# ZigBee Based Electric Meter Reading System

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**Abstract**

According to the market requirements of Electric Meter. Nowadays, the system will use ZigBee and GSM system for communication protocol. The ZigBee is used since the application don't need high speed data rate, need to be low powered and low cost. Presenting the remote wireless Electric Meter Reading System, this aims at resolving the shortcomings of the technology of the traditional Electric Meter Reading, combining the characteristics of the ZigBee technology and IEEE802.15.4 standard. The hardware implementation was designed, and then analyzed the use cases for Electric Meter.

**Keywords-ZigBee; IEEE802.15.4; Market Requirements**

## 1. INTRODUCTION

Automatic Electric Meter reading is one method reading and processing data automatically with computer and communication. It is the need of improving the automatic level of energy consumption and the necessity of rapid development of computer and communication technology too. It not only may relieve reading person's labor intensity, reduce the reading mistake, but also has the advantage of high speed and good real-time. With the project of the wireless Electric Meter reading for wireless communication technology, complete the design of automatic Electric Meter reading system. Through researching the characteristic of main wireless communication protocol, ZigBee is chosen as lower layer communication protocol. With these applications, the standard is optimized for low data rate, low power consumption, security and reliability. Here describes the functional requirements to solve the technical issues related to the market applications.

## 2. IEEE802.15.4 AND ZIGBEE

### 2.1. IEEE 802.15.4

The ZIgBee protocol stack is described in Figure 1 .As we can see, IEEE 802.15.4 and the ZigBee network are tightly coupled to provide the consumer standardization for low-power and low-rate wireless communication devices.IEEE802.15.4 PHY layer provides 16 channels for ISM 2.4GHz,10 channels for ISM 900 MHz, and 1 channel for 868 MHz IEEE 802.15.4 PHY provides LOI(Link Quality Indicator) in order to characterize the quality of links between nodes, as well as data transmission and reception, IEEE 802.15.4 MAC uses the Carrier Sense Multiple Access with Collision Avoidance(CSMA/CA) mechanism for accessing the channel, like other wireless networks such as IEEE802.11 and IEEE 802.15.3 . There are two variations: Beacon Enabled Network which uses the CSMA/CA. Moreover, it provides the GTS (Guaranteed Time Slots) allocation method in order to provide real time data communication.

### 2.2 ZigBee

Based on IEEE 802.15.4 PHY/MAC , the ZigBee network layer provides functionality such as dynamic network formation, addressing, routing, and discovering 1 hop neighbors . The size of the network address is 16 bits , so ZigBee is capable to accept about 65535 devices in a network , an the network adderss is assigned in a hierarchical tree structure . ZigBee provides not only star topology, but last mesh topology. Since any device can communicate with other devices except the PAN Coordinator, the network has high scalability and flexibility. Besides, the self-formation and self-healing features makes ZigBee more attractive , The deployed ZigBee devices automatically construct the network, and then changes such as joining/leaving of devices are automatically reflected in the network configuration.

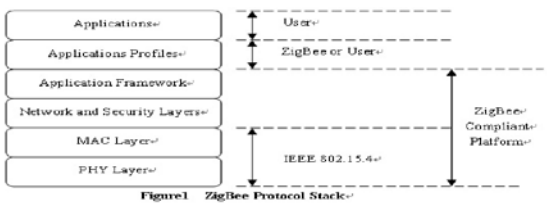


Figure1 ZigBee Protocol Stack

## 3. THE MARKET REQURIREMENTS

### 3.1 Market Needs

The utilities and Electric Metering companies continually look for improved methods to support their day to operations, which include: Providing flexible billing dates for customers, Performing Monthly/Cycle billing reads, Implementing Time-of-Use billing, Capturing Peak Demand, Supporting Critical Peak Pricing events, Forecasting energy usage, Positive outage and restoration detection and notification., Theft detection, Remote connect and validation, Market advanced Electric Metering and billing programs

### 3.2 Market Analyses

Within the typical ZigBee network there is a single "owner" or "stakeholder." This owner can determine which devices are allowed on the PAN by only sharing network keys with trusted devices. There may be two stakeholders for a single network: the utility and the end customer. Neither of these stakeholders necessarily trusts the other. The utility wants to be sure that the end customer cannot use ZigBee to inappropriately manipulate a load control or demand response system, or attack an energy service portal. The customers want to be sure that the energy service portal does not allow the utility to take liberties with their equipment or compromise their privacy. This results in four primary network ownership / deployment scenarios: utility-private, customer-private, shared, and bridged. Each of these scenarios has different implications. All of these scenarios are valid for EMI deployments, though their use may be specific to particular use cases or markets .

#### 3.2.1 Utlity-Private

Utility Private HAN might include an in-home display, or a load control device working in conjunction with energy service portal, but it would not include any customer controlled devices.

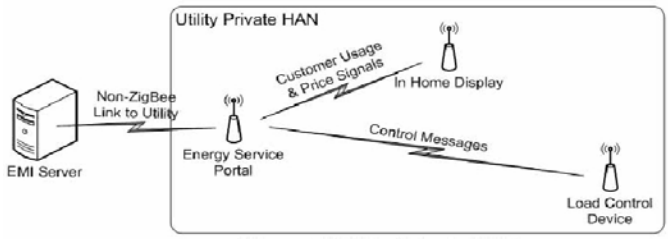


Figure 2 Utility Private HAN.

#### 3.2.2 Customer-Private

In the most extreme form, a customer private network might not even include an ESP on the ZigBee network, instead relying on some sort of customer provided device with non-ZigBee access to usage, consumption, and price data. Control messages in these examples would be one determined by the end customer, not the utility, and programmed into a home energy management console.

#### 3.2.3 Customer and Utility Shared

The shared HAN represents the worst security scenario for an EMI deployment. Devices are on a network they cannot trust, with other devices they cannot trust. Application level authentication and authorization are required to support a shared network environment.

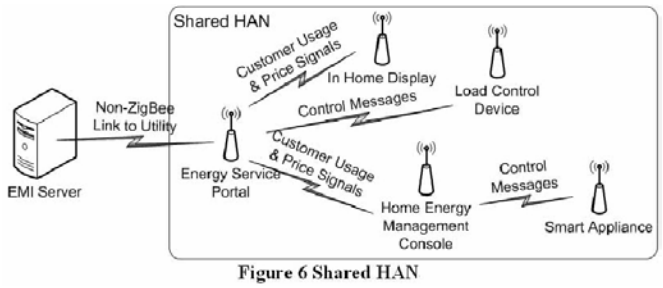


Figure 6 Shared HAN

#### 3.2.4 Application-Linked

As an example, in the scenario below, the Utility HAN is made available strictly to utility controlled devices. The Home Energy Management Console is a utility approved device that also lives on a customer provided HAN. It can respond to EMI commands, as well as sending out HA commands to devices within the home.

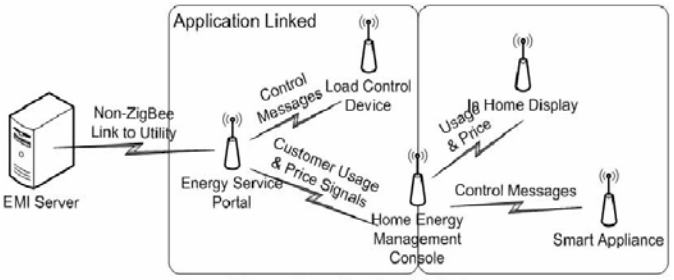


Figure 7 Application-Linked

### 4. DESIGN OF EMI

According the design for this system, the hardware design of EMI is divided to two parts: The Electric- Meter End Devices and The Data Acquisition Device. The former is to acquire the data of the Electric-Electric Meter, then transmit the data to the Data Acquisition Device through ZigBee network. Meanwhile display the energy and system time on the Electric Meter for customer. The latter functioned as a coordinator in the whole ZigBee network. Its function is to obtain all the information of the Electric Meters. And then transmit them to the energy management center through the parallel port

### 4.1Design for End Electric Meter Device

The CC2430 comes in three different versions: CC2430-F32/64/128, with 32/64/128 KB of flash memory respectively.

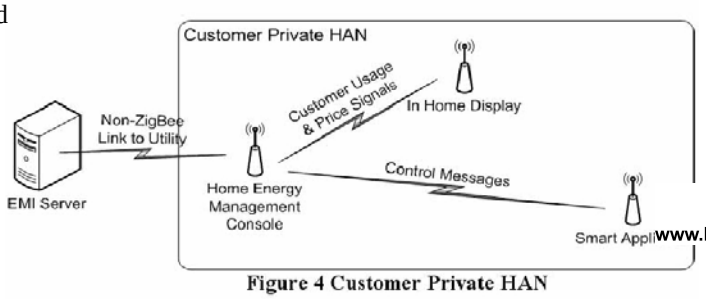


Figure 4 Customer Private HAN

The CC2430 is a true System-on-Chip (SoC) solution specifically tailored for IEEE 802.15.4 and ZigBee applications. It enables ZigBee nodes to be built with very low total bill-of-material costs. The CC2430 combines the excellent performance of the leading CC2420 RF transceiver with an industry-standard enhanced 8051 MCU, 32/64/128 KB flash memory, 8 KB RAM and many other powerful features. Combined with the industry leading ZigBee protocol stack (Z-Stack) from Figure 8 Wireless / Chipcon, the CC2430 provides the market most competitive ZigBee solution.

### 4.2 Designs for Data Acquisition Device

As the ZigBee node has to be used with Electric Meter Module, and it should be powered by battery, so the size of the ZigBee node is small, low-rate, and high-stability. Choose the small encapsulation designation circuit, and use the PCB as the wireless antenna. Make the bulk of the module to be minimized. Use the PIC18F4620 as the MCU, at the idle and sleeping state, it can minimize the power consumption of the system, choose the Chip on CC2430 which conforms to ZigBee protocol stack standard, and it needs a few external equipments, stable performance and the power consumption is low.

The interface circuit between PIC18F4620 and CC2430 is simple and the external equipments is fewer, simplify the difficulty of the debug, improve the stability of the system. In the addition of using the PCB , this system can communicate 60 miles.

The Data Acquisition Device reads the data from the Electric Meter timely, which read the impulse of the sensor, sending the data to the gather through the ZigBee communication module, till the Electric-Electric Meter data transport module read the data of this area.

## 5. SOLUTION USE CASES

The following sections describe the predominant areas of use cases for the EMI/EMR Market space, they are:_

1. Mobile EMR: Describes the market needs and the utilization of ZigBee to facilitate Electric Meter reading using mobile reading devices.
2. Energy Management: Provides the use cases that utilize the ZigBee based devices that support or enable EMS programs within premises.

### 5.1 Mobile EMR

Mobile EMR solutions consist of two scenarios, a Walk-By solution where Hand Held Computers are typically used to gather Electric Meter information, and a Drive-By solution where Computers used in conjunction with dedicated radios are installed in vehicles to remotely read Electric Meter information. Below are examples of both scenarios .

As depicted in the above diagram, a ZigBee based profile is used to transport the Electric Meter information to both the Walk-by and the Drive-by solutions. The types of Electric Metered information collected on a monthly basis ranges from simple Consumption to very complex Electric Metering including TOU (Time of Use), Load Profile (profile of consumption), Peak Demand.
The steps to accomplish this use case are:

- The CIS/MDMS requests the EMR solution to collect a series of Electric Meter reads. This may be for all Electric Meters or may be only for ones needed for that day business needs.
- The Electric Meter Reading Host Processor breaks the read requests into the appropriate routes for the individual Hand Held Computers or Vehicle based equipments.
- The Electric Meter Readers Proceed to collect the Electric Meter information along their designated routes.
- The Electric Meter information id uploaded to the Electric Meter Reading Host Processor and then forwarded upstream to the CIS/MDMS.

### 5.2 Energy Management Use Cases

ZigBee is to be utilized as the communication medium between home and building automation devices, Electric Metering devices, in-home displays, and fixed network devices such a gateways, bridges or access points. ZigBee based solutions for Energy Management should be capable of operating independently but in conjunction with current and future EMI solutions.

*1) Utility Customer Reduces Load Voluntarily In Response to CPP (Critical Peak Pricing)*

When the utility determines that the next day will be a Critical Peak Pricing (CPP) day and needs to invoke a voluntary load reduction program, it will notify its customer base of the impending event. The notification can occur using a variety of methods such as newspaper, TV, website, email, etc but may also include providing notice through the EMI solution via the Electric Metering device or customer display.

*2)* Utility *Customer Accesses Pricing Information*

Customers are becoming aware of the importance of understanding how much energy they are using and when it is being used. Customers want to understand how their energy consumption habits affect their monthly energy bills and to find ways to reduce their monthly energy

costs. The utility and regulatory agencies also want customers to be aware of the energy they are consuming and associated costs. By providing customers better visibility to their energy usage and cost at their site, they can make more educated energy related decisions regarding participation in load reduction programs, be more inclined to install energy efficient equipment and potentially to change their energy consumption habits. EMI solutions will enable improved communications between the utility and its customers by making if possible to remotely transmit energy usage, cost and other related utility messages to the EMI solution and down to the customer display device within the home or business.

*3)* Utility *Customer Uses Prepayment Services*

Most utility customers pay for usage after the fact. The utilities would also like to provide customers the ability to prepay for their electric quantities. This would apply to purchasing power for a residence or commercial site.

## 6. CONCLUSION

ZigBee technology is a new wireless protocol that widely used various areas for it excellent performance in reliability, capability, flexibility and cost, ZigBee corresponds to a large market. This paper provides an application in the field of automatic Electric Meter Reading System. With the developments of the ZigBee technology and the communication network technology of computer, wireless Electric Meter Reading System will grow up and practical mostly.

## 7. REFERENCES

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## AUTHORS PROFILE

S.Arun was born on 18th october 1979 Tiruvanamalai**,** India. He is working as Assistant Professor in Vel Tech High Engneering College Chennai and pursuing Ph.D. in the School of Electronics and Electrical Engineering, Singhania University, Rajasthan, India. He obtained M.E. degree in Communication systems 2004, Anna University and B.E. degree in Electronics and Communications Engineering from University of Madras, Chennai, India in the year 2001. . He has also published papers on image processing, wireless communication in National and International Conferences. His current research interests are Robotics, wireless Communications.

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