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Evaluation of Different Parameters of IEEE 802.15.4 and Other Short Range Networking Technology

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ABSTRACT

Zigbee is a high level communication protocol based on IEEE 802.15.4 standard. Zigbee 802.15.4 is used to create personal area networks for communication between hand held devices like cell phone or tabs etc, with small, low-power digital radios such as for home automation, medical device data collection. This technology is very suitable for sensor and control devices used in industry as well as home which require slow speed, less power consumption, low-bandwidth needs and wireless connection designed for small scale projects. Zigbee provides Medium access control and physical layer wireless standard. Zigbee operates in the industrial, scientific and medical (ISM) over different radio bands i.e. 868 MHz in Europe and 915 MHz in the USA and Australia, 784 MHz in China. It is being used with small transmitters for next generation automated manufacturing in industry, to connect a central computer with other devices in a project allowing a less expensive and longer power supply for communication between devices and central computer.

Keywords: WPAN, Bandwidth, MAC, SEP, CSMA/CA, FFD.

I. INTRODUCTION

Zigbee is a new technology to support short range wireless communication which provides a smart alternate to other existing technologies like Bluetooth or wireless fidelity. It is known for its smart energy saving features because it consumes very less power which enabled the batteries to last longer as compared with other technologies and with fewer expenses. The name Zigbee came from the communication method employed by honey bees in the form of dance called waggle dance. In this paper we will study about various devices which are used in zigbee communication and protocols in stack, and compare specifications of zigbee with other similar technology. In zigbee communication, a group of a group of technology are employed to make standard to meet self organising, self robustness and a scalable network. Zigbee over IEE 802.15.4 standard supports a generic mesh topology in which each device has a dedicated connection with other devices in the network. Zigbee supports both tree as well as star network topologies. Zigbee has a defined transmission rate of 250 Kbit/s which is good rate for periodic or irregular data transmission. It is well suited for a single signal transmission from a sensor or input device. The 802.15.4 standard zigbee network addressing follows 64-bit IEEE and 16-bit short addressing, which support over 65,000 nodes per network.

I. OVERVIEW OF 802.15.4 STANDARD

IEEE 802.15.4 is a standard for wireless communication and is defined and maintained by the IEEE 802.15 working group. It specifies the physical layer and media access control for low range wireless personal area network. It was defined in 2003. The 802.15.4 form basis for zigbee and others such as ISA100.11a, MiWi (Microchip Wireless protocol), SNAP and wirelessHART (Highway Addressable Remote Transducer Protocol) .The 802.15.4 can also be used with 6LoWPAN technology, which can be used to define the upper layers to deliver the IPv6 version of the Internet Protocol(IP) over WPANs.

In this section we will examine the structure, devices and application of zigbee. Zigbee operates over Media access control (MAC) and physical layer defined by IEEE in

802.15.4 standard which support a low rate wireless personal area network for home held networking as well as industry. The basic unit of data transmission is frame, frames are of four fundamental types (data frame, acknowledgment frame, beacon frame and MAC command frames), which enable a user for a reasonable tradeoffs between simplicity and robustness.

II. ARCHITECTURE AND WORKING OF 802.15.4 STANDARD

ARCHITECTURE

In 802.15.4 standard, devices are connected over a simple wireless network to communicate with each other. Network layer is defined on the basis of OSI reference model. Only the lower layers are defined in this but mapping with the upper layers may be provided by using logical link control (802.2) accessing the MAC. There are three frequency bands available on which devices can operate; these are 868MHz (870MHz), 915MHz (902 to 928 MHz) and 2450MHz (2.4GHz). Data rate may ranges from 20kbps to maximum rate of 250kbps. An 802.15.4 protocol stack is shown in figure 1.

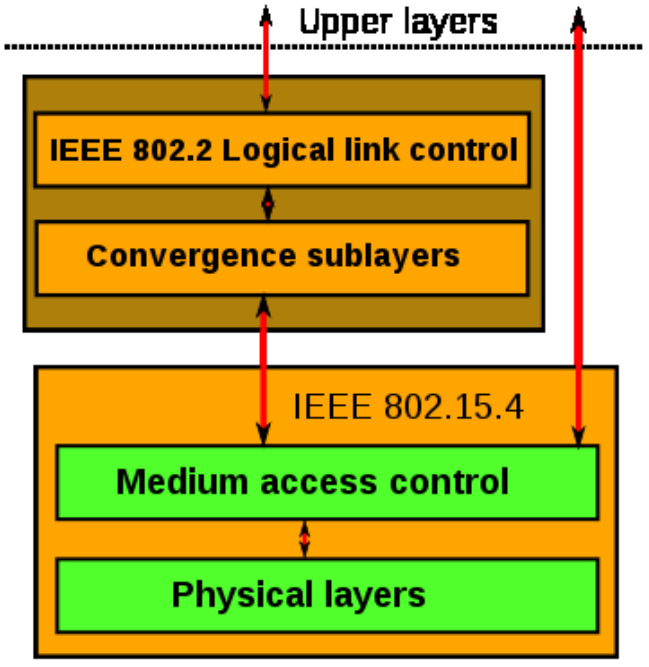

Fig. 1 The IEEE 802.15.4 protocol stacks.

Zigbee plays its role above physical layer and MAC in network layer and application framework and also concern with security in network layer. Above these in the upper layers its responsibility of user profiles in application layer as the profiles are user defined.

Physical layer- Physical layer is lowest layer which is closest to physical transmission media and it responsible for ultimately data transmission service. This layer perform channel selection, signal and energy management functions. It manages RF transceiver. It operates on one of three different frequency bands:

- 868.0–868.6 MHz- this band allows single communication channel. It is used in Europe.
- 902–928 MHz- supports up to 10 channels and in use in North America. Channels are extended up to 30.
- 2400–2483.5 MHz- It is used worldwide, it supports up to sixteen channels.

These frequency bands are unlicensed. Initially in the first version (2003) of standard there were two techniques based on direct sequence spread spectrum (DSSS) ,one among them 868/915 band with speed of 20 and 40kbps and other technique on 2.4GHz with data rate of 250kbps. In the next version 2006 data rate was improved which supports 100 and 250kbps for 686/915 band. In the later versions, IEEE 802.15.4c and IEEE 802.15.4d were released expanding the available PHYs with several additional PHYs: one for 780 MHz band using O-QPSK or MPSK another for 950 MHz using GFSK or BPSK.

The MAC layer- the transmission of MAC frames is enabled with MAC layer through use of the physical channel. Along with the data service, it also provides a management interface and access to the physical channel it manages itself. It offers network beaconing. It also guarantees time slots, controls frame validation, and handles node associations. And finally, for security service it offers hook points.

IEEE 802.15 standard does not exchange standard Ethernet frames because it does not use 802.1D or 802.1Q. The physical frame-format is specified in IEEE802.15.4-2011 in section 5.2.

Upper Layers-In IEEE802.15.4 standard upper/higher layers are not defined. Interpretability sub layers are also not defined.

Types of Node- standard has defined two types of network node these are “full function device’ (FFD) and

"reduced function device" (RFD). FFD works as a coordinator for WPAN and act as a general node on network while RFD is simple device which can communicate only with FFD and hence cannot act as a coordinator node.

Zigbee Smart Energy -version 2.0 (SEP 2) is the latest version for product development, SEP 2 avails a global standard for IP-based control, both wired and wireless, for energy management in WPAN. SEP 2 version is an evolution of Zigbee Smart Energy 1.x and offers new capabilities i.e. control of plug-in hybrid electric vehicles (PHEVs) charging, HAN deployments in multi-dwelling units such as apartment buildings.

WORKING

Topology-In zigbee, two types of network can be formed, one is peer to peer network and other is star network. On each type of network, a full function device must act as a coordinator on network. Groups of devices with a limited range of distance construct the network. Each device on network is assigned a unique 64 –bit address identifier. But a shorter identifier may also be used in personal area network. In point to point or peer to peer network, network can be extended to the limit of distance between pair of connected devices. Because standard do not define any network layer, routing in not performed however additional layer can support a multimode communication in the network. The network structure can be extended to form a Mesh network in which each node has a dedicated link with other nodes on the network which increase reliability. A star network is more structured network in which the coordinator node is the central node to which other hops are connected. A star network is formed when a full functioning device (FFD) create its own personal area network. FFD itself act as a coordinator. All other devices or nodes which are connected to network are independent of other nodes in the network.

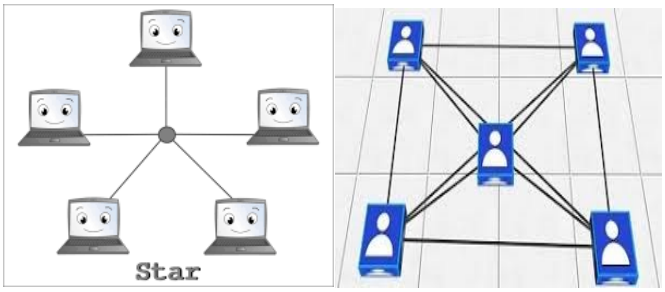

Fig. 2. Star and point to point network topology.

The basic unit of data transmission is frame; frames are of four basic types data frame, acknowledgment frame, beacon frame and MAC command frames. Generally all implemented procedures follow a typical request-confirm or indication-response scheme. Two types if addressing schemes are possible Direct Addressing and Indirect Addressing. Endpoint identifiers and radio address both are used in direct addressing scheme. While every relevant field like address, cluster, endpoints and attributes are consulted in indirect addressing. In indirect addressing, association and translation requests for communication are managed by network coordinator node. To minimise storage requirements and keep devices simple, indirect addressing is better than direct addressing. A coordinator node on the network can also define a superframe. In point to point network, unslotted CSMA/CA (carrier sense multiple access with collision avoidance) or other synchronization methods to avoid collision. A beacon synchronization phase is required to coordinator data transfer followed by CSMA if a superframe is in use. Device request is followed in data transfer, but signal request is followed if beacon are in use. If a request is received, coordinator node acknowledges the request and sends the requested data in packets and after receiving data, the device send acknowledgments. The devices which are communicating must use a common application protocol. These application protocols are grouped in profiles.

Device Types- there are three categories of Zigbee devices. These are Zigbee coordinator, Zigbee Router and Zigbee end device (Zigbee Leaf Node). Among them coordinator is most powerful and capable device which help to connect two network and act as a bridge between. It behaves as root or centre of tree network. There is only one coordinator device in a network which as a repository contains information about the network. Router in zigbee performs the function of routing data from hope to hope. And an end device in zigbee is less expensive device because it needs least amount of energy and long lasting battery time. It can only communicate to router or coordinator device but cannot forward any data from one to next node.

Device discovery-Various different types of methods are can be used in device discovery on network, selection of method depends upon the available information about the device. If a network address is not known then IEEE

address can be requested using broadcast scheme but when network address is valuable then unicast method is used to request IEEE address. External devices are assisted by extended discovery protocol to locate a device on the network.

Security- In Zigbee 128Bit AES Encryption and also application layer security is used. There are two modes a Secure MAC Mode and insecure MAC mode. Desired level of protection can be reached using MAC sub layer and upper layers. Symmetric key cryptography may be performed by upper layers processes. An access control list is constructed to secure group of devices to enforce security constraints. Access control list can also be used in peer to peer networking. 16 bit CRC protection is implemented in zigbee.

III. COMPARISON WITH OTHER TECHNOLOGIES

In this section we will compare various short range communication technologies. Other similar technologies to create a small network are Wi-Fi, Bluetooth, Mi-Fi, SNAP and wirelessHART (Highway Addressable Remote Transducer Protocol). But out of these only Bluetooth and Wi-Fi are in use, so we will compare various parameters of them with the help of a table.

Parameter	**Difference with other techniques**
Standard	Zigbee is defined under 802.15.4 standard of IEEE, and Bluetooth was defined under 802.15.1 but now it not under IEEE. Wi-Fi is defined in IEEE 802.11ac.
Frequency	Zigbee operates in three different frequencies i.e. 968MHZ, 918MHz and 2400MHz in different regions, while Bluetooth and Wi-Fi operates over 2.4GHz.
Distance Coverage	Zigbee can cover from 10 to 1600 meter distance while Bluetooth and Wi-Fi can cover 10 to 100 meters.
Data Transmission Speed	Zigbee supports up to 250kbps data transfer rate which is lower than that of Bluetooth (1Mbps) and Wi-Fi which has a excellent data rate of 1-54Mbps.
Number of Hopes supported	Zigbee support a large number of nodes around 65335 as compared with Bluetooth and Wi-Fi which supports 8 and 50nodes respectively.
Energy consumption and Battery life	Poser consumption is very low as compared with other similar technology as result battery last long (for Years) while in case of Wi-Fi and Bluetooth its only in hours or days.
Architectural Complexity and cost	Complexity of Zigbee is very simple as compared to more complex structure of Wi-Fi. And operating cost is also low than these other techniques.
Spectrum technique and network application type	Bluetooth works on Frequency Hopping Spread Spectrum technique while Zigbee uses Direct Spread Spectrum technique. Zigbee is generally used to build a small Personal area network PAN and Wi-Fi is suitable to Wireless Local Area Network (WLAN) for high data rate transfer.
Security and Reliability	In Zigbee 128Bit AES Encryption and also application layer security is used. In Bluetooth 64 bit and 128bit encryption scheme is applied and in Wi-Fi WPA/SSID is applied. 16 bit CRC is used for protection in Zigbee which is 32 bit in Wi-Fi for CRC. So Zigbee can be considered reliable networking method.

Table 1. Comparison of parameters of zigbee and other technologies.

IV. DISCUSSION AND CONCLUSION

From above comparison it is clear that Zigbee can be proven to be a better alternative to existing technology for a small personal area networking which require a long lasting power backup with minimum expense. Latest version of zigbee can cover longer distance than Bluetooth or Wi-Fi; hence it is a good option to use for controlling and monitoring in small scale industry or offices, hospitals and other organisation. So these technologies differ in application. Zigbee is better in controlling and monitoring where low data rate transmission speed is sufficient as it posses about 250kbps data transfer speed limits, but Wi-Fi is more suitable for high speed transmission. Selection of appropriate alternative is depends upon distance or area to be covered in network. Wi-Fi is suitable for creation of wireless local area network and zigbee is applicable in wireless personal area network. Numbers of nodes or devices to be connected is also an important factor. Zigbee 802.15.4 supports a large numbers of nodes as compared with Bluetooth or Wi-Fi. Zigbee is used in various appliances, because it can be programmed in chip and embedded in devices to function automatically. One can control and monitor whole organisation only sitting in control room with the help of devices connected through zigbee. Less expensive and long lasting backup enable vendors to embed small devices with zigbee chip so that these devices can be controlled through personal area networking at a reasonable cost and ensuring proper security.

V. ACKNOWLEDGEMENTS

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