A

Seminar report

on

ZIGBEE TECHNOLOGY

Submitted in partial fulfillment of the requirement for the award of degree
of Computer Science

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Preface

I have made this report file on the topic **ZIGBEE TECHNOLOGY,**I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to ……..who assisting me throughout the prepration of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

Abstract:

ZigBee is the name of a specification for a suite of high level communication protocols using small, low-power digital radios. The technology is intended to be simpler and cheaper than other WPANs such as Bluetooth. The most capable ZigBee node type is said to require only about 10% of the software of a typical Bluetooth or Wireless Internet node. The estimated cost of the radio for a ZigBee node is about $1.10 to the manufacturer in very high volumes. Most ZigBee solutions require an additional microcontroller driving the price further up at this time.

ZigBee is the newest and provides specifications for devices that have low data rates, consume very low power and are thus characterized by long battery life. Other standards like Bluetooth and IrDA address high data rate applications such as voice, video and LAN communications.

The target networks encompass a wide range of devices with low data rates in the Industrial, Scientific and Medical (ISM) radio bands, with building-automation controls like intruder/fire alarms, thermostats and remote (wireless) switches, video/audio remote controls likely to be the most popular applications. So far sensor and control devices have been marketed as proprietary items for want of a standard. With acceptance and implementation of ZigBee, interoperability will be enabled in multi-purpose, self-organizing mesh networks.

Introduction:

When you hold the TV remote and wish to use it you have to necessarily point your control at the device. This one-way, line-of-sight, short-range communication uses infrared (IR) sensors to enable communication and control and it is possible to operate the TV remotely only with its control unit. Add other home theatre modules, an air-conditioner and remotely enabled fans and lights to your room, and you become a juggler who has to handle not only these remotes, but also more numbers that will accompany other home appliances you are likely to use. Some remotes do serve to control more than one device after ‘memorizing' access codes, but this interoperability is restricted to LOS, that too only for a set of related equipment, like the different units of a home entertainment system

Now picture a home with entertainment units, security systems including fire alarm, smoke detector and burglar alarm, air-conditioners and kitchen appliances all within whispering distance from each other and imagine a single unit that talks *with* all the devices, no longer depending on line-of-sight, and traffic no longer being one-way. This means that the devices and the control unit would all need a common standard to enable intelligible communication. **ZigBee** is such a standard for embedded application software.

Why Zig Bee? :

> The “Why ZigBee” question has always had an implied, but never quite worded follower phrase “…when there is Bluetooth”.

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.

History

- ZigBee-style networks began to be conceived about 1998, when many engineers realized that both WiFi and Bluetooth were going to be unsuitable for many applications. In particular, many engineers saw a need for self-organizing ad-hoc digital radio networks.
- The IEEE 802.15.4 standard was completed in May 2003.
- In the summer of 2003, Philips Semiconductors, a major mesh network supporter, ceased its investment. Philips Lighting has, however, continued Philips' participation, and Philips remains a promoter member on the ZigBee Alliance Board of Directors.
- The ZigBee Alliance announced in October 2004 that its membership had more than doubled in the preceding year and had grown to more than 100 member companies, in 22 countries. By April 2005 membership had grown to more than 150 companies.
- The ZigBee specifications were ratified on 14 December 2004.
- The ZigBee Alliance announces public availability of Specification 1.0 on 13 June 2005

Device types

There are three different types of ZigBee device:

- **ZigBee coordinator (ZC):** The most capable device, the coordinator forms the root of the network tree and might bridge to other networks. There is exactly one ZigBee coordinator in each network. It is able to store information about the network, including acting as the repository for security keys.
- ***ZigBee Router (ZR)*:** Routers can act as an intermediate router, passing data from other devices.
- **ZigBee End Device (ZED):** Contains just enough functionality to talk to its parent node (either the coordinator or a router); it cannot relay data from other devices. It requires the least amount of memory, and therefore can be less expensive to manufacture than a ZR or ZC.

Protocols

ZigBee protocols are intended for use in embedded applications requiring low data rates and low power consumption. ZigBee's current focus is to define a general-purpose, inexpensive, self-organizing, mesh network that can be used for industrial control, embedded sensing, medical data collection, smoke and intruder warning, building automation, home automation, domotics, etc. The resulting network will use very small amounts of power so individual devices might run for a year or two using the originally installed battery.

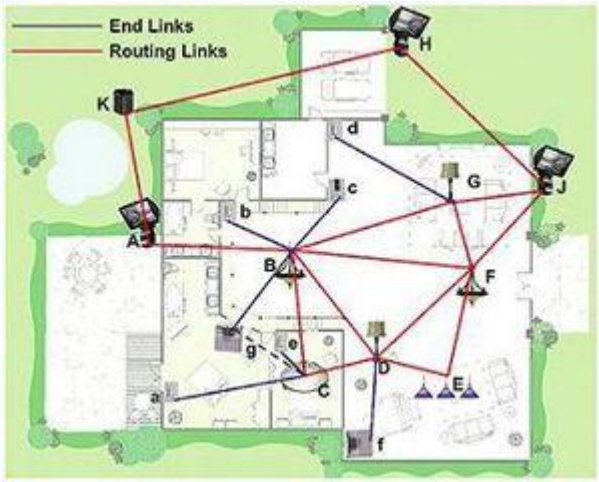
In non-beacon enabled networks (those whose beacon order is 15), an unslotted CSMA/CA channel access mechanism is used. In this type of network ZigBee Routers typically have their receivers continuously active, requiring a more robust power supply. However, this allows for heterogeneous networks in which some devices receive continuously, while others only transmit when an external stimulus is detected. In beacon enabled networks, the special network nodes called ZigBee Routers transmit periodic beacons to confirm their presence to other network nodes. Nodes may sleep between beacons, thus lowering their duty cycle and extending their battery life. However, low duty cycle operation with long beacon intervals requires precise timing which can conflict with the need for low product cost. In general, the ZigBee protocols minimize the time the radio is on so as to reduce power use.

Software and hardware

The software is designed to be easy to develop on small, cheap microprocessors. The radio design used by ZigBee has been carefully optimized for low cost in large scale production. It has few analog stages and uses digital circuits wherever possible.

Even though the radios themselves are cheap, the ZigBee Qualification Process involves a full validation of the requirements of the physical layer. This amount of concern about the Physical Layer has multiple benefits, since all radios derived from that semiconductor mask set would enjoy the same RF characteristics. On the other hand, an uncertified physical layer that malfunctions could cripple the battery lifespan of other devices on a ZigBee network. Where other protocols can mask poor sensitivity or other esoteric problems in a fade compensation response, ZigBee radios have very tight engineering .

ZigBee Home Automation Example



ZigBee Home Automation Example

The practical example shown is a home with a ZigBee network controlling lights, security system, fire system, and the heating and air conditioning.The diagram shows a number of devices -- red marks a "router to router" link, and blue link an "end node to router" link.

Here, lighting fixture B (which might also be the "coordinator") has identified and established routes via routers embedded in lighting fixtures A and F, mains-powered (with battery backup) smoke detector C, and table lamp D.

All the routers are mains-powered devices (lamps, heat pump, lighting fixtures, smoke alarms) and the "end" devices are battery-powered (switches, thermostats, motion detectors). Sensors are bound to actuators sometimes through user choices, otherwise because of bindings specified by the manufacturers.

Layers of zigbee network:

Though WPAN implies a reach of only a few meters, 30 feet in the case of ZigBee, the network will have several layers, so designed as to enable intrapersonal communication within the network, connection to a network of higher level and ultimately an uplink to the Web.

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: 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: media access control layer permits use of several topologies without introducing complexity and is meant to work with large numbers of devices. There are three different ZigBee device types that operate on these layers in any self-organizing application network. 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.

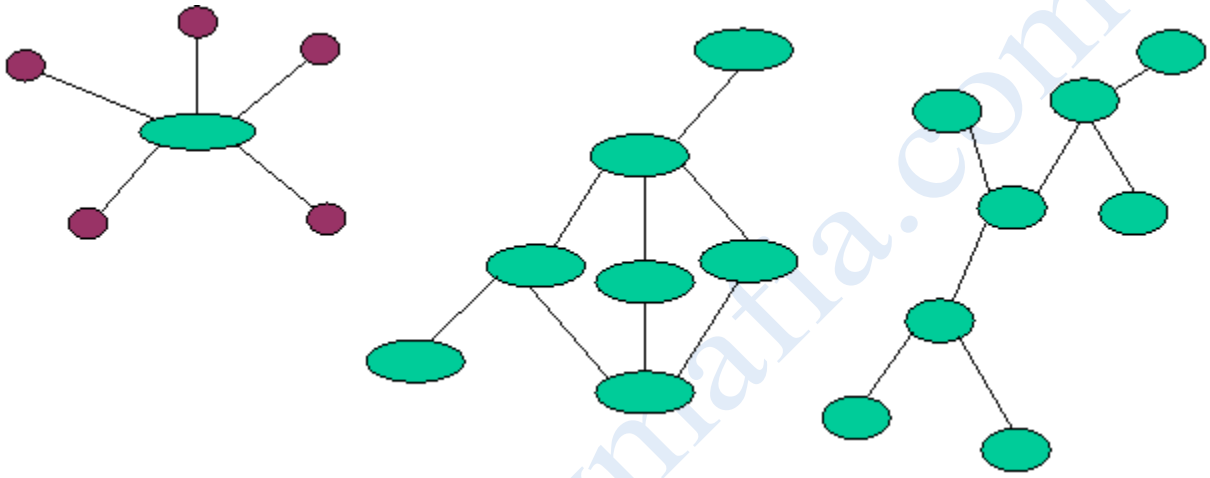
2. The full function device FFD: The FFD is an intermediary router transmitting data from other devices. It needs lesser memory than the ZigBee coordinator node, and entails lesser manufacturing costs. It can operate in all topologies and can act as a coordinator.

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.

Topologies:

• Different topologies as illustrated below: star, peer-to-peer, mesh

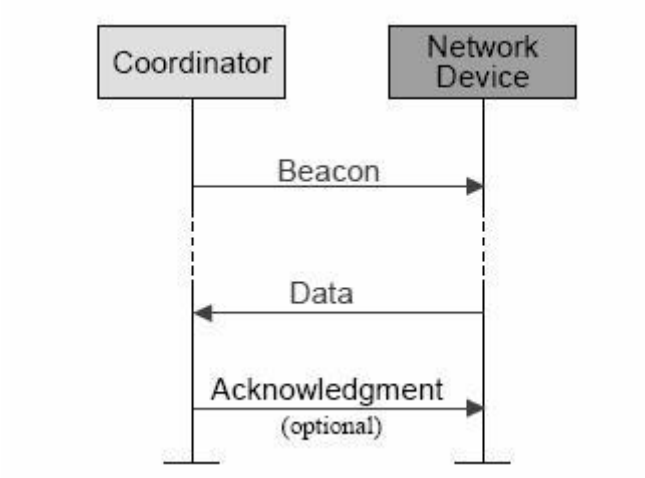


Topologies

ZigBee employs either of two modes, beacon or non-beacon to enable the to-and-fro data traffic. Beacon mode is used when the coordinator runs on batteries and thus offers maximum power savings, whereas the non-beacon mode finds favor when the coordinator is mains-powered.

In the beacon mode, a device watches out for the coordinator's beacon that gets transmitted at periodically, locks on and looks for messages addressed to it. If message transmission is complete, the coordinator dictates a schedule for the next beacon so that the device ‘goes to sleep'; in fact, the coordinator itself switches to sleep mode.

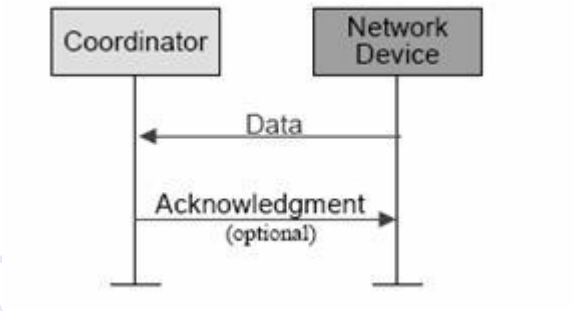
While using the beacon mode, all the devices in a mesh network know when to communicate with each other. In this mode, necessarily, the timing circuits have to be quite accurate, or wake up sooner to be sure not to miss the beacon. This in turn means an increase in power consumption by the coordinator's receiver, entailing an optimal increase in costs.



Beacon Network Communication

The non-beacon mode will be included in a system where devices are ‘asleep' nearly always, as in smoke detectors and burglar alarms. The devices wake up and confirm their continued presence in the network at random intervals.

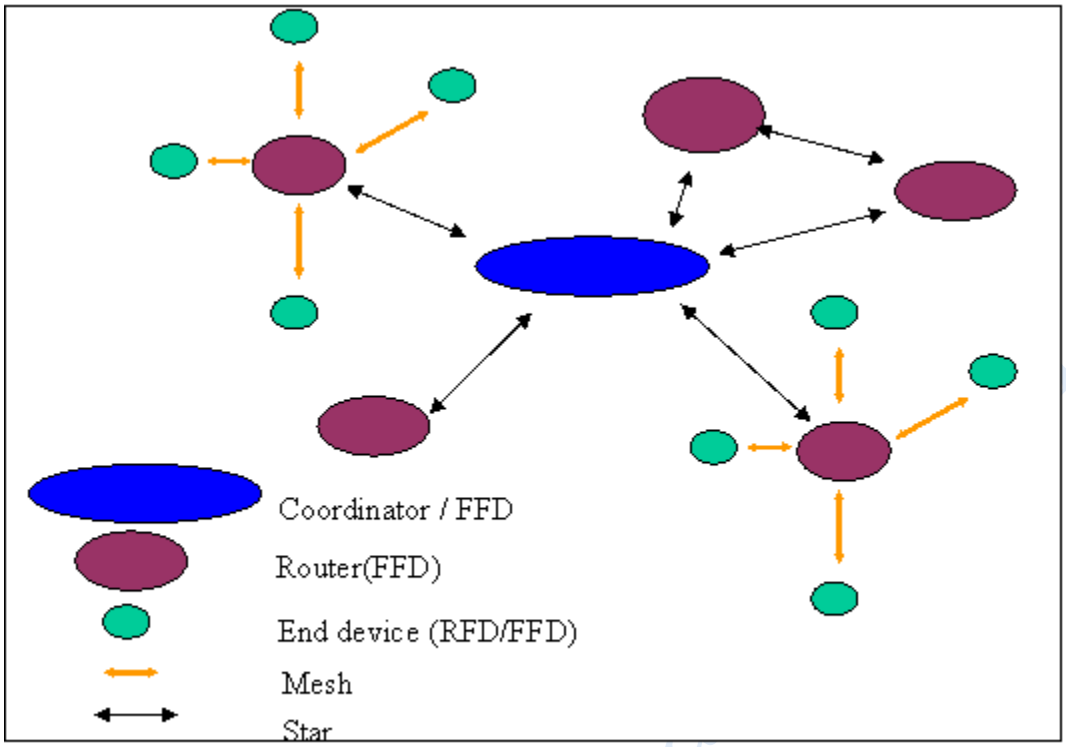
On detection of activity, the sensors ‘spring to attention', as it were, and transmit to the ever-waiting coordinator's receiver (since it is mains-powered). However, there is the remotest of chances that a sensor finds the channel busy, in which case the receiver unfortunately would ‘miss a call'.



Non-Beacon Network Communication

*T*he functions of the Coordinator, which usually remains in the receptive mode, encompass network set-up, beacon transmission, node management, storage of node information and message routing between nodes.

The network node, however, is meant to save energy (and so ‘sleeps' for long periods) and its functions include searching for network availability, data transfer, checks for pending data and queries for data from the coordinator.



ZigBee Network Model

For the sake of simplicity without jeopardizing robustness, this particular IEEE standard defines a quartet frame structure and a super-frame structure used optionally only by the coordinator.

The four frame structures are

- Beacon frame for transmission of beacons
- Data frame for all data transfers
- Acknowledgement frame for successful frame receipt confirmations
- MAC command frame

These frame structures and the coordinator's super-frame structure play critical roles in security of data and integrity in transmission.

With ZigBee designed to enable two-way communications, not only will the consumer be able to monitor and keep track of domestic utilities usage, but also feed it to a computer system for data analysis.

Uses:

In all of its uses, zigbee offers four inherent, beneficial characteristics:

1. Low cost:

The typical zigbee radio is cost effective. chipset prices can be as low as $12 each in quantities as few as 100 pieces while the 802.15.4and the zigbee stacks are typically included in this cost, crystals and other discrete components are not; design in module fall in the neighborhood of $25 in similar quantities. This pricing provides an economic justification for extending wireless networking to even the simplest of devices.

2. Range and obstruction issue avoidance:

Zigbee routers double as input devices and repeaters to create a form of mesh networking. If two network points are unable to communicate as intended, transmission is dynamically routed from the block node to a router with a clear path to the data's destination. The use of low cost routers can also extended the networks effective reach when the distance between the base station and remote node exceed the device range, an intermediate node or nodes can relay transmission, eliminating the need for separate repeaters.

3. Multisource products:

As an open standard, zigbee provides costumers with the ability to choose vendors as needed. Zigbee alliance work in groups defines interoperability profiles to which zigbee certified devices must ad hire.

4. Low power consumption: ·

Low power consumption, with battery life ranging from months to years. Considering the number of devices with remotes in use at present, it is easy to see that more numbers of batteries need to be provisioned every so often, entailing regular (as well as timely), recurring expenditure. In the ZigBee standard, longer battery life is achievable by either of two means: continuous network connection and slow but sure battery drain, or intermittent connection and even slower battery drain. basic zigbee radios operate at 1mw RF power and can sleep when not involved in transmission(higher RF –power zigbee radios for application needed greater range also provide the sleep function.) because this makes battery-powered radios more practical then ever, wireless devices are free to be replaced without power cable runs in addition to eliminating data cable runs

Future of ZigBee:

A recent analyst report issued by West Technology Research Solutions estimates that by the year 2008, "annual shipments for ZigBee chipsets into the home automation segment alone will exceed 339 million units," and will show up in "light switches, fire and smoke detectors, thermostats, appliances in the kitchen, video and audio remote controls, landscaping, and security systems."

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 individualized office automation applications, ZigBee is here to stay. It is more than likely the basis of future home-networking solutions.

Conclusion:

ZigBee is one of the global standards of communication protocol formulated by the relevant task force. ZigBee is the newest and provides specifications for devices that have low data rates, consume very low power and are thus characterized by long battery life. Other standards like Bluetooth and IrDA address high data rate applications such as voice, video and LAN communications. So with all these features ZigBee in future will surely becomes the talk of the town.