ZigBee Based Industrial Automation Profile for Power Monitoring Systems

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Abstract—Industrial automations which are mostly depend upon the power systems & which requires distance controlled and regulated systems. Mostly voltage and current equipped parameters along with power and energy management system forms the industrial scenario for automations. Wireless technology which meets to cost, speed and distance scenario will always be a point of an interest for research. In this research work we mainly monitored power related parameters and enable remote switching devices for proper power management systems using ZigBee. This paper proposes a digital system for condition monitoring, diagnosis, and supervisory control for electric systems parameters like voltage and current using wireless sensor networks (WSNs) based on ZigBee. Its main feature is its use of the ZigBee protocol as the communication medium between the transmitter and receiver modules. It illustrates that the new ZigBee standard performs well industrial environments.

Keywords- ZigBee, wireless sensor networks, Power Monitoring System.

I. INTRODUCTION

Wireless technology, which has boomed in the IT sector over the past years, can be suitable for industrial control networks as well, providing solutions with high ROI for diagnostics, control and safety. Wireless Sensor Networks (WSNs) have revolutionized the design of emerging embedded systems and triggered a new set of potential applications. In addition to building automation, environmental surveillance, or military operations Industrial automation is also expected to greatly benefit from WSNs in terms of faster installation and maintenance, cost savings, and easier plant reconfiguration. ZigBee is an emerging short-range, low-rate wireless network technology. ZigBee also presents some potentially interesting features for supporting large-scale ubiquitous computing applications, namely power-efficiency, timeliness and scalability.

In managing the move to wireless, it is clear that common wireless protocols such as Wi-Fi and Bluetooth can be utilized on the factory floor [3]. The challenge is to understand how to utilize wireless solutions, developed for IT applications, as replacements for wired systems in time-critical scenarios typical of factory floor domains. To date, most wireless systems in production systems are focused on applications that require polling frequencies on the order of seconds or longer. However, the fundamental capabilities of these protocols allow support of much higher-speed applications such as motion control and closed loop distributed logic. To address this challenge, the following issues must be addressed in wireless technology for manufacturing:

- Determining the performance of wireless technology (data rate, transmission, jitter and link reliability)
- Developing best practices for wireless solution deployment and maintenance.

- Implementing standardized device testing across industries, including automated performance benchmarking. But, while considering applications specific to Industrial environment system demands:

1. Profile the performance of wireless de-vices and systems as it relates to metrics important for production system applications (e.g., speed, determinism and jitter)
2. Provide best practices for migrating to and maintaining wireless systems in manufacturing domains
3. Give a plant engineer a prior knowledge of performance limitations and tools to identify potential liabilities
4. Provide a platform for industry standardized testing and benchmarking of wireless devices and systems
5. Provide an understanding of the implementation areas for wireless that will provide the highest return on Investment.

As a unique protocol of IEEE 802.15.4 satisfy these entire requirements [5] [8], a compliant technology for this will be required. ZigBee provides all suitable data rates as compared to other wireless technology so this withstands suitably for such applications. This paper describes a power supply parameters measurement in a wireless network connected up by the ZigBee protocol for use in industries [1] [2]. Thus, monitoring the power supply parameters at the same time achieves the functions such as controlling and protecting related equipments.

Standardization of technology again plays an important role for globalization of these profile developments. ZigBee due to its standardize operational and network management properties will be suitable wireless interface technique, ZigBee also have low data rates over a middle distance and AES encryption properties which are again guaranteed for required communication scenario.

This article is broken down into the different sections: after this introduction section II sums up the main features of the ZigBee protocol, stack architecture and network topology for ZigBee; section III then describes the hardware architecture of the project; the next section shows the test results while the last section draws the final conclusions from the work carried out.

II. ABOUT ZIGBEE

ZigBee is the product of the ZigBee Alliance, an organization of manufacturers dedicated to developing a networking technology for small, ISM-band radios that could welcome even the simplest industrial and home end devices into wireless connectivity[4][7][11]. The ZigBee specification was finalized in December 2004, and products supporting the ZigBee standard are just now beginning to enter the market [6] [7].

ZigBee is designed as a low-cost, low power, low-data rate wireless mesh technology. The ZigBee specification identifies three kinds of devices that incorporate ZigBee radios, with all three found in a typical ZigBee.

■ A coordinator, which organizes the network and maintains routing tables.
■ Routers, which can talk to the coordinator, to other routers and to reduced-function end devices.
■ Reduced-function end devices, which can talk to routers and the coordinator, but not to each other.

To minimize power consumption and promote long battery life in battery-powered devices, end devices can spend most of their time asleep, waking up only when they need to communicate and then going immediately back to sleep. ZigBee envisions that routers and the coordinator will be mains-powered and will not go to sleep [10] [15].

A. ZigBee Protocol Stack Architecture

As in figure 1, ZigBee Protocol Stack architecture shows, three areas of architectural responsibility are in a ZigBee engineering effort [12] [15]:

■ The physical and MAC layers take full advantage of the physical radio specified by IEEE 802.15.4. The 802.15.4 specification describes a peer-to-peer radio using direct sequence, spread spectrum (DSSS). The specification also calls out the data rates, channelization and modulation techniques to be employed.

■ The ZigBee Alliance specifies the logical network, security and application software, which are implemented in a firmware stack. It is the ZigBee networking stack that creates the mesh networking capability. Each microcontroller/ RF chip combination requires its own ZigBee stack due to the differences in microcontrollers and RF chips. Typically, the ZigBee stack is included with either the microcontroller or RF chip. The stack may belong to the chip vendor, be provided by the chip vendor from a third-party source, or be provided by a third-party source for a specific microcontroller/RF chip combination.

■ The application layer is defined by profiles, of which there are two types: *public profiles* are those certified by the ZigBee Alliance for interoperability purposes, and *private profiles* are for use in closed systems.

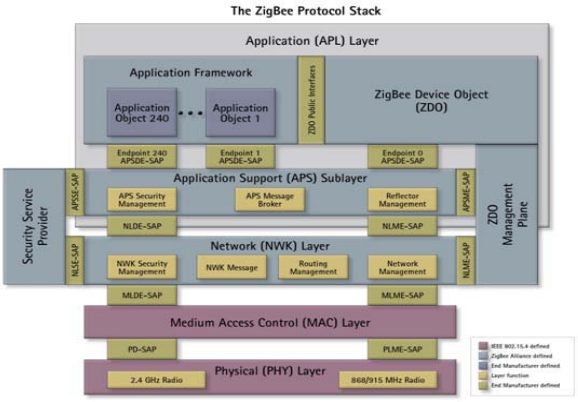


Fig. 1. ZigBee Protocol Stack Architecture

B. Network Topology for ZigBee

The ZigBee network layer (NWK) supports star, tree, and mesh topologies. In a star topology, the network is controlled by one single device called the ZigBee coordinator [13]. The ZigBee coordinator is responsible for initiating and maintaining the devices on the network. All other devices, known as end devices, directly communicate with the ZigBee coordinator. In mesh and tree topologies, the ZigBee coordinator is responsible for starting the network and for choosing certain key network parameters, but the network may be extended through the use of ZigBee routers. In tree networks, routers move data and control messages through the network using a hierarchical routing strategy. Tree networks may employ beacon-oriented communication as described in the IEEE 802.15.4-2003 specification. Mesh networks allow full peer-to-peer communication. ZigBee routers in mesh networks do not currently emit regular IEEE 802.15.4-2003 beacons. This specification describes only intra-PAN networks, that is, networks in which communications begin and terminate within the same network [16] [17].

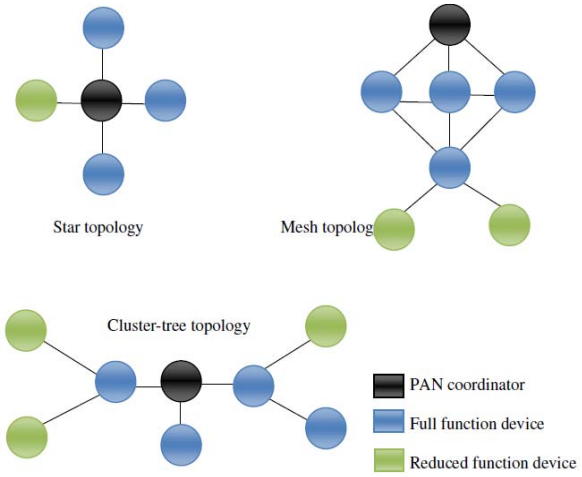


Fig. 2. Network Topologies

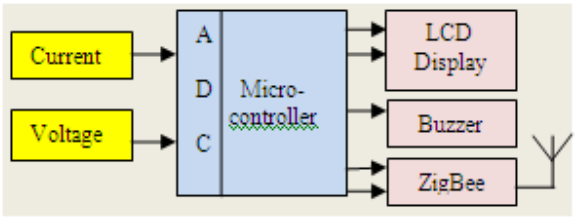
III. HARDWARE DESIGN

This section gives a hardware description of the elements making up the Power supply parameter measurement with ZigBee connectivity. Looking to the need of trustworthy power monitoring system for industrial environments, a ZigBee modeled system has to be designed which will comprise of the following modules:

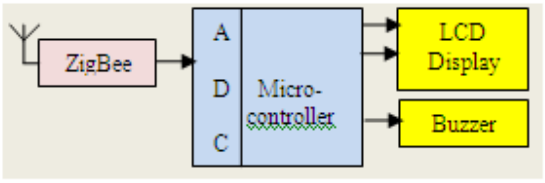
- Transmitter module
- Receiver module.

The system consists of the hardware elements (end point device), microcontroller, LCD display and ZigBee module. In the application development, microcontroller mainly meant for the function of the data processing, data storage, human interfacing and interoperability with the external environment. The things that taken into account While developing application platform on microcontroller are:
a) To choose requirement specific microcontroller with further scope of up gradation.
b)To study development tools with their version specification.
c) To study and apply High Level Language specification for application development as per compiler variations.

For our project work we are going for the controllers and developments tools of **Microchip Technology.** Module of XB PRO Series2 of Digi will be used here as a part of ZigBee stack which will then be addressed by mixed API mode with hardware controlled flow control for USART interfacing with the desired baud rate. So, ZigBee protocol used for wireless communication between transmitter and receiver module. LCD display is used to display the current and voltage parameters. Fig. 3 shows the hardware block diagram of the system.



(a) Transmitter Module



(b) Receiver Module

Fig. 3. Hardware System Architecture

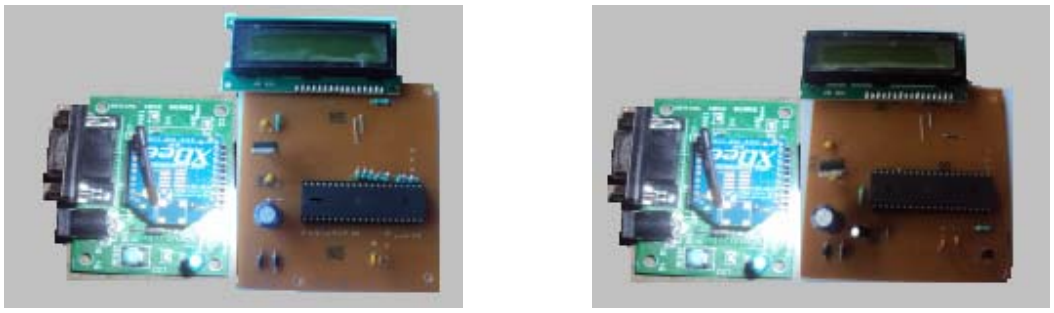
IV. EXPERIMENTAL SETUP

The proposed project research industrial machineries will be controlled & regulated by the switching actions performed by FFD side. This FFD side also displays the status of the RFD side system on the LCD connected on its panel. Alarm & Indications as shown that corresponds to status monitoring effects on server side due to remote machine parameter dependency.

Both the devices will be wirelessly linked by ZigBee with STAR topology. Industrial Automation profile of the ZigBee will be implemented here. As the whole data is transferred via Wireless radio link system will eliminates the loopholes of the traditional wired system.

In the proposed module, transmitter module receives the parameters from the device; display parameters on the LCD display and send it to the receiver side through ZigBee connectivity. In the same

way receiver module receive data sent by the transmitter through ZigBee connectivity and display it on LCD display connected to the receiver side. Both transmitter and receiver side will generate the alarm if any parameter exceeds its preset value. Thus, it avoids the malfunctioning of the devices due to the variations in the current and voltage parameters and also avoids the system failure.



(a) Transmitter module with Zigbee base PCB (b) Receiver Module with Zigbee base PCB

Fig. 4. Transmitter and receiver module

Figure 4 shows the transmitter and receiver module used in the system. Figure 5 shows the real implemented system. As shown RFD side will be switched by FFD for production controlled mechanisms. Secondly electrical parameters will also be sensed on this side for the purpose of data transmission to FFD.

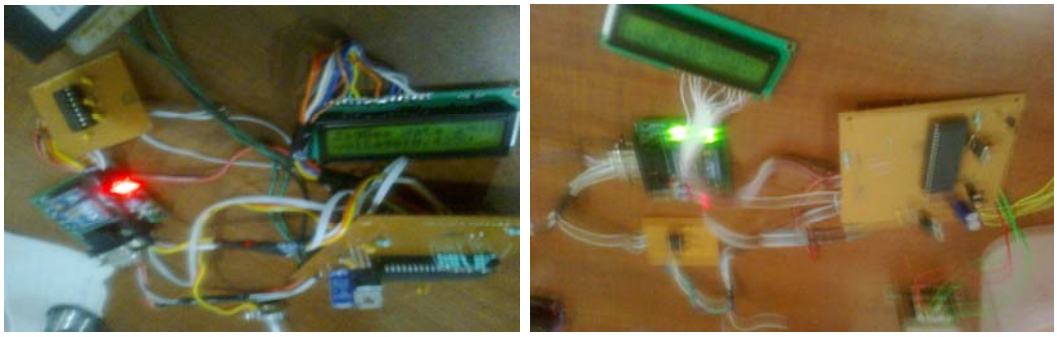


Fig. 5. Implimented Transmitter and Receiver module

V. CONCLUSION & FUTURE SCOPE

Wireless communication is a cheap and easy way to provide network communication at places where there is no wired infrastructure. In addition, because the communicating entities can freely move, one can place the monitoring system wherever it is required without the cost incurred with cabling when adopting the wired communication approach.

Wireless communication technologies can often be useful within industrial applications. As a unique protocol of IEEE 802.15.4 satisfy these entire requirements, a compliant technology for this will be required. ZigBee provides all suitable data rates as compared to other wireless technology so this withstands suitably for such applications. This paper presents a system for measuring the power supply parameters using the ZigBee protocol for communicating with other elements. The device presented here in fulfils the objective of a power automation interconnected by ZigBee. So, ZigBee technology is completely suitable for the application in power monitoring system, and it can provide reliable protection for the operation of electric power systems. ZigBee has a lot to offer industrial automation applications because of Low cost deployment and redeployment, Mesh networking to cover entire industrial plants and factories, Open standard with multiple vendors and its Battery operation features. Hence Industrial automation will demand the wide scope to utilize ZigBee for improve control & operations in terms of Power Monitoring System.

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