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Design a Low Power Zigbee based smart energy Metering

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Abstract:
The Designing and implementing a system based on wireless communication. This paper presents an implementation methodology for a wireless automatic meter reading system using LabVIEW platform and ZigBee network technology. A system design using low power radio communication which is low cost, high performance, highest data rate, highest coverage area and most appropriate to deal with shortcomings of traditional meter reading system , which are related errors in reading the data , inaccuracy of parameters, and timely availability of data . The system is designed and tested wireless in lab environment against it performance, data payload, and reliability.The system is designed using electric meter, National Instruments software and, and ZigBee module. This system performs tasks creating the wireless network and transmits and receives the command for meter reading. This proposed system had potential to save meter reading cost, and additional enabling the many advance services of electrical utilities.
Keywords: ZigBee, GPRS, NI, LabVIEW, Mesh Network

1. Introduction

Wireless networks represent a rapidly emerging area of growth and importance for providing ubiquitous networking connections. The induction of information technology to automate the distribution utilities manual process are constantly increasing ,eventual there is lot for information sharing between the devices connected to each other's and the need for networking increases. Wireless networks are more adaptable, easier to integrate and more economical way to support network requirement for automation [1].

In Today's world for inter connected system, where a huge data is being shared between the different system, there is a need of reliable and economical communication network system.

- Optimal systems are required that can ensure the data transmission and delivery, with large payload to support the increasing demand of faster and large data packets.
- The communication system will be easy to create and use free ISM, lower power consumptions and support larger networks.
- In many areas large communication networks are required for the monitoring to read the data on regular interval is cost effective and reliable manner.
- Remote motoring system requires the communication network that can provide the information without the human intervention, for the optimal operation [2].

Energy utilities, requires meter reading on regular interval and presently it manual and time consuming process, and data collected manual is not accurate and on time results in erroneous bills and customer complaints. Over the traditional metering system and metering devices have gone through big changes in technology, improvement, and are expected to become even more advance, offering more data payload , and faster communication. Meters in the past are electromechanical devices withhaving poor accuracy and lack of scalability and provide very less information. Today the customers temper the meter to reduce the bills using advance methods, and it big challenges for utilities to detect and eventually reduce the losses. There is clear demand of system that can provide the information online on interval basis, and for long term data management [3].

We developed a flexible meter reading using National Instruments products family, in conjunction with ZigBee module to establish a low power network to collect data from the energy meters device. The NI platform LabVIEW provides a good solution for processing the energy meter data, and handling multiple tasks simultaneously [4]. The system provides two way communications between meter and host system to reach the goal of wireless meter reading.

2. System Architecture

We created a low power wireless meter reading System for utility companies to remotely collect the data from energy meters without any human intervention. The Communication links such as GPRS/GSM are not viable for reading a large network of meters because of recurring charges for connectivity. The lower power network protocol is based upon IEEE 802.15.4 standard and used the free 2.4 GHz ISM band for creating lower power network. This makes it viable to read a large number of metering nodes and justifies its deployment costs. The ZigBee module has a transmission range of 1.6 km in line of sight and 30 m in indoor urban areas, and support mesh network for more than 64,000 nodes in a single network. In addition provide a data rate of 250 Kbit/s, and 128-bit encryption .

3. System Configuration

The complete lower power monitoring system has following main components

- Labview Graphical platform for programming
- Zigbee RF modules
- Energy Meter

LabVIEW, is a graphical programming language, is ideal for creating flexible proto type systems, scalable, to support many protocols to create flexible applications to meet the industries requirement. LabVIEW provides the Data acquisition, Data analysis, Data visualization tools that researchers. We used the LabVIEW as a platform to coordinate with ZigBee module (coordinator) for collecting the data from different ZigBee nodes (router/end device).

DigiMesh is a proprietary networking topology for use in wireless end-point connectivity solutions. It supports advanced networking features including sleeping routers and dense mesh networks.DigiMesh supports multiple network topologies such as point-to-point, point-to-multipoint, and mesh networks. With support for sleeping routers, DigiMesh is ideal for power-sensitive applications that rely upon batteries or power-harvesting technology. X-CTU is a Windows-based application provided by Digi, designed to interact with the configuration files to interface with other software platforms. A ZigBee Module is configured by X-CTU as well as LabVIEW. In LabVIEW, TX and Rx are the transmit (input) and receive (output) mode, respectively used for the execution of the AT commands (referring to the Network Discovery Front Panel Window) similar to the Terminal tab in X-CTU.

AC Three phase four wire Static energy meter, with RS232 communication module, is used for measures all the electric quantities of three- phase electric network:

- Current of all the phase
- Voltage (phase to phase , Phase to neutral)
- Power Frequency
- Power factor each phase , average power factor
- Total active power, reactive and apparent powers
- Energies (Active , reactive and Apparent)

4. System Description

The Computer is interface with ZigBee nodes coordinator to create a wireless network with the end node connected to energy meter for data collection. Meter will be interfaced with ZigBee node (Router/End Device), either through optical probe or serial cable depending on their availability communication port on the meter. Mesh network enables read the number of metering device in the single wireless network. It provides connections management, auto discovery and reconfiguration of broken communication path. Each module can be configure act as a router to extend the network reach , hence automatically routes the data through different paths making network reliable and insure the data availability.

An application is develop using the LabVIEW application which has following functionalities

- Auto network discovery of RF modules
- Establish the mesh networks with collision avoidance technique
- Receiving and transmission of commands over the RF communication
- Meter data processing and visualization

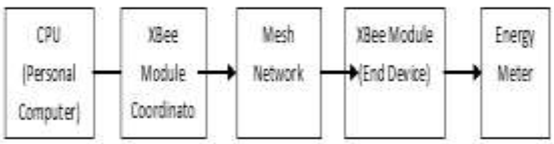


Figure 1: Meter Reading System Block Diagram

LabVIEW program for auto network discovery of the RF modules in the Mesh network ,the ZigBee module is discovered either through AT commands in TX - Rx or by the Discover Network button. Once the module is discovered at the remote end the destination is set in 'DH' and 'DL'.After the device discovery, the UI controlling the remote end reading is run to obtain the meter parameters at the substation remote end. The Modbus to Serial UI has the serial parameters settings of the meter.

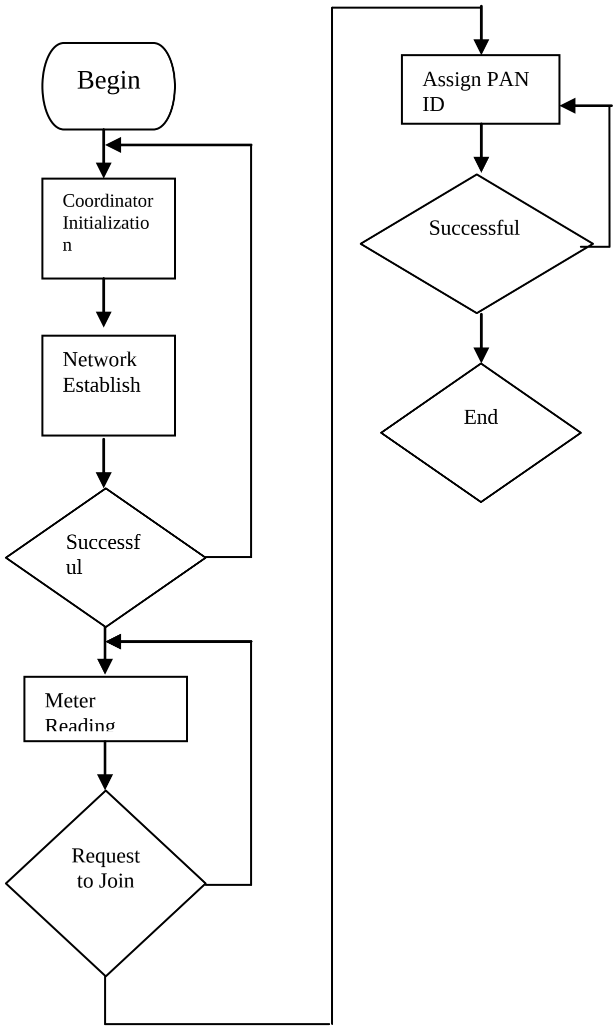
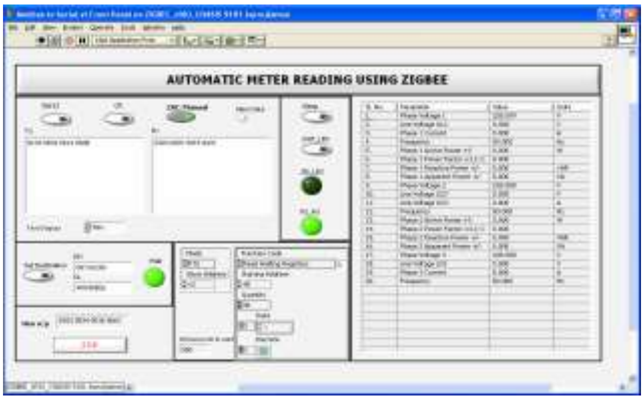


Figure 2: Metering System Flow Diagram



FiFigure 3: ZigBee Network Discovery Front Panel

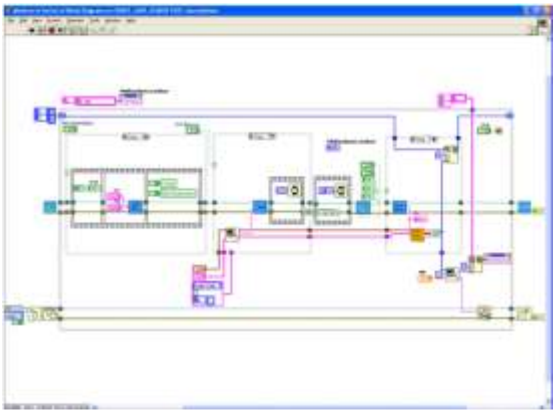


Figure4: Block Diagram representation of Labview Code

The block diagram shows the complete back end functionality. Firstly, the port gets initialized and the ZigBee coordinator discovers the end device with the serial settings in its own network and the destination is set. Next the serial settings are matched with the coordinator and the mode is set. Then, the zigbee end device reads the parameter values from the energy meter and broadcasts it from the substation end to the coordinator in the network at the server end. One by one the parameters get enlisted in the tabular representation as shown above.

First, the master node acting as the coordinator sends a request to establish the network and creates a network. The various command the application layer of the coordinator, and will be sent to its NWK layer management entity, which requests to the associated nodesto form a network. Second, when a network is formed, coordinator allows devices to join to the network through the request command and similarly router devices join other equipment in the network.

The ZigBee module is used to design the meter reading system which has the function of transmitting and receiving data and commands. There is a picture which describes an overall process about how to read the meter through the ZigBee module.

5. Test Setup

In order to test the functionalities, capabilities and consistence of wireless system a test set up is developed which includes following components:

- 6 Metering point with RF module (End devices)
- Coordinator unit
- Energy Meter (Modbus compliant)

Meter data reading consistence in various configuration

- Mesh Configuration
- Meter reading for different distance to check the capability

Objective

- The system is tested to read the meter from varying distance and at different payload.
- Meter response is consider in to the performance of entire system
- The system shows the overall the latency and delay under varying condition in the actual field implementation.

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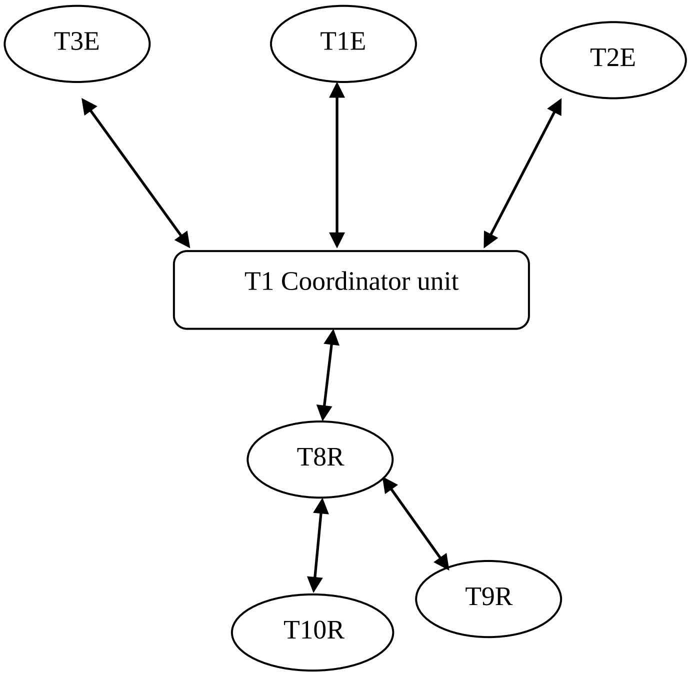
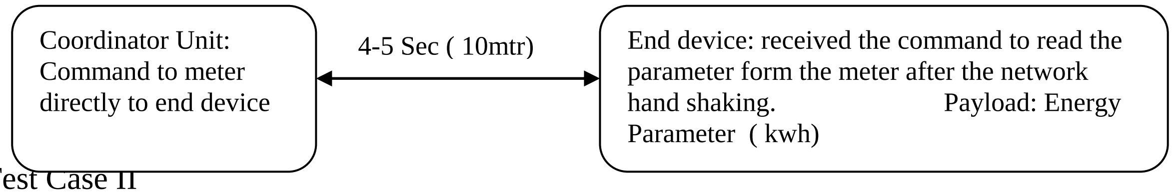
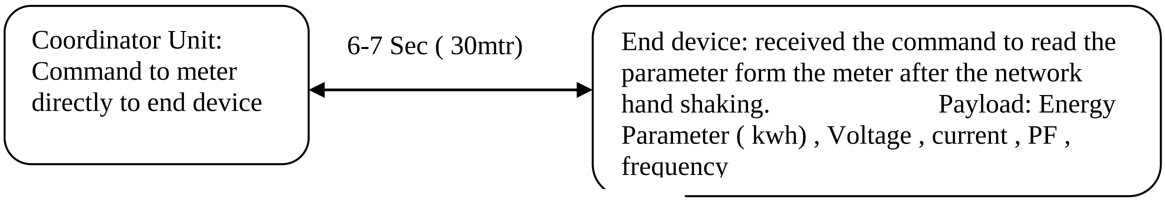


Figure 5: Mesh Configuration

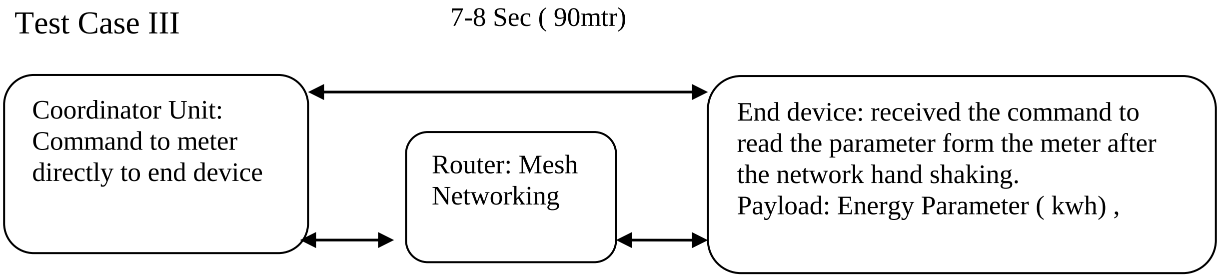
Test Case I



Test Case II



Test Case III



Test Case IV

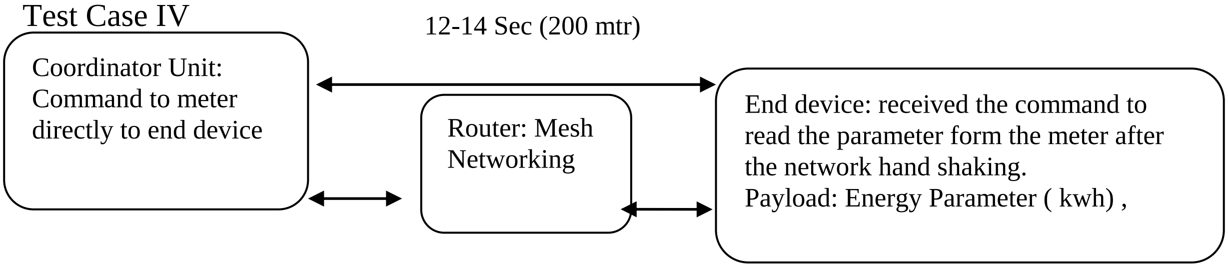


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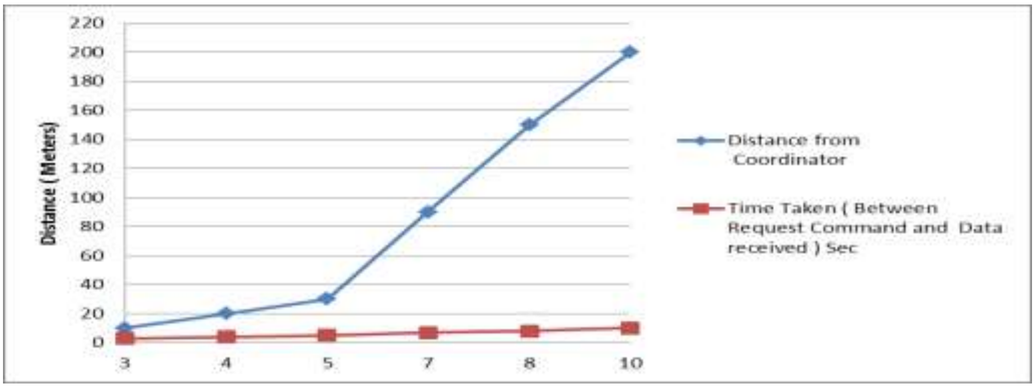
Table 1: Mesh Configuration results

Test Results					
Unit No.	Data Reading	Distance from coordinator (Line to Sight) in meters approx.	Time Taken (Between Request Command and Data received)	Parameters (KWH)	Remarks
T1	End Device	10	3 sec.	1.3	Consistence
T2	End Device	20	4 sec	1.7	Consistence
T3	End Device	30	5sec	2.4	Consistence
T8	Repeater	90	7Sec	1.7	Consistence
T9	Repeater	150	8 Sec	2.5	Consistence
T10	Repeater	200	9 Sec	1.3	Consistence



Graph: 1

Table 2: Mesh Configuration results

Test Results (with same payload and increase distance)					
Unit No.	Data Reading	Distance from coordinator (Line to Sight) in meters approx.	Time Taken (Between Request Command and Data received)	Parameters (KWH)	Remarks
T1	End Device	15	4 sec.	1.3	Consistence
T2	End Device	30	5 sec	1.7	Consistence
T3	End Device	50	6sec	2.4	Consistence
T8	Repeater	120	8 Sec	1.7	Consistence
T9	Repeater	170	9 Sec	2.5	Consistence
T10	Repeater	250	10 Sec	1.3	Consistence

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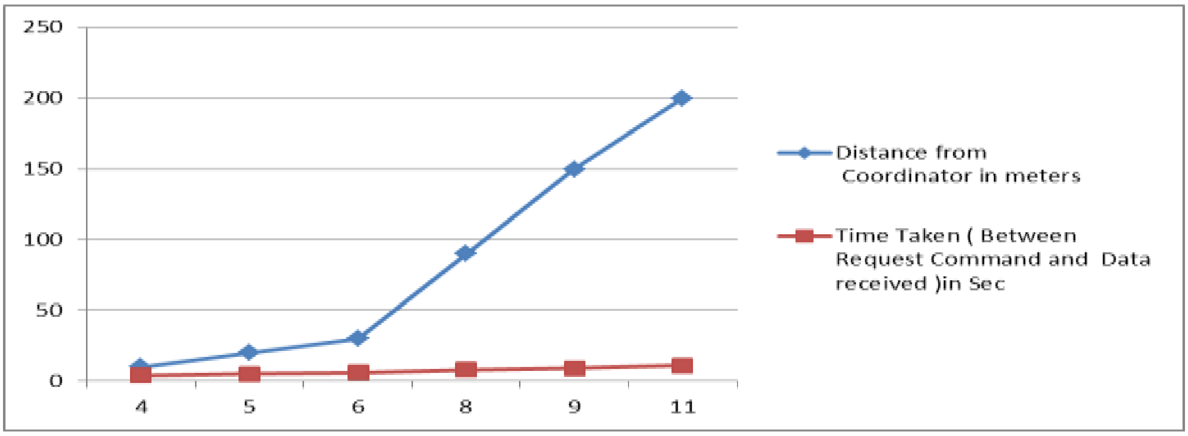
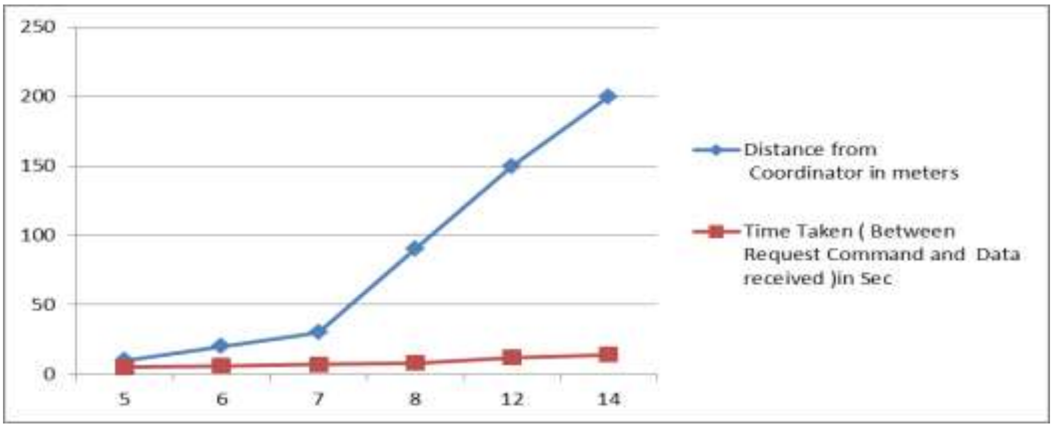


Graph 2

Table 3: Mesh Configuration results

Test Results (With More Payload)					
Unit No.	Data Reading	Distance from coordinator (Line to Sight) in meters approx.	Time Taken (Between Request Command and Data received)	Parameters (Energy Parameter (kwh) , Voltage , current , PF , frequency KWH,)	Remarks
T1	End Device	10	5 sec.	1.32kwh,220v,2 amp,0.95,50Hz	Consistence
T2	End Device	20	6sec	1.75,220,2 ,0.95,50	Consistence
T3	End Device	30	7sec	2.44,220,2 ,0.95,50	Consistence
T8	Repeater	90	8Sec	1.72,220,2 ,0.95,50	Consistence
T9	Repeater	150	12Sec	2.54,220,2 ,0.95,50	Consistence
T10	Repeater	200	14Sec	1.36,220,2 ,0.95,50	Consistence



Graph 3

6. Conclusion

- Mesh Networking improve the capability of the lower power network to read meter with greater distances.
- Mesh networking can be used to cover large area or more metering point, but latency in data is observed.

- Number of metering point per coordinator need to be carefully selected based upon the application and required data read frequency.
- Range of lower power module decreases with obstacle in between like wall, concreate slabs etc.
- Mesh networking is ideal in those areas where the density of building is more and line of sight is not available between each meter node
- More will be parameter to read from the meter , more will the time required to read the meters
- As we increase the number for parameter to ready form the meter , means we are increasing the payload latency in getting the data will be observed
- Meter response to the command (to ready the parameter), depends upon the it performance and it varies from meter to meter.
- Network latency is observed when the distance is increased and with more payload.

7. Future Scope

- The system has wide application in the area of reading the data from the network of meters.
- The network needs to manage in optimal way, by placing the coordinate and router in such a way, which meet the performance requirement and must be economical.
- The network need to manage so that the meter reading activity will be completed in stimulated time and data is shared for analysis and billing purpose.
- During the large scale deployment , the network requirement need to study for the SLA.

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