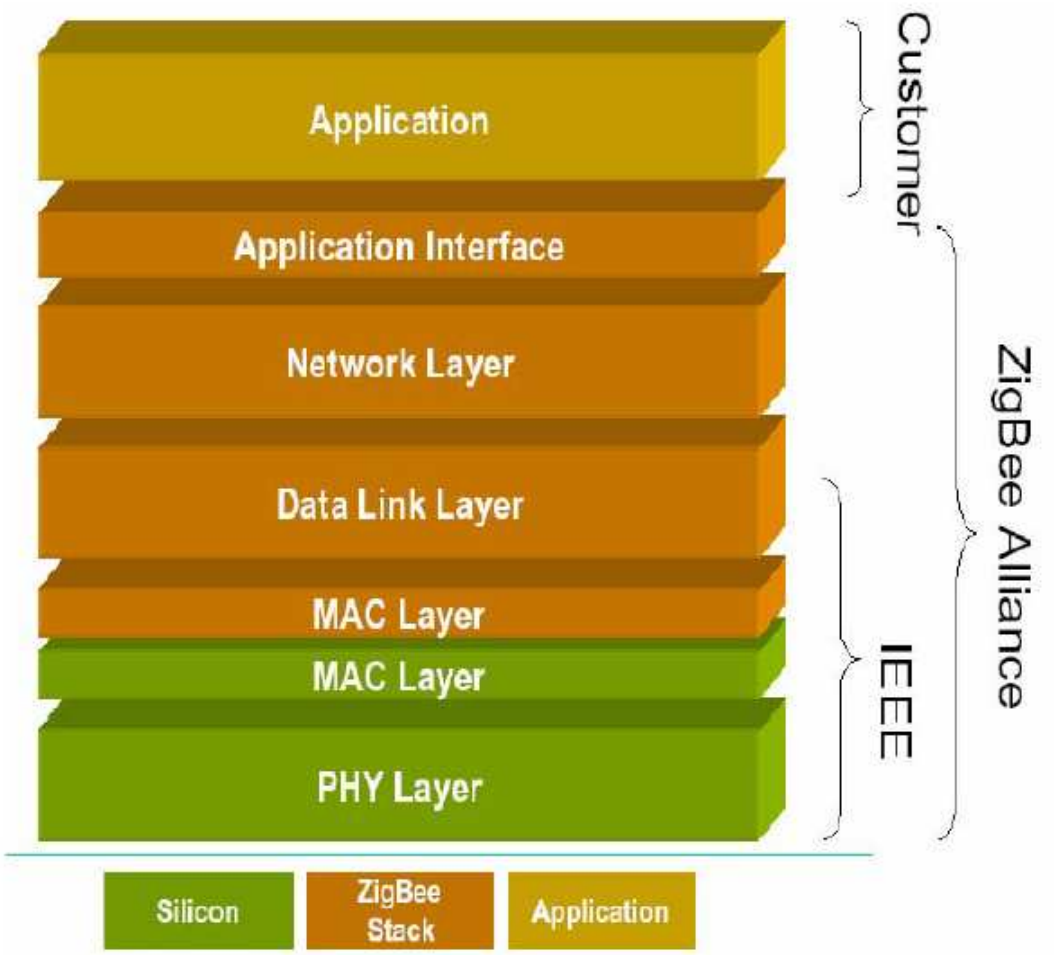
●Even if the ack is not received, the coordinator shall consider the device disassociated.If an associated device wants to leave the PAN, it shall send a disassociation notification command to the coordinator.

●Upon reception, the coordinator sends ack. Even if the ack is not received, the device shall consider itself disassociated.

●An associated device shall disassociate itself by removing all references to the PAN. A coordinator shall disassociate a device by removing all references to that device.

6. NETWORK MODEL

The ZigBee Standard has evolved standardized sets of solutions, called ‘layers'. These layers facilitate the features that make ZigBee very attractive: low cost, easy implementation, reliable data transfer, short-range operations, very low power consumption and adequate security features.



1.Network and Application Support layer :

The network layer permits growth of network sans high power transmitters. This layer can handle huge numbers of nodes. This level in the ZigBee architecture includes the ZigBee Device Object (ZDO), user-defined application profile(s) and the Application Support (APS) sub-layer.
The APS sub-layer's responsibilities include maintenance of tables that enable matching between two devices and communication among them, and also discovery, the aspect that identifies other devices that operate in the operating space of any device.
The responsibility of determining the nature of the device (Coordinator / FFD or RFD) in the network, commencing and replying to binding requests and ensuring a secure relationship between devices rests with the ZDO (Zigbee Define Object). The user-defined application refers to the end device that conforms to the ZigBee Standard.

2. Physical (PHY) layer :

The IEEE802.15.4 PHY physical layer accommodates high levels of integration by using direct sequence to permit simplicity in the analog circuitry and enable cheaper implementations.

3. Media access control (MAC) layer :

The IEEE802.15.4 MAC media access control layer permits use of several topologies without introducing complexity and is meant to work with large numbers of devices.

7. TECHNOLOGY COMPARISONS

Blue Tooth v/s Zigbee

●The “Why ZigBee” question has always had an implied, but never quite worded follower phrase “…when there is Bluetooth”. A comparative study of the two can be found in ZigBee: 'Wireless Control That Simply Works' .

●The bandwidth of Bluetooth is 1 Mbps, ZigBee's is one-fourth of this value. The strength of Bluetooth lies in its ability to allow interoperability and replacement of cables, ZigBee's, of course, is low costs and long battery life.

●In terms of protocol stack size, ZigBee's 32 KB is about one-third of the stack size necessary in other wireless technologies (for limited capability end devices, the stack size is as low as 4 KB).

●Most important in any meaningful comparison are the diverse application areas of all the different wireless technologies. Bluetooth is meant for such target areas as wireless USB's, handsets and headsets, whereas ZigBee is meant to cater to the sensors and remote controls market and other battery operated products. In a gist, it may be said that they are neither complementary standards nor competitors, but just essential standards for different targeted applications. The earlier Bluetooth targets interfaces between PDA and other device (mobile phone / printer etc) and cordless audio applications.

●The IEEE 802.15.4–based ZigBee is designed for remote controls and sensors, which are very many in number, but need only small data packets and, mainly, extremely low power consumption for (long) life. Therefore they are naturally different in their approach to their respective application arenas.

8. APPLICATIONS

Applications Areas

Zigbee protocol has been developed with the emphases on low cost battery powered application such as consumer electronics, industrial automation, home and building automation, PC peripherals, medical sensor applications, toys and games.

Some of the major applications include:
• **Remote sensing:** Water/sewage level monitoring, Temperature sensing.
• **Industrial and commercial** : Monitor, control and automation links
• **Building automation** : Security, light, thermostat, Air condition control
• **Heath care :** Patient monitoring, data logger, remote diagnosis
• **Memory tagging** : Automotive service record, maintenance logging, inventory control/tracing.
Description of some of the application is explained below.

1.Water Level Sensing:

Zigbee can be installed in remote locations where conventional GSM modems would be out of their network coverage area, such as inside water tanks.Zigbee tranceivers can be hermetically sealed with batteries and co-located with the sensors.Each tranceivers transmits periodically to another unit installed above ground.A GSM modem transmits the data back to base.

2.In-building Control

Zigbee-enabled switches and lights can reduce installation costs in new buildings by eliminating the need to route light control through the walls, and remove the need to call in a qualified electrician when switches need to be relocated.Thermostats and air-conditioning controls can also be placed anywhere free of any wiring constraints.

3.Radio Systems

The freescale solution is one of the first on the market. It comprises an RF data modem IC supporting the 2.4GHz band of the 802.15.4 standard, the world renowned 68HCS08 microcontroller, and software meeting current Zigbee protocols.

9. FUTURE ENHANCEMENT

●Futurists are sure to hold ZigBee up and say, "See, I told you so".

●The ZigBee Alliance is nearly 200 strong and growing, with more OEM's signing up. This means that more and more products and even later, all devices and their controls will be based on this standard.

●Since Wireless personal Area Networking applies not only to household devices, but also to individualised office automation applications, ZigBee is here to stay. It is more than likely the basis of future home-networking solutions

10.CONCLUSION

- ZIGBEE and underlying IEEE 802.15.4 communication technology could form the basis of ***FUTURE WIRELESS SENSORS***, OFFERING

1. **DATA RELIABILITY**
2. **LONG BATTERY LIFE**
3. **LOWER SYSTEM COST.**
4. **GOOD RANGE & FLEXBLE NETWORK**.

11.REFERENCES

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