

RESEARCH ARTICLE



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USE OF WIRELESS TECHNOLOGIES IN ENERGY MONITORING

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ABSTRACT

Modern world is very much depended on energy for its different appliances. People are using more and more devices like mobiles, laptops, washing machines and others which are totally useless if we don't have electricity. With so many devices using electricity can cause scarcity of the energy in the near future. Thus it is necessary to use energy in optimum way. One of the ways is to monitor the amount of the energy that we use on daily or monthly basis. Though we get a monthly bill for our usage but that is not the correct measure of our energy usage and thus requires more effective method. With emergence of wireless technology, we have a new way of tracking our energy usage with greater accuracy and have more control over the money we spent on the energy usage. In this paper we will try to get familiar with different wireless technologies available today and their use in energy management and monitoring. There are some previous work that we will discuss which uses Zigbee, GSM for effective energy monitoring and thus helping in tracking the energy usage for better understanding of energy consumption habits. This will help us to get idea of different methods used to make energy monitoring system and their working using wireless technologies.

Key Words: wireless technology, energy monitoring, electricity, ZIGBEE, GSM

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1. INTRODUCTION

Electrical energy plays very important role in our daily life. Be it our house or office we are unable to do anything without electricity. This is because as we have modernized our life, it is more dependent on the different appliances and electrical devices which require electricity for its smooth working. For example, mobile phones now a day are getting more features and becoming more valuable, but they also require charging on daily basis if we want to use them. Certainly electricity is essential to us and therefore it is critical to monitor its usage on daily basis. The old system of manual reading with use of meters is very time consuming. It is also error prone which leads to wrong meter readings and other miscalculations. It also requires physical attendance of the reader

which is sometimes becomes very difficult when the area to be covered is very vast. Thus this method is very costly and inefficient. There is change in energy needs of the consumer and it is due to various factors such as economical, political and environmental. There are also regulations for power quality and energy certification for houses. This change is due to electrical appliances with lower energy consumption, low cost and lesser environmental impact. It is also known that most of the energy demand is from residential, agricultural and public services. Other thing that is responsible for energy waste is power quality problem of electricity power grid.

Electric consumption and power quality problems are affecting the energy sources and has impact on the economy as this wastage of energy is extra

burden on the economic resources of the country. Traditional energy metering devices don't give us any solution for these problems. Hence we need to adopt some smart, efficient solutions which are not very costly for the normal consumers and will them to reduce their energy consumption.

Energy consumption can be reduced if consumer has an idea of how and where he is consuming the most of the energy. This tracking of usage will facilitate him to take measures so that he can reduce his energy consumption. The main problem to employ this method is lack of efficient systems to give this tracking ability. As in current scenario we don't know much about the metering system and meters are not equipped with functionality which will enable it to send the reliable data to the consumer. But the energy management and monitoring systems are changing with advance of different technologies and it is required to make consumer aware of their energy usage so that they can control it.

Industrial area also needs to consider these energy monitoring solutions as their electricity consumption is also very high. The power quality problems are more evident in the industrial area as they have heavy machinery which demand more power to work smoothly. Thus energy monitoring is very important and requires good research to get good result.

The advancement in wireless technologies has given solutions for the current problems of usage tracking and energy management. There are many systems based on ZIGBEE, GSM and other wireless communications have enabled the systems to communicate with consumers about their energy usage.

In this report we will study and describe various wireless technologies that are being used in the area of energy management and monitoring. Also we will discuss their application in the energy management and future scope for energy conservation.

2. WIRELESS TECHNOLOGY

Wireless technologies transfer data using electromagnetic waves. It does not require propagation medium which require wires. Thus it does not require network of wires and we can

communicate from anywhere. The use of electromagnetic waves permits very high speed communication in space as well as inside the medium like cable. Thus it is required to have better understanding of the electromagnetic waves and different medium used for the communication.

Wireless technology has evolved from early stages and has become the fastest growing technology in the recent time. It started with IEEE 802.11 standard in 1997 and development of interoperability certification by WIFI Alliance. Wireless technology uses electromagnetic waves to transfer information with the help of different modulation techniques. The modulation techniques used are amplitude modulation (AM), frequency modulation (FM), phase modulation. Modern versions of these techniques are used in current wireless data transmission which is a complex process but has speed and high data rate benefits.

Before 1997 the companies would use their own method for data transmission over wireless channels. But with introduction of IEEE standards in 1997 for Wireless Lan medium access (MAC) and physical layer (PHY) specification, things changed rapidly. This standard became necessary as consumers were facing problems using different equipment from different suppliers which sometimes would not work together and with advance features it was essential to get new equipment as older ones would not support those features. Thus these IEEE standards gave uniformity to the methods and equipment used for wireless technology. It also made sure that costs are down as these products were future proof and worked together with other products very well.

Today wireless technology is used in many areas and communication systems are the most benefitted areas of the all. As we have different mobile phones, remote controllers for home appliances, hand held walkie-talkies are all use wireless technology for communication. The same technologies can also be applied in other areas like tracking systems, management and monitoring systems etc.

Energy management and monitoring system can be employed using different wireless technologies. In this paper we will take overview of

different wireless technologies and their application in the energy monitoring systems. We will also see how they work and some examples to demonstrate their advantages over the current manual systems

The wireless technology is growing rapidly and has used in many applications. The various systems like LAN, ZIGBEE, WAN, Bluetooth, GSM or cellular networks, RFID are increasingly used for better and environment friendly systems. We will look at these techniques in brief in following part of this report.

2.1 Cellular Network

Cellular network is a communication network where the last link is wireless. The network is divided into number of divisions known as cells. These cells are spread over large areas. There is at least one fixed transceiver in each cell which works as a base station. Thus cell gets network which can be used for voice calls, data exchange and other purpose. These cells are joined together to get network in large geographic area. Thus we can use any portable device to communicate using its own transceiver and the base station. It is also possible to communicate even if we are moving through different regions. Cellular networks give large capacity, large coverage area and lower power consumption than satellites or large transmitter. The cellular networks are widely used for mobile communications and it has grown very rapidly in recent time. It uses different modulation techniques CDMA and GSM and has very high speed data transmission.

GSM modem is a device similar to mobile phone which can use cellular network with the help of SIM card. It uses mobile subscription from mobile operator and can be used to communicate with other devices. It can be connected to the computer through serial communication and allow the user to use mobile internet. With GSM modems are also used in different applications to wirelessly contact to the consumer. One such example is different home appliances which can be turned off or on by sending SMS using mobile devices.

Same techniques can be used in the energy monitoring for bill tracking and sending alerts in case of overuse of electricity. There are many

applications currently using GSM modules. The demand for e-metering is increasing and it requires automatic meter reading systems that can be used for getting data of electricity usage by the consumer. It can be employed at the residential or industrial area and has micro-controller based system at its core

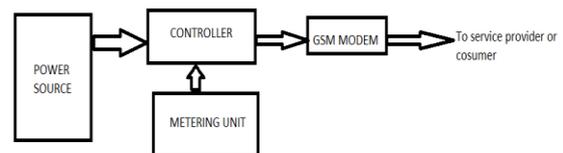


Fig.1: block diagram for GSM modem based energy monitoring

As shown in fig.1 we can use GSM modem with microcontroller to track the energy usage. This microcontroller based system is called as e-meter or electronic meter. Metering unit can be directly connected to the microcontroller for counting power usage. Microcontroller then can generate the billing statement and provide the information to service provider. GSM modems can worked on cellular as well as serial communication, thus making it very suitable for such systems. GSM modem is connected to microcontroller based embedded system through serial communication. The modem has slot for placing the sim and after placing sim inside it, we can directly use it for communication. Consumers can make enquiry about their usage by sending SMS and device will respond through the GSM modem.

Same system is employed at the service provider as a base station. It is the connected to the computer through serial communication. Base station will receive the information send by e-meters through GSM modems and can update database. The information is given to computer through serial communication. Computer has software for automatically update consumer information as it will receive it from the electronic meter. The details are periodically managed by the computer software and provide all the information to the consumer at one place.

The modems are used with AT commands which are special commands to use modems with microcontroller or computer. With the help of these commands we can program GSM modem to

make calls or send SMS to the particular number. These commands are very simple to use and anyone can easily use them to control GSM modem. The format for AT command is AT<x><N> where <x> is command to dial number or to send SMS and <N> is the argument which is mostly number.

Currently cellular communication is working with 4G networks and with the coming 5G and next generation networks the system is getting more faster and will have connections for more devices other than mobiles.

2.2 Bluetooth

Bluetooth is a wireless specification used for transferring data for very short range anywhere in the world. The range is 10 meter maximum hence is used mainly in mobile communication for transfer of data and audio files. This technology is very cost effective and uses very low power and can be used in homes, offices or even in cars. For example we have car systems that can sync with mobiles phones with the help of Bluetooth and then we can access the contents of the phone and even receive calls using car system without having to touch the phone.

It uses 2.4GHz of frequency throughout the world and functions with the help of a microchip which is used to send and receive data. It is very safe medium for data transfer and also it is protected against interference. In the beginning data speed was 1 Megabits per second and it has increased tremendously now.

The standard for Bluetooth is IEEE 802.15.1 which is approved by IEEE. Thus it became industry standard and is used worldwide for wireless transmission. Though bandwidth used for data transmission changes with different countries. For example, bandwidth in United States and Europe is 2.400 to 2.4835 MHz and in Japan it is 2.471 to 2.497 MHz.

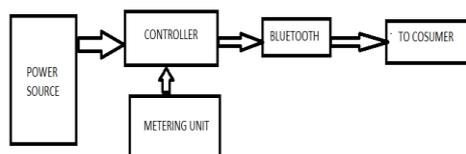


Fig.2: block diagram for Bluetooth based energy monitoring

As shown in fig.2 we can use Bluetooth in energy monitoring to communicate with the microcontroller based system and with the consumers. As it is very short range system consumers can communicate with it using their mobile phones. Consumers will always be closer to the metering system when implemented in residential area. We can provide prepaid service with prepaid meters. Consumers can use Bluetooth facility to enquire about their balance information and also can track their energy usage. The device will have Bluetooth chip in it and it can connect to the consumers' mobile phones for communication. Its great technique for residential purpose as the meters are placed in each building and it can be in the range of the consumers' mobile devices. The system is very secure with different features but has range of 10 meters only. This limits its use in long range devices. But with time we can overcome these limitations and can have better metering devices using Bluetooth.

2.3 ZIGBEE Technology

It is special wireless standard which is used for controlling home appliances. It uses very low power technology which can be used in smart energy devices for energy monitoring. It is also very cost effective and does not require the any additional wired connections. Devices with ZIGBEE can self-assemble themselves in mesh networks and can operate on battery power only for years. It is the most preferred standard in home area networks or HANs.

Though it was there for some time, it became big in 2008 with in smart energy metering with ZIGBEE smart energy profile. This profile provides standard for smart home appliances and enables the usage of ZIGBEE standards in smart energy metering and other home networks. Consumers can manage their energy consumption with real time tracking and automation.

ZIGBEE is used in many home area networks as it gives real time communication option between consumers and utilities. It enables owners to manage their bills and cut the cost on energy consumption. There are many vendors who offer ZIGBEE based products such as Landis+Gyr, Computime limited, Greenbox Technologies, LS

Industrial Systems etc. there are companies like certicom which provide encryption technology for secure wireless communication in ZIGBEE based products. Secure communications are necessary so that only authenticated persons are given access to the systems.

ZIGBEE is simple to use and can be implemented in the home automation devices. It is also scalable and robust and can support many devices in its network. It also does not get affected by the interference by other radio networks like Bluetooth or WIFI. Some devices have WIFI and ZIGBEE both in the same device.

ZIGBEE is useful in home area network for connecting it to smart energy meters which are connected in homes for energy measurement. These meters provide the meter reading which are communicated through ZIGBEE and it then given to service providers for billing and updating purpose through home area networks.

ZIGBEE is useful for ultralow power, highly reliable monitoring applications. It is based on the IEEE 802.15.4 radio standards. This standard defines physical layer and media access control for wireless communication. It operates in 2.4GHz band at 250 kbps and is unlicensed in most of the world.

ZIGBEE alliance has specified the ZIGBEE standards and it is 300 member company. This alliance use their own labs to test and certify the ZIGBEE products so that they are in accordance with the standard set by the alliance. ZIGBEE standards are open and multi-vendor standard that is available today.

2.4 Wireless Sensor Networks

Wireless sensor networks are tiny, small size electronic devices which are used in remote places to sense the data and communicate to the central station for further processing. These tiny sensors are can be merged in one system with microcontroller as central unit to form a wireless networks. Each network also contains communication devices to communicate with other networks or with the central station. In fig.3 shows main components of the wireless sensor networks.

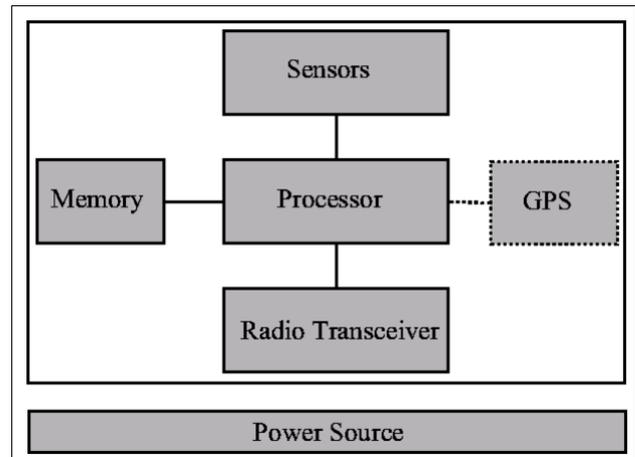


Fig.3: Main components of the wireless sensor network

These networks are very low cost and are small so can be fitted in small areas for monitoring purpose. They are also very robust to the environmental hazards hence are ideal in the places which are dangerous for humans. They are very reliable and has good accuracy. Some of the modern wireless sensors are as follows

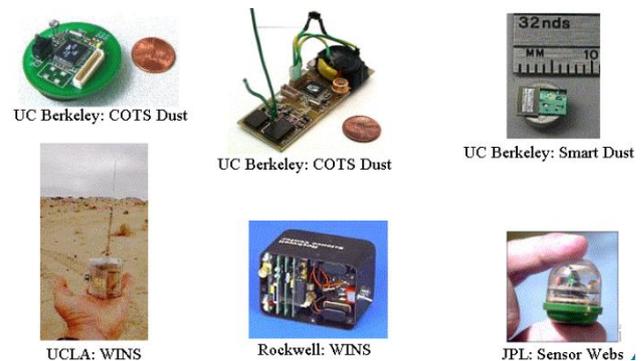


Fig.4: Modern wireless sensor networks

The wireless sensors are build using semiconductor techniques and are very cost effective. They can be used for monitoring purpose as they are very robust and can operate on low power. In energy monitoring system these networks are used as the nodes with each node connected to several meters collecting metering data to be transmitted through wireless network.

Below is the example of wireless sensor network use for energy monitoring. Different wireless networks can be implemented in different buildings in the area and these networks are then commonly connected to the home area network through ZIGBEE or other wireless technology. It then transmits the information to the data collector

and management center which is the service provider. Service provider will then use this information to update its databases and to process the billing for the individual consumer.

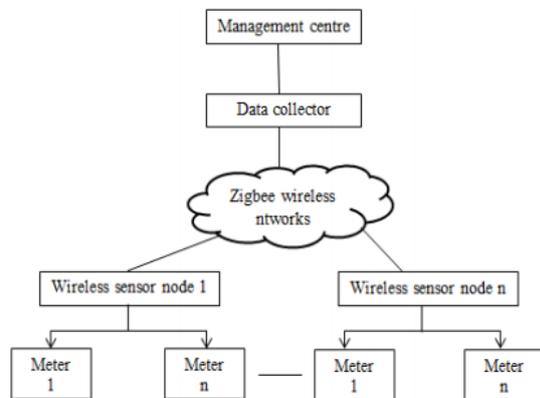


Fig.5: energy meter using wireless sensor nodes

Data is collected remotely so there is no need of physically being there at the meter site. Figure above gives basic structure for the energy monitoring system using wireless sensor networks.

The wireless technology has given new techniques for better energy management and reduce the consumption. The wireless sensor networks are efficient in providing robust and cost effective solution for energy monitoring and data usage.

2.5 WIFI Networks

WIFI is short for wireless fidelity. WIFI networks are local area networks used for data transmission over very large area. It is IEEE 802.11 standard. It provides broadband connectivity for the users. It is very fast and can connect number of devices in its network simultaneously. There are many devices and appliances which have WIFI facility and can connect to the internet. This gives many benefits for embedded engineers as these devices can be effectively used in data monitoring and management applications. We can access remote location as there are no wires to interfere with and cost is also reduced. It also gives flexibility to the system. With the help of WIFI different devices can be connected to internet when an access point is located. Access point can cover one or more areas which are known as hotspot.

The connection to WIFI is through access point. The access point sends a beacon over the network. These beacons are nothing but packets

containing its service set identifier. There are number of clients who want to connect to the WIFI network and thus accept this packet when they come in the vicinity of the access point. The packets are sent at 1Mbits per second speed for every 100ms. Once the packets are accepted by the client they can communicate using the WIFI network.

Energy monitoring is very useful application of WIFI networks. We can use it at the base station or as home area network to collect information from smart energy meters and also from other networks like ZIGBEE. It can be used to process the data at the service provider's end and are useful in maintaining the user database. The database has all the information if the consumer and we can also provide billing information and online bill payment facility with WIFI network.

With many devices having access to the internet through WIFI client can track his data usage using mobile or cellular devices. With correct authentication the service provider can let the user access his record and thus can make him aware of his electricity consumption. This will allow the user to control his usage and this then can lead to better energy management in the residential and industrial areas.

2.6 Internet of Things (IOT)

This is new emerging technology which has smart devices always connected to the internet. Smart devices are embedded systems developed for specialized application. It has microcontroller as central processing unit and also consists of sensors, actuators and communication devices. They have internet connectivity so that they are always connected to the WIFI network taking data and giving outputs. IOT has given a good option to be used in home automation, smart energy management and monitoring systems. It can have many number of devices in its network. Though it is dependent on the application but it is growing at fast pace and in near future can have most number of homes with IOT systems in them.

This is future of the smart energy management systems. Devices are interconnected with each other through some gateway may be ZIGBEE protocol or Bluetooth and they provide data of the energy consumption and other important

information. This data continuously given to the central unit and is processed to take action. This central unit will be connected to the bigger service provider through internet which will monitor data and energy management.

3. CONCLUSION

Various wireless technologies are discussed in this report. These technologies provide better energy management and monitoring. The systems are mainly provide better communication and fast data transmission. Use of GSM enables user to directly connect to the smart metering devices to get the usage data. But these devices will be charged according to their cellular voice rates and also have network issues. On the other hand ZIGBEE is very cost effective and has good networks at remote areas also. But they can operate over certain range and are therefore used in mesh networks or other network topologies.

Bluetooth is the most weakest of them all as it has very short range but it can give information directly to the consumer for tracking data. Wireless sensor networks are very robust and can work very well in remote areas. They are very good for industrial areas. But power requirement is measure issue in their deployment.

WIFI is used to provide connection to the internet. In all applications it is mostly required to gather data from smart metering devices and maintain the consumer database. It is mostly used by the service provider to manage the databases of the consumers

In the end it is noted that these different technologies have different advantages and can be used better if combined together. They will provide greater control over monitoring and controlling process and make the system more robust and effective.

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