WIRELESS SENSOR NETWORK BASED INTELLIGENT HOME IMPLEMENTING USING ARDUINO AND ZIGBEE

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***Abstract*— Automation and security is a one of the important issue in a modern domestic environment. This system focus on developmental and research issues of Wireless Sensor Network based Smart Home. Wireless Sensor Network based smart home monitoring system provides a secure and safe living environment. A Wireless Sensor Network (WSN) is a network which is constructing by using small autonomous nodes (sensors). Its purpose is to monitor certain environmental parameters such as temperature, humidity, brightness, pressure, sound, motion, etc.**

This system describes the development of a smart home environment based on accurate Wireless Sensor Network using Zigbee and also describes residential energy monitoring and controlling techniques for smart home networking system. This paper propose a simple and flexible wireless network for domestics automation of temperature, humidity, gas, motion and light by implementing reliable sensor nodes which can be controlled as well monitored. This technology offers exciting and new opportunity to increase the connectivity of devices within the home for the home automation.

***Keywords*—Home automation, Wireless sensor network, Arduino and Zigbee**

I. INTRODUCTION

In developing world everyone feel happier in a comfortable and secure home environment. Constructing an intelligent and safe home environment is one of the important and most attractive issues for many researchers and engineers. Several industries and research have attempted to construct intelligent environment by installing intelligent sensors and devices. To provides services for user all these sensors, devices are integrated by wireless network [2].

Integration of smart devices as well smart network in residential area can be making it smart and also helpful to manage energy appropriately, effectively. Such a smart home provides various advantages with Wireless Sensor Network includes remote monitoring, continuous data recovery, energy consumption, location tracking, management of temperature and humidity, motion detection, understanding and observation of the people's environment [12].

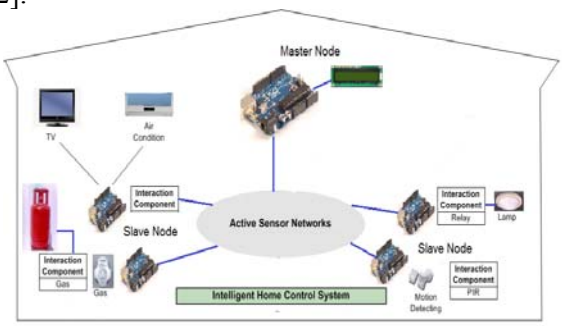

Fig. 1 Intelligent Home Control System

Smart home system is an intelligent home network together with advanced communication technology and sensing control technology to carry out effective control and information exchange [10]. WSN are gradually being used in the home for energy management services likes lighting is automatically controlled through information such as the resident's movement or

the intensity of illumination gathered by WSN and consumer devices are monitored and controlled by WSN installed in the home [1].

The Home Automation system provides mutual interoperability among the different electronics and electrical devices. This system also provides interactive interface for people to control their operation and this will very helpful to optimize and economize energy consumption [8]. Home automation is upcoming trends that people looks for residential houses, apartments, commercial uses. People want to live in more intelligent living spaces to make their life easier, safer and more enjoyable [9].

Zigbee based wireless sensor network is used as a new short range wireless communication technology which is low data rate, low power consumption, highly reliable, fast reaction, programmable, robustness and security [2]. Zigbee is a local area network designed specifically for application of automation or control system [8]. Zigbee is a best solution for WSN which is based on IEEE 802.15.4 standard and is extended with network and application for upper layers for simplifying the design effort of a WSN application. With proper integration of Zigbee and sensors it would be efficient to develop and build wireless real time monitor and control system [11].

II. REQUIREMENTS OF A HOME AUTOMATION SYSTEM

A Home Automation System fulfils the following requirements in order to improve existing conditions of environment. Home Automation is applied to a wide range of products and systems in the home likes refrigerator, washing machine, dishwasher, oven, vacuum cleaner, home theatre, DVD, television, night lights, electricity, security against fire, gas leaks, water leaks, electrical leakage and short circuit, assistance to disabled person, elderly and children, domestic environmental monitoring, energy consumption monitoring, health monitoring, etc.

1. Comfort: The system needs all the tools to simplify and make easier the liveability within the home. It ensures that the level of perceived occupant comfort is as high as possible which includes ease of use of the various Home Automation System functions.
2. Energy saving: In this all the techniques and systems capable to optimize energy consumption which able to source the cheapest energy source.
3. Safety: System is intended as protection from possible malfunction of equipment potentially dangerous or harmful to people and housing which are used fire protection systems, anti-flooding, different sensors like gas, smoke etc., loads of power transmission.
4. Security: Security is the control of the access from the outside like burglar alarms and access control systems, computer attacks, since they are coming from the external network, are managed by several technologies such as Proxy, Firewall.
5. Stability: Stability is a system ability to react to failures of individual modules in order to avoid mistakes that could compromise the functioning of the entire automated environment [4].

III. WIRELESS SENSOR NETWORK

Recent advances in sensing, computing and communication technologies coupled with the need to continuously monitor physical phenomena have led to the introduction of Wireless Sensor Networks (WSNs). Wireless sensor networks (WSNs) are special kind of ad-hoc and dynamic wireless network which consists of number of wireless sensor nodes. Each sensor node is capable of limited amount of processing and power. But when they are coordinated with other nodes in the network, they have the ability to communicate over the large range.

WSNs are an emerging technology that is being used to collect information for various environmental parameters such as temperature, pressure, illumination of light, humidity etc. WSNs are has a variety of application domains e. g. home, office, automation and control, transportation, logistics, healthcare, environmental monitoring, security and surveillance, process monitoring, vehicle monitoring and detection and it also have concerns about energy-efficiency, security, reliability and scalability, habitat monitoring, and disaster detection, vehicular traffic management, precision agriculture.

WSN consist of four major components: A radio, a processor, sensors and battery. The key constraints for development of WSNs are limited battery power, cost, limited computational capability, and the physical size of the sensor nodes. Wireless sensor networks

have features like Reliability, Accuracy, Flexibility, Cost efficiency, Ease of Installation. Most commonly used wireless communications standard in WSNs is based on the IEEE 802.15.4, known as Zigbee.

A recent issue regarding WSNs is that it is one of the top 10 emerging technologies according to IEEE spectrum. WSNs may either connect to the various cellular networks or through the wired internet. A sensor network provides easy access for the information from anywhere at every time. This should be achieved by collecting; processing, analysing and spreading data thus wireless sensor network plays an important role in creating smart environments.

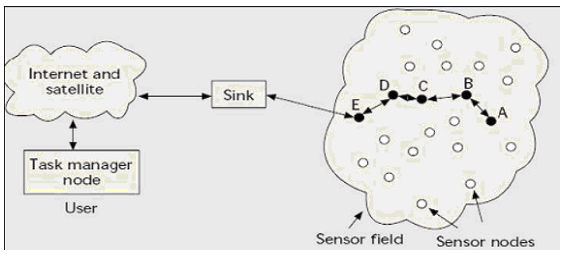

Fig. 1 Wireless Sensor Network architecture

The typical wireless sensor network consists of following fields:

Sensor Field*:* A sensor field is nothing but the area in which the nodes are placed.

Sensor Nodes*:* Sensors nodes are the heart of the network, they are in charge of collecting data and routing this information back to a sink.

Base Station*:* It is a centralized point of control within the network, which extracts information from the network and disseminates control information back into the network, also serves as a gateway to other networks. It is a powerful data processing and storage center and an access point for a human interface also. The base station is nothing but a workstation.

User: User is the controller or a person who want the information of wireless sensor network to take decision [13].

IV. ARDUINO

The fundamental unit of Wireless Sensor Network is a Sensor Node, also called as mote. Each sensor node is required to be capable of sensing, processing and communicating the processed data to the neighbouring nodes to form a network. Sensor node is hence composed of sensors to sense the physical phenomenon, analog to digital converter, microcontroller for controlling and data processing, memory for algorithms and data storage, radio unit for short range wireless communication and battery unit to power all the units.

Fig. 2 Wireless Sensor Network node - Arduino

Arduino is a tool for making computers that can sense and control more of the physical world than your desktop computer. It's an open-source physical-computing platform based on a simple microcontroller board, and a development environment. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. The Arduino programming language is an implementation of Wiring, a similar physical-computing platform, which is based on the Processing multimedia-programming environment.

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter [ ].

V. ZIGBEE OVERVIEW

ZigBee is a wireless communication technology for short coverage, low data rate, less complication, low power and low cost. It's widely used in the field of auto-control and remote control. ZigBee is based on IEEE802.15.4 standard and it co-ordinates thousands of tiny sensors. These sensors send the data from one sensor to another through radio waves and consequently provide high telecommunication efficiency. In brief, ZigBee

is a low cost, low power, short coverage wireless network communication technology compare with the other existing technology such as WiFi, Bluetooth, IR, etc.

Table 1.Comparision of Wireless technology

Features	Wi-Fi	Bluetooth	ZigBee
Battery Life Time	Several hours	Several days	Several years
Complexity	High	Complex	Simple
Nodes Number	32	7	65,000
Communication time	3 seconds	10 seconds	30 milliseconds
Coverage	100m	10m	10m-several Km
Data Rate	11 Mbps	1 Mbps	250 Kbps

A. *Zigbee network architecture*

In general, a complete ZigBee network contains 3 major parts: ZigBee Coordinator, ZigBee Router and End Device.

- ZigBee Coordinator: The coordinator is the central unit of a Zigbee network. The generation of network beacon, controlling the formation of network topology and coordinating the communication and flow rate of the devices in the network.

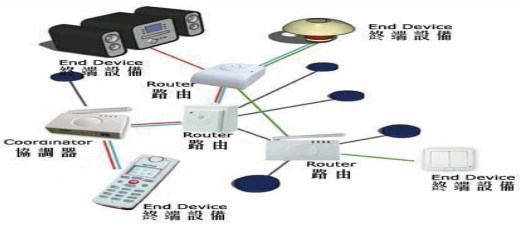

Fig. 3 Zigbee network architecture

- ZigBee Router: The transmission of data, coordination of flow rate of some devices in the network, sending and receiving commands and data, and permitting subsidiary device comes under the supervision of router. It also helps to extend the coverage of ZigBee network that's why it is also called as repeater.
- End Device: End device present at the bottom of network topology, which supervise sending and receiving data and execute commands. Generally, there should not be hand over data to other devices [3].

VI. SYSTEM ARCHITECTURE

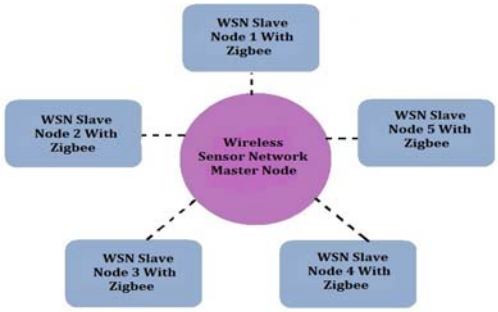

Fig. 4 system architecture

System architecture consists of one master node and several slave nodes which are connected wirelessly in a network. The sensor node includes Arduino uno board, Zigbee module and different sensors like temperature, light, gas, humidity and PIR sensor. These sensors are interface with the Arduino board. The detail of sensor node will be in next section.

A. *WSN node with its components*

A sensor node, also known as a mote in a wireless sensor network that is capable of performing processing, gathering sensory information and communicating with master or other connected nodes in the network. A mote is a node but an every node is not always a mote.

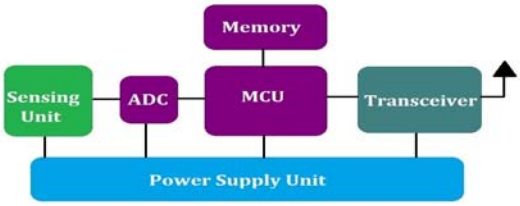

Fig. 5 sensor node

A sensor node generally consists of following major parts:

- Computation: It consists of a microcontroller (MCU) which is responsible for the control of the sensors and execution of communication protocols. The controller performs tasks, processes data and controls the functionality of other components in the sensor node. MCU's usually operate under various operating modes for power management. Shuttling between these operating modes involves consumption of power, so the energy consumption levels of the various modes should be considered for the battery lifetime of each node.
- Communication: The possible choices of wireless transmission media are radio frequency (RF), optical communication

(laser) and infrared communication. Radio frequency-based communication is generally fits for most of the WSN applications. WSNs tend to use license-free communication frequencies like 173, 433, 868, and 915 MHz; and 2.4 GHz. The functionality of both transmitter and receiver are combined into a single device known as a transceiver which consists of a short range radio device which is used to communicate with neighboring nodes and the outside world.

- Sensing: It consists of a group of sensors. Sensors are hardware devices that produce a measurable response to a change in a physical condition like temperature or light. Sensors measure physical data of the parameter to be monitored. The continual analog signal produced by the sensors is digitized by an analog-to-digital converter and sent to controllers for further processing.
- Power Supply: It consists of a battery or external supply of power to its corresponding node. Usually the rated current capacity of a battery being used for a sensor node is lesser than the minimum energy consumption required leading to the lower battery lifetimes which can be increased by reducing the current drastically or even turning it off often.[6]

B. *Structure of proposed system*

Fig. 6 General structure of proposed system

In proposed system different electrical appliances or devices can be controlled by WSN master node through WSN slave node. The communication between master node and electrical devices can be performed by Zigbee transceiver which is a wireless communication device located at WSN nodes.

Any electrical appliances such as light, FAN or AC, T.V. etc can be controlled depending upon the reference point stored in the memory of master node which is useful for decision of performance of electrical appliances e.g. if light intensity is set to 20 luminous. If illumination of light intensity goes below 20 then sensor will detect that change in intensity of light. This information is transmitted to WSN master node. Information is collected from number of WSN slave node connected to light through relay. Every slave node connected to master node by using Zigbee transceiver. According to reference point stored at master node it will take action to turn ON the light.

In the system the different sensors are used which is placed according to star topology. Each slave node connected to the required electrical appliances or devices needs to be control. The sensors will detect its corresponding physical parameter convert it into electrical signal. The converted signal will transmit the information to the WSN master node from WSN slave node. After getting the information mater node will check it with reference value of parameter and pass controlling information towards corresponding slave node to take the necessary action and through relay the electrical appliance can be operated. Likewise all the different electrical devices can be control through the automation and minimize the energy consumption.

VII. CONCLUSIONS

This paper focused on development of wireless sensor node and coordinator for intelligent home system based on Zigbee technology. We address a new intelligent home control system based on sensor networks to make home networks more intelligent and automatic. We suggest new ubiquitous home scenarios based on this proposed system. The proposed system is flexible and easy to implement sensor network having low cost, low power more reliable. An intelligent home control system can provide both significant cost savings in a home environment, as well as a great level of flexibility and control for the building administrators and great comfort for the occupants. This work focused on the smartening of home through automation with wireless sensors working in network to continuously monitoring and controlling of different electrical devices.

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