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ZigBee (IEEE 802.15.4) Standard and It's Applications: A Review

Prof. J. R. Gangane, Niyaj S. Nadaf
Electronics & Telecommunication Department,
Sinhgad Institute of Technology,
Lonavala, India

Abstract*— *ZigBee is wireless technology issued by IEEE 802.15.4 standard for low power low cost low data rate wireless Personal Area Network. The ZigBee standard provides network, security, and application support services operating on top of the IEEE 802.15.4 Medium Access Control (MAC) and Physical Layer wireless standard.An IEEE 802.15.4-based Wireless Sensor Networkis considered, and the relationship between the IEEE 802.15.4topology formation mechanism and possible routing strategies atthe network layer is studied.This paper focuses on ZigBee as a technology innovation which would bring about low cost connectivity, its architecture, input output configuration and applications.

Keywords*—*IEEE 802.15.4 standard ZigBee based wireless Networks,ZIGBEEbased Automation System.

I. INTRODUCTION

ZigBee technology is a low data rate, low power consumption, low cost; wireless networking protocoltargeted towards automation and remote control applications. ZigBee is expected to provide low cost and low power connectivity for equipment that needsbattery life as long as several months to several years but does not require data transfer rates as highas those enabled by Bluetooth. In addition, ZigBee can be implemented in mesh networks largerthan is possible with Bluetooth. ZigBee compliant wireless devices are expected to transmit 10-7meters, depending on the RF environment and the power output consumption required for a give application, and will operate in the unlicensed RF worldwide(2.4GHz global, 915MHz Americas or868 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 linklayer). 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 arange of wireless home and building control solutions, provide interoperability compliance testing,marketing of the standard, advanced engineering for the evolution of the standard. This will assureconsumers to buy products from different manufacturers with confidence that the products will worktogether.IEEE 802.15.4 is now detailing the specification of PHY and MAC by offering building blockfor different types of networking known as"star, mesh, and cluster tree". Network routingschemes are designed to ensure power conservation, and low latency through guaranteed timeslots. A unique feature of ZigBee network layer is communication redundancy eliminating"singlepoint of failure" in mesh networks. Key features of PHY include energy and link quality detection,clear channel assessment for improved coexistence with other wireless networks.

This paper is organized as follows. Section II presents ZigBee and IEEE 802.15.4. In Section III ZigBee architecture is presented. Section IV presents ZigBee input output configuration. In section V industrial applications review is presented. The conclusions presented in section VI.

II. ZIGBEE AND IEEE 802.15.4

ZigBee is developed by ZigBee alliance, which has hundreds of member companies (Ember, Freescale,Chipcon, Invensys, Mitsubishi, CompXs, AMI Semiconductors, ENQ Semi conductors etc), from semiconductor andsoftware developers to original equipment manufacturers. ZigBee and 802.15.4 are not the same. ZigBee is astandard based network protocol supported solely by the ZigBee alliance that uses the transport services of theIEEE802.15.4 network specification. ZigBee alliance is responsible for ZigBee standard and IEEE is forIEEE802.15.4. It is like TCP/IP using IEEE 802.11b network specification. ZigBee alliance (software) defines thenetwork, security and application layers. IEEE802.15.4 (hardware) defines the physical and media access control layers for LR-WPAN.

III. ZIGBEE ARCHITECTURE

ZigBee layered architecture can be described by referring to the 7-layer Open System Interconnection reference (OSI) model for layered communication systems.These layers facilitate thefeatures that make ZigBee very attractive: low cost, easyimplementation, reliable data transfer, short-range operationsvery low power consumption and adequate security features.Fig. 1 shows layered architecture. It shows Silicon, ZigBee Stack and Application part separetely.

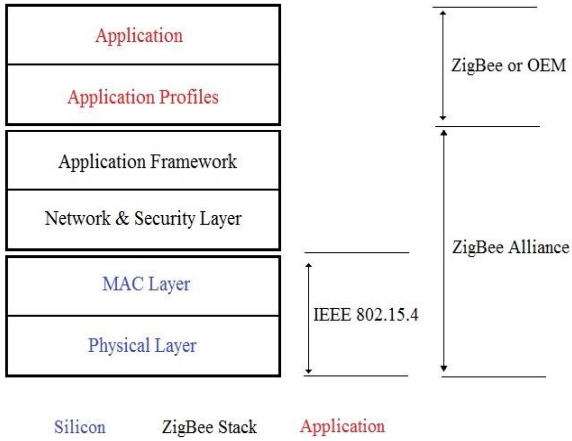

Figure 1 ZigBee Architecture

Physical layer: The IEEE 802.15.4 physical layeraccommodates high levels of integration by using directsequence to permit simplicity in the analog circuitry andenable cheaper implementations. Due to this layer we can obtain highest data rate of 250 Kbps. The 2.4 GHz PHY gives a 16-ary quasi-orthogonal modulation technique. Data sequence modulated onto the carrier using offset quadrature phase-shift keying (O-QPSK)

Media access control layer: The IEEE 802.15.4 mediaaccess control layer permits use of several topologies without introducing complexity and is meant to work with largenumbers of devices [4]. The IEEE 802.15.4 is based on CSMA (Channel Sense Multiple Access). It provides transmitting beacon frames, synchronization and providing a reliable transmission mechanism.

Network layer: The network layerhas been designed to allow the network to spatially growwithout requiring high power transmitters. The network layeralso can handle large amounts of nodes with relatively lowlatencies. This layer is used to join and leave a network, and to route frames to their desired destinations. It plays important role in the discovery of nodes.

Application Support layer: The APS sub-layer's responsibilities includemaintenance of tables that enable matching between twodevices and communication among them, and also discovery,the aspect that identifies other devices that operate in theoperating space of any device.

IV. INPUT OUTPUT CONFIGURATION

TRANG modules are designed with low to medium transmit power and for high reliability wireless networks. The modules require minimal power and provide reliable delivery of data between devices. The interfaces provided with the module help to directly fit into many industrial applications. The modules operate within the ISM 2.4-2.4835 GHz frequency band with IEEE 802.15.4 baseband [13]. Figure 2 shows Tarang ZigBee module.

Figure 2Tarang ZigBee

Role of TMFT software:

TMFT Software is used to configure the TARANG ZigBee via RS -232 or USB cable [14].

Module Programming:

Step1: Open TMFT Software.
Step2: Connect the TARANG module to the Serial/USB Port.
Step3: Choose the appropriate Port and serial parameters in terminal software& press query modem.
Step 4: For setting I/O pins as input and output the following steps should be followed-
Step 5: Enter the command mode with '+++' Response from modem should be ok.
Step 6: Enable the desired I/O pin as input with command ATIDxx. In this example first I/O line ID0 is used. For configuring it to Digital I/O input, send command as ATID02. Response from module should be 'OK'.
Step 7: Write these parameters to memory with 'ATGWR' command.
Step 8: Follow the same steps for configuring I/O pins to INPUT.
Step 9: Exit command mode with 'ATGEX' command.

Note: Once I/O pins are configured to input their default status Will be logic high (3.3V).

Step 10: Enable the desired I/O pin as input with command ATIDxx. In this example first I/O line ID0 is used. For configuring it to Digital I/O input, send command as ATID40. Response from module should be 'OK'.

ZigBee is the wireless technology falls in the category of wireless domain like GSM and RF technology. It indicates that ZigBee reduces the cost and maintenance of the wires used for connections. Thus ZigBee replaces the wired technology and provides a wireless communication.

As the wireless PLCs use modem for transmitting signals from PLC to the process here we are using ZigBee as the communication interface which is used for transmitting and receiving the signals from the PLC to process and vice-versa.ZigBee is a wireless network developed as an open global standard to address the unique needs of low-cost and low-power wireless personal area networks (WPANs). This wireless network uses full advantage of 802.15.4 [13].

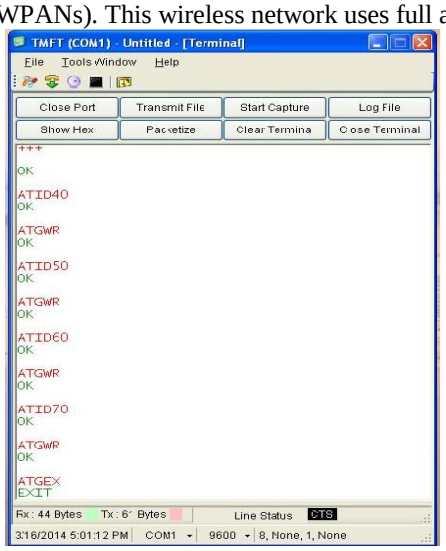

Figure 3 TMFT Window

V. INDUSTRIAL APPLICATION REVIEW

Following are some of the Industrial applications discussed.

- **Role of ZigBee Technology In Agriculture Sector**

The sensing technologies allow the identification of pests in the crops, drought or increased moisture. Having such information at a real-time interval, automated actuation devices can be used to control irrigation, fertilization and pest control in order to offset the adverse conditions. This technology can be applied for wireless applications in agriculture sector [9].

- **ZigBee Wireless Sensor Network Technology Studyfor Paddy Crop Field Monitoring**

In this application idea about monitoring the crop field area without man power is presented.The fundamental concept of this paper is to provide a highlyenabled monitoring of paddy crop field. In this paper they havedetailed about how to utilize the sensors in paddy crop fieldarea and explained about Wireless Sensor Network (WSN), ZigBee technology, Protocol stack of ZigBee. They checked out the ZigBee technology with two differentcommercial modules (Xbow and ZigBee). The analysis ofbattery life did under sensor deployed in the water conditions andthe evaluation of the reliability of communications andmeasurements [10].

- **Water Level Control System Using PLC andWireless Sensors**

In this application describes designed and implemented a water level control system based on the usage of PLC system and wireless sensors. One of the main advantages of using a design based on PLC is the simplicity, flexibility and reliability in comparison with other classic control solutions. The study tests were performed by using an experimental SIEMENS LOGO 24RL PLC system. In this paper they are presented two water level measurement systems, one uses resistive electronic sensors, contactors and a contactor coil that turns off the water pumping installation, and the other one uses wireless sensors and a PLC. The main disadvantage of contactor is the reduced capacity of resisting to overloads and short-circuits; this disadvantage can be eliminated by using ultra fuses. The system based on PLC and wireless sensors is cost effective and allows easy customization. Nowadays PLC and wireless sensors based systems represent modern solutions that are suitable for controlling the time driven event systems such as the case of water tank control [8].

- **Image Transmission over IEEE 802.15.4 andZigBee Networks**

In this application both ZigBee networking (NWK) and IEEE 802.15.4 MAC layer protocols are implementedon a single M16C microprocessor. Transport layer functionalities such as fragmentationand reassembly are performed at the application layer, since the ZigBee NWK does not have afragmentation support. The multiple access scheme is CSMA/CA, therefore only the best effortmulti-hop transmission of JPEG and JPEG-2000 images are tested; Observations and resulting statistics are presented, and open issues are discussed [12].

VI. CONCLUSION

The review on a ZigBee and its applications in industrial automation system is presented. Paper focuses on configuration of ZigBee module with TMFT software.

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ABOUT AUTHOR

Mrs. Jyoti R. Gangane received her B.E. degree in Electronics from Marathwada University in 1991, M. E. (E&TC) from Mumbai University in 2007 and Pursuing Ph.D in wireless communication from University of Malaga, Spain. Her area of interest is Digital signal processing, wireless communication, Control system. She has twenty three years teaching experience and working as Associate Prof. at SIT, Lonavala, E&TC Department.

Mr. Niyaj S. Nadaf received his B.E. degree in Electronics and Telecommunication Engg. fromShivaji University at AITRC, Vita in 2013 and is pursuing M.E. in E&TC from Sinhgad Institute of Technology, Lonavala. His area of interest is Industrial Automation & Embedded systems.

