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AUTOMATIC METER READING SYSTEM USING WIRELESS SENSOR NETWORK AND GSM

AMRUTA KOTASTHANE[1] & HATE S. G[2]

[1]Research Scholar, (VLSI & Embedded System), Department of Electronics and Telecommunication, SGR's GHR COEM Chas Ahmednagar, India

[2]Assistant Professor, Department of Electronics, GHRIET, Wagholi, Pune, India

ABSTRACT

An emerging technology called wireless sensor network is one of the most efficient technology which can be used in various applications because of its low power, ease of use, low cost communication protocols. In this paper we present a model which is used for controlling and measuring use of our daily utilities water, electricity and gas by using wireless sensor network. WSN is a collection of widely distributed sensors which monitors physical or environmental conditions, such as temperature, sound and cooperatively passes their data through the network to a center location. It is a current most interesting area of research in field of electronics and communication. The system proposed consists of three meters, controller, a ZigBee operated wireless sensor network and GSM. GSM module used in this system is also used to advance its characteristics such as sending bills, sending notices, due dates of bill payments to customers. This system performs tasks such as taking meter reading, distribution of bills, sending notice, cutting and reconnection of flow automatically. The proposed model can lead to great deal of costs saving in water, electricity and gas metering.

KEYWORDS: Arm7, GSM, Wireless Sensor Network, ZigBee

INTRODUCTION

The traditional metering systems mostly consist of wired systems. In these systems meter readings are taken manually. But these systems has many disadvantages , manual reading has shortcomings such as errors in reading, inaccuracy, external conditions affecting readings , delayed work .These techniques also requires huge manpower.

One another way to implement metering system is automatic meter reading system by using communication mediums such as RF or GSM/GPRS. These mediums can be used depending on the characteristics of technology and requirements of the implementation sites. But these mediums are generally costly and power consuming. Hence selecting the right communication technology is vital to the success of the project.

One emerging technology called wireless sensors are capable of to overcome all above disadvantages. Unlike traditional networks which only consist of relation between humans and data bases, sensor/actuator network is connected with physical world directly. By using sensors, this network senses physical environment and decides control action based on its observations and performs suitable operations. The costs involved in manual reading of the meter are eliminated and the consumption data becomes more transparent. [2].

Wireless Data Collection

A wireless data collecting system consists of flexible combinations of sensors, controller, and wireless communication devices. Wireless communication greatly reduces the time, cost and disruption involved in deploying sub-metering installations. It offers following advantages:

- **Cost Effective:** Wsn are more affordable than traditional wired medium because it saves cost and time required to put miles of wires.
- **Flexibility:** wireless sensor networks are more flexible as it can be applied to any system.
- **Scalability:** Few sensing devices and a single control module can be installed in large building, or a complex or hundreds of nodes and scores of controls can be used throughout a colony which makes WSN more scalable.
- **Reliability:** Due to Advances in technology and long battery life wireless sensor network can reliably work in structures of all sizes. Mesh networking's remarkable self forming and self healing ability further enhances this reliability of WSN.

WSN Structure

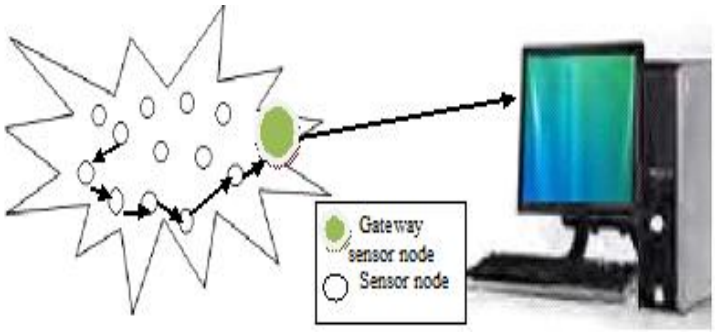

Figure 1: Structure of WSN

Continuous advancements in sensing, computing and communication technologies together with the necessity of monitoring physical phenomena continuously have led to the development of Wireless Sensor Networks (WSNs). The WSN consists of "nodes". Each such sensor node has typically several parts: a sensor for sensing the physical environment, a radio transceiver with an antenna, a microcontroller for processing the data, an electronic circuit for interfacing with the sensors and an energy source. This energy source is usually present in the form of a battery or an embedded form of energy harvesting. A WSN is formed by densely deployed sensor nodes in an application area. There can be from a few to several hundreds or even thousands of nodes and each node is connected to one or several sensors.

As the basic unit of Wireless Sensor Network is a Sensor Node, each sensor node must be capable of sensing, processing and communicating the processed data to the neighboring nodes in order to form a network. Sensor node is hence composed of sensors to sense the physical phenomenon, analog to digital converter, microcontroller for controlling and processing data received from sensors, memory for algorithms and data storage, radio unit for short range wireless communication and battery unit to power all the units. Chargeable battery units based on solar power can also be used to minimize power, the failure of sensors and maintenance cost. Nodes communicate with each other using radio transmitters and receivers. They build networks with other nodes that change with the positions of the nodes. Most commonly used wireless communications standard in WSNs is based on the IEEE 802.15.4, usually referred to as ZigBee. These are used because of its features such as very low cost and very low power signal design of the WSN radio chip, Reliable and self healing, Support large number of nodes, Easy to deploy, Secure, can be used globally.

IMPLEMENTATION

System Architecture

Our proposed model is concerned with three main household utilities which are water electricity and gas distribution network. In mentioned system, there are meters used for recording amount of family's consumption. As seen

previously wireless sensor network consists of nodes, one house containing these meters can be considered as one node. Data i.e. consumption of one house is transferred to next house by using wireless sensor network. In this model main office is considered as central node of a network.

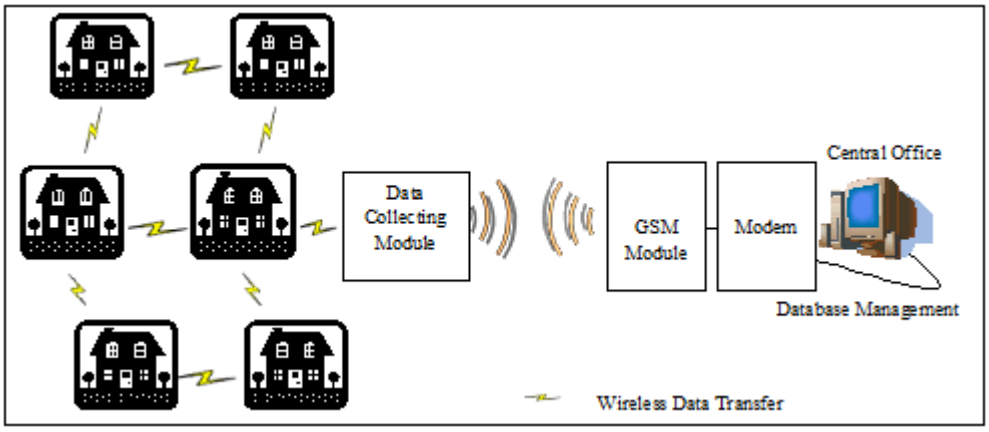

Figure 2: Architecture of System

As shown in figure above, this model works such as one house sends its data to next house i.e. one node sends its data to neighboring node. This node then sends its data along with data of previous house to further node and process continues. Data gathered from every node is collected in data collecting module through ZigBee network. Finally all data is send to central office via gsm communication for billing and further analysis [1]. The ZigBee network is formed by using a coordinator and 'children' nodes. The coordinator is responsible for network formation. It starts communication by sending request packets. In this model mesh network of ZigBee is employed as largest possible area needs to be covered. The software part can be designed for ZigBee client node in two parts: In first part subroutine for network can be developed and in next part subroutine for meter reading can be designed. Computer system receives the data of each meter with gsm module. It determines the cost bills and persons who should to receive notification. This system is also coupled with GSM module to broadcast messages of bills of individual houses, due dates for payments, confirmation of bill payments etc

System Block Diagram

The figure 3 shows Block diagram of one sensor node, which consists of

- Sensing part
- Controlling part using microcontroller
- Transceivers part

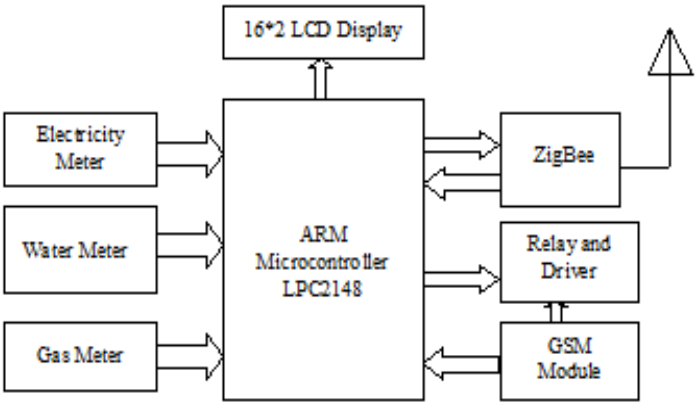

Figure 3: Block Diagram of System

Sensing Part

Basic unit of system is sensing part which consists of three meters namely water, gas and electricity meters, which are used for taking readings from individual houses.

An electricity meter or energy meter is a device that measures the amount of electric energy consumed by a residence, business, or an electrically powered device. Electricity meters are typically calibrated in billing units, the most common one being the kilowatt hour [kWh] and operate by continuously measuring the instantaneous voltage (volts) and current (amperes) to give energy used (in joules, kilowatt-hours etc.). Single-Phase Power/Energy Meter with Tamper Detection is used for detecting amount energy consumed. This electricity meters give adjustable Energy Pulse Output which goes beyond 10 pulses / kWh.These pulses are given directly to microcontroller.

A gas meter is a specialized flow meter, used to measure the volume of fuel gases such as natural gas and propane. Gas meters are used at residential, commercial, and industrial buildings that consume fuel gas supplied by a gas utility. Diaphragm meter are the most common type of gas meter, seen in almost all residential and small commercial installations. Within the meter there are two or more chambers formed by movable diaphragms. With the gas flow directed by internal valves, the chambers alternately fill and expel gas, producing a near continuous flow through the meter. As the diaphragms expand and contract, levers connected to cranks convert the linear motion of the diaphragms into rotary motion of a crank shaft which serves as the primary flow element. This shaft produces electrical pulses which can be given directly to microcontroller.

Water meters are used to measure the volume of water used by residential and commercial building that is supplied with water by a public water supply system. The flow of water is detected with water meter .this meter is connected to active sensor. This meter is based on principle of change of induction. Meter can also operate in harsh environmental conditions by designing sensor to work in such conditions, so that magnetic tempering will not take place. This meter also gives output in the form of pulses, which are given to microcontroller.

Controlling Part

Controlling part involves Microcontroller which performs tasks, processes data and control the functionality with other components in the sensor node. This also sends the data to the RF transceivers for the transmission of data to the base station. The microprocessor has a number of functions including:

- Managing data collection from the sensors
- Performing power management functions.
- Interfacing the sensor data to the physical radio layer.

  Arm microcontroller selected in this model because of its

  - Low power
  - Less area
  - High speed
  - Better accuracy
  - Cost

The microcontroller is connected to LCD for continuous display of values of water, electricity and gas consumed. Controlling part is also included in the module by connecting the microcontroller through the relay driver and relay which cuts and resumes supply if bill payment is not done.

The LPC2148 microcontrollers are based on a 32 bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combines the microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB. A For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty. A blend of serial communications interfaces ranging from a USB 2.0 Full Speed device, multiple UARTS, SPI, SSP to I2Cs and on chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edges or level sensitive [7].

Transceivers: ZigBee Technology

In this system the RF transceivers are used to transmit & receive data from one node to another node wireless node or data collecting module and vice versa. In recent years with development of wireless communication, there is need of low cost technology, which resulted in evolution of zigbee.ZigBee is emerging Technological Standard Created for Control and Sensor Networks based on the IEEE 802.15.4 specification for wireless personal area network. It is short-range, low power, low cost and low complexity of wireless communications technology. ZigBee uses FM technology and spread spectrum technology to work in the 2.4GHz .data rates supported by ZigBee are 250kbps, 20kbps and 40kbps [6].

The ZigBee communication module changes the physical data into data packets of ZigBee communication protocol which are then transmitted to the ZigBee coordinator. The ZigBee coordinator after receiving the data packets from the sensor node performs GMM communication with computer in central office to save and process all collected data for billing and further analysis.

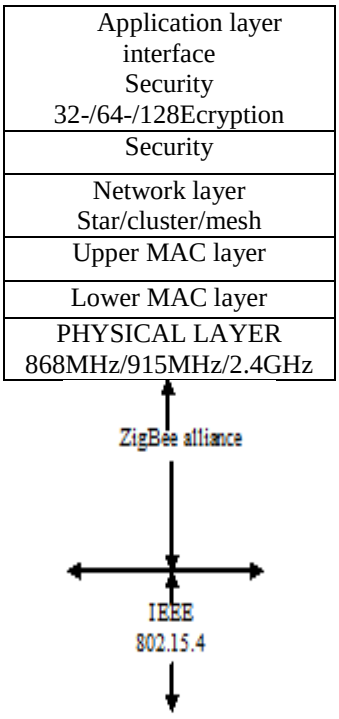

Figure 4: ZigBee Protocol Stack

Data Collecting Module

Data collecting module consists of the Microcontroller (arm7) with external memory for storing data of specific node, ZigBee transceiver which forms the coordinator, and GSM module. The coordinator is the device which initializes the network. And it is the only device in the network which is always on. The coordinator is responsible for maintaining synchronization between all the devices in the network. It starts communication by sending readout requests to metering devices which then sends its data to further node. And after receiving data from all nodes coordinator sends all data to central station for billing and further analysis. It also maintains specific data of each and every individual node. User can access coordinator through GSM module [4].

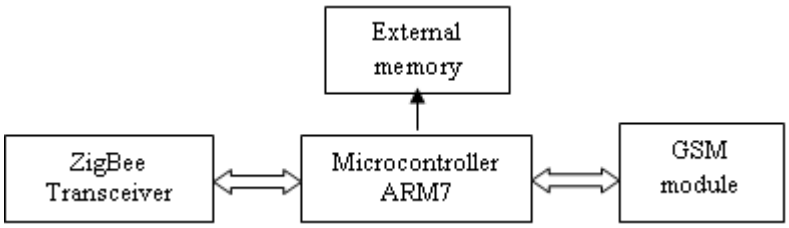

Figure 5: Data Collecting Module

GSM Module

GSM is the European Telecommunications Association. The GSM standard was developed as a replacement for first generation (1G) analog cellular networks, and originally described a digital, circuit switched network optimized for full duplex voice telephony. Global System for Mobile communication (GSM) is an architecture used for mobile communication in most of the countries. It is technological innovation which is used for exchanging and transmitting data in groups. It shares wireless channel, using IP to PPP to achieve data terminals in high speed and in distance [5].

GSM/GPRS module is used to establish communication between a computer and a GSM-GPRS system. GSM/GPRS module consists of a GSM/GPRS modem assembled together with power supply circuit and communication interfaces (like RS-232, USB, etc) for computer. The MODEM is the soul of such modules.GSM/GPRS module assembles a GSM/GPRS modem with standard communication interfaces like RS-232 (Serial Port), USB etc., so that it can be easily interfaced with a computer or a microprocessor / microcontroller based system. The power supply circuit is also built in the module that can be activated by using a suitable adaptor.

In this model GSM is used to communicate between user and central station. Data is transferred from meter in each and every house to data collecting module through ZigBee and then it is transferred to central station via GSM.

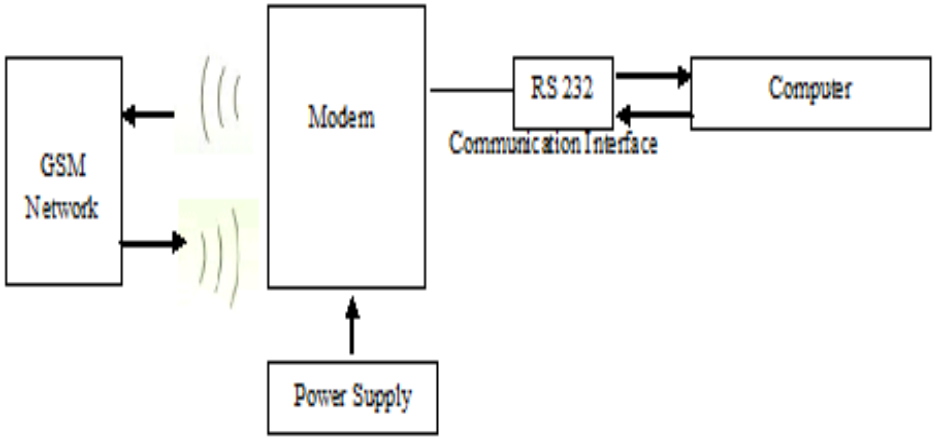

Figure 6: GSM Module

RESULTS & DISCUSSIONS

Recent progresses in integrated circuits manufacturing technology in small sizes and expansion of wireless communication technology are reasons resulted in designing of wireless sensor-actuator networks. Automatic meter reading system model presented in this paper uses WSNs for three main household utilities which are related to user of water, gas and electricity. This process includes taking meter reading, distribution of bills and sending notice about due dates via sms, cutting and reconnection of flow. The wireless automatic meter reading system described in this model is based on ZigBee technology which gives the high performance, extremely low power consumption and is low cost. This technology is very effective as compared with other wireless technologies. This system is implemented using combination of WSN and GSM technology. Wireless automatic meter reading technology can save human resources to great extent. This technique greatly improves the accuracy and instantaneity of the meter reading [3]. This also enables central authority to timely and easily access records of each and every consumer for billing and further analysis. Further, no cabling is required which reduces cost of investment. Wireless communication can be developed between nodes quickly and easily. The system can be checked very easily for detection of faults simply checking wireless data module to find it out and restore normal operation of system.

For future works, Development of Micro-Electric Mechanical Systems, or MEMS, can be used to further the progress of WSNs. MEMS are extremely small chips with integrated electrical circuits and mechanical processes to both record and process data in a single chip. This not only saves huge amounts of space, but also cuts down the power usage for each device.

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