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Implementation of Smart Home Control by Using Low Cost Arduino & Android Design

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Abstract: This paper provides a low cost-effective and flexible home control and monitoring system with the aid of an integrated micro-web server with IP connectivity for access to and control of equipment and devices remotely using Android-based smartphone app. The proposed system does not require a dedicated server PC with respect to similar systems and offers a new communication protocol for monitoring and controlling the home environment with more than just switching functionality. Smart home interfaces and device definitions to ensure interoperability between ZigBee devices from various manufacturers of electrical equipment, meters and Smart Energy enables products to allow manufactured. We introduced the proposed home energy control systems design intelligent services for users and provides, we show their implementation, with smartphone.

Keywords: ZigBee, Smart Home, Home Automation, Android, Smartphone.

I. INTRODUCTION

Intelligent management of the power system, facilitate the joint use the current and minimizes power loss during transmission and power consumption is highlighted by the global community, academic institutions, and State administration. To gain full utility and customer protection dimensions, the idea of a smart grid enabling technologies used in In recent years, attracting a great deal of attention in the energy industry and academia Such studies.

With continued growth in popularity and functionality of mobile devices, demand advanced mobile applications widespread human life continue to grow. The use of Web Services is an open and interoperable method for providing remote access service or applications can communicate with each other. An attractive market for home.

Automation and network of busy families and individuals will be physical Limitations. IBOARD is Ethernet Shield, and it was the smart Home micro web server. Arduino open source electronics prototyping platform based on Flexible, easy-to-use hardware and software. The Arduino IBOARD Microcontroller Board of Based on the IBOARD with 54 digital input / output pins. The Ethernet interface is Arduino Arduino via the SPI pins. Low-voltage switching relays were used to integrate Devices with Arduino is to show switching functionality. The LM35 temperature Sensor is used to control a smart home environment.

A supervisory control system Intranet, low cost and high performance can react The ZigBee technology. An end node, the node sends data to the coordinator, and the coordinator Hub sends the data back to the terminal end of the loop. Since all devices have their own IP Address based on IPv6, they can be directly connected to an external network. So, all smart devices It can not only through the handheld remote control device to the central and local home, but can also be controlled remote computer control through the introduction of home Internet Gateway machine.

II. RELATED WORK

A. general smart home design

Smart Home is applied in order to provide comfort, energy efficiency and better security. Smart Home System is still rarely used in Indonesia because of the cost and the difficulty of getting the device. The objective of this paper is to offer a Small Smart Home System designed and created by utilizing WLAN network based on Arduino microcontroller. The system is able to monitor and control lights, room temperature, alarms and other household appliances. Results from testing the system show proper control and control monitoring functions can be performed from a device connected to a network that supports HTML5. [1]

Smart home network excite new possibilities. We proposed a new smart home energy management system based on ZigBee sensor networks to make home networks more intelligent and automatic in figure1. The role of the SHEMS for managing energy usage is a crucial factor in addressing the home's growing energy concerns. The Smart Energy initiative serves these needs by providing an adoptable and sustainable experience by linking new and useful digital technologies to the needs of consumers. By empowering consumers with near real-time information of their energy usage through an array of products and services, the intent is to help consumers use energy more efficiently and also to minimize their personal impact on the environment.

We implement the proposed system and develop related hardware and software. We suggest new SHEMS based on the proposed system. We expect that our work contributes towards the development of ubiquitous home networks. As a part of future work, we will apply IEEE 802.15.4 standard technology in our home. [2]

Wireless sensor networks (WSNs) and power line communications (PLCs) are used in this work to implement a smart home control network.

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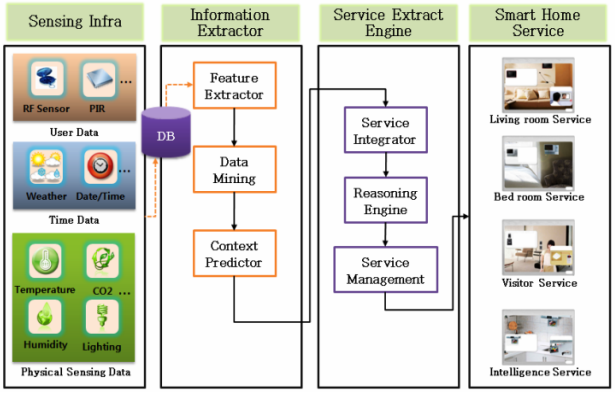

Fig.1 Block diagram of the SHEMS

The goals are to reduce the impact of wireless interference on a smart home control network and unnecessary energy consumption of a smart home. An isolated WSN with one coordinator, which is integrated into the PLC transceiver, is established in each room. The coordinator is responsible for transferring environmental parameters obtained by WSNs to the management station via PLCs. The control messages for home appliances are directly transferred using PLCs rather than WSNs. According to experimental results, the impact of wireless interference on the proposed smart home control network is substantially mitigated on figure2.[3]

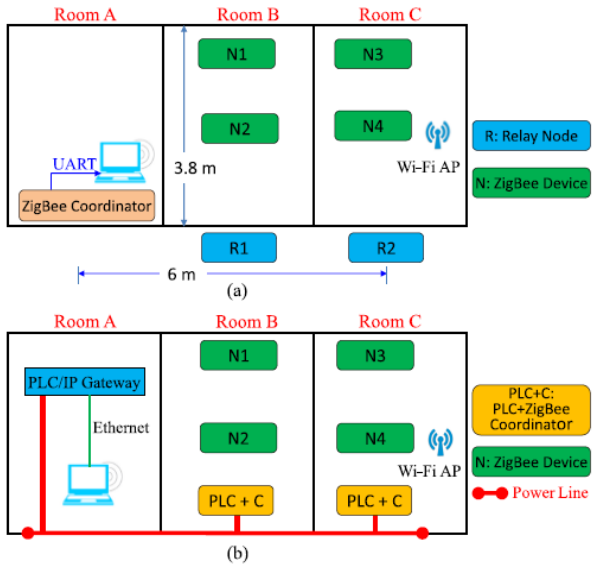

Fig.2. Architecture of smart home control network based on (a) WSN with relay nodes, (b) WSN plus PLC

B. brain of the system

A central controller (our Arduino board) receives user commands to execute. It has Internet connectivity through an Ethernet shield mounted on the Arduino. On the user side, a mobile device provides interface with the system as a whole through a user-friendly application. The mobile device can be either wired to the central controller (through USB cable for instance), or communicates with it wirelessly. Within the scope of the home, wireless connectivity can be achieved using an Ethernet shield on the central controller.

This way, we would be able to access the controller either locally or remotely through the Internet in Figure 3.[4]

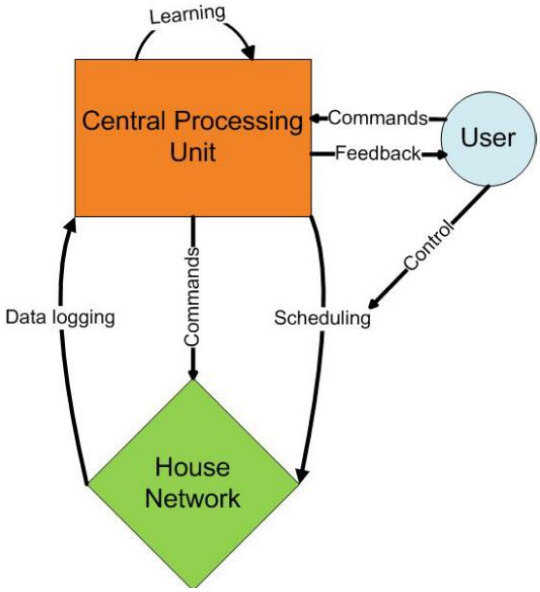

Fig. 3 Functional diagram of the system

C .Communication protocols between Home Automation devices Equations

The control centre of network is home gateway system, which is, from inside, to coordinate all household appliances, control their working condition and inquiry their current status, and, from outside, connect with Internet, receive remote users' instructions and transfer related information to business sites.

Internal Communication Every data transmit between ZigBee networks can be communicated by each other, so people in any room can control the other room's devices. The query flow-work of home appliance is shown as follows: Appliance receives information from home gateway by ZigBee module and detects the household appliance's status, and then corresponding status will be transmitted to the home gateway by ZigBee module. If all appliances work properly, home gateway stores appliances' status. If not, home gateway reports an error message to supplier.

External Communication Home gateway interconnects Internet and the home network. It sends all devices information in home network to the portal server via TCP/IP socket. And also it can control and monitor the devices with date packet communication. Thus it enables users to control and monitor the home networks through Internet and even mobile phone since the portal server has the mobile interface.

The control flow-work of home appliance is shown as follows: Home gateway receives external packets, then unpacks and gets the destination address. The next step is to select routing (destination appliance) and then transmit the data. Appliance receives the data and tests them. If the data are error, the appliance then returns an unsuccessful message to the home gateway.

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If proper, appliance implements corresponding operation and returns the operation information to home gateway. [5]

D. Hardware Implementation and Home Automation Devices

The Arduino Uno and Ethernet shield were used to implement the micro Web-server for the Home gateway in figure 4. Home gateway connects to the Internet a. The Arduino Uno is an open-source microcontroller that uses ATMEGA 328, an Atmel AVR processor which can be programmed by the computer in C language via USB port. Arduino Uno also has on-board 5 analog pins and 13 digital pins for input and output operations, supporting SPI and I2C which can be used to interface with other devices.

The Ethernet module acts as a bridge to connect the Home Gateway to the local proxy. A conventional light switch was integrated with the Arduino using relays to demonstrate the switching capability as illustrated in our and an LM35 temperature sensor was used for temperature monitoring while a non-invasive 30A current sensor was utilized for power monitoring. Used to successfully integrate the current sensor with the Arduino Uno. The hardware architecture presented is flexible and allows other home appliances and devices to be seamlessly integrated with minimal changes. [6]

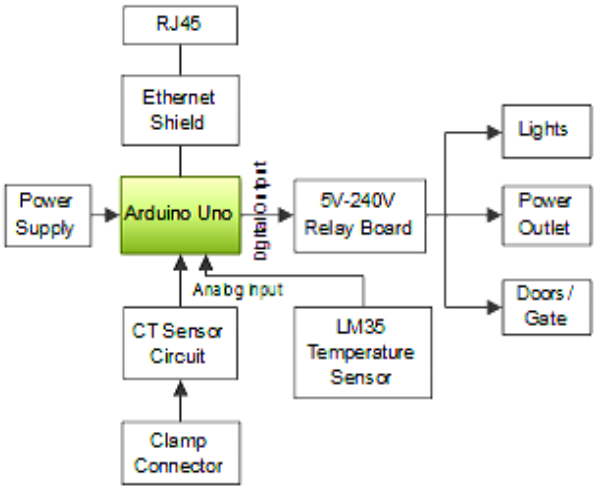

Fig. 4Hardware architecture and implementation

E. Energy Management

Consumer-side energy management is a part of the smart grid program.

The customer can control the power consumption according to the power line's load, Smart-grid enabled smart homes with time-of-use metering and energy management devices and tools help consumers monitor, manage andcontrol energy usage, while helping them optimize performance and reduce energy losses from major appliances, heating, cooling and lighting. With a smart home energy management system, consumers can manage energy usage and costs throughout the day, without compromising their lifestyles. The network architecture of SHEM system is illustrated in Figure 5.

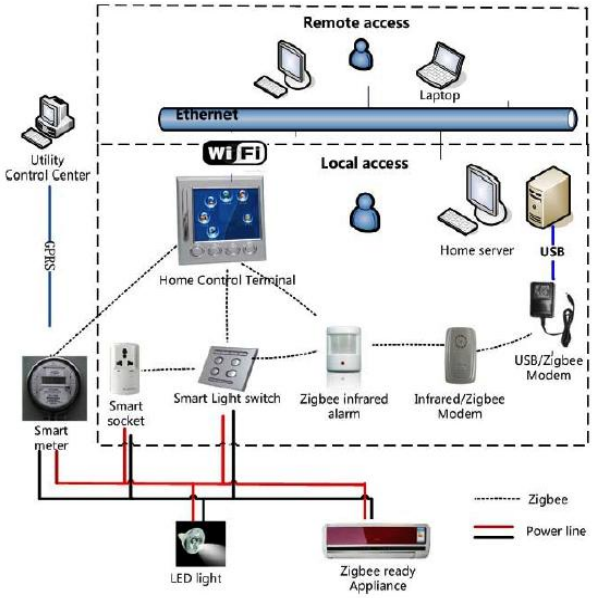

Fig.5. Network architecture of a smart home energy management system

F. System Architecture

In the proposed design, a low cost smart home system for remotely controlling and monitoring the smart home environment is presented. An overview of the proposed system architecture is shown in Figure 6. The system consists of an app developed using the Android platform and an Arduino Ethernet based micro web-server. The Arduino microcontroller is the main controller that hosts the micro web-server and performs the necessary actions that needs to be carried out. The sensors and actuators/relays are directly interfaced to the main controller. The smart home environment can be controlled and monitored from a remote location using the smart home app, which will communicate with the micro web-server via the internet. Any internet connection via Wi-Fi or 3G/4G network can be used on the user device. The features that the proposed design offers are the control of energy management systems such as lightings, power plugs and HVAC (heating, ventilation and air conditioning) systems; security and surveillance system such as fire detection and intrusion detection with siren and emailnotifications; automatic smart home environment control such as maintaining a certain room temperature; voice activation for switching functions and has user authentication to access the smart home system.[8]

G. The android platform app

There are several platforms for developing smart phone applications such as Windows Mobile, Symbian, iOS and Android. In the proposed system, the Android platform app is developed as most of the phones and handy devices support Android OS. Java programming language using the Android Software Development Kit (SDK) has been used for the development and implementation of the smart home app. The SDK includes a complete set of development tools such as debugger, libraries, a handset emulator with documentation, sample code and tutorials.

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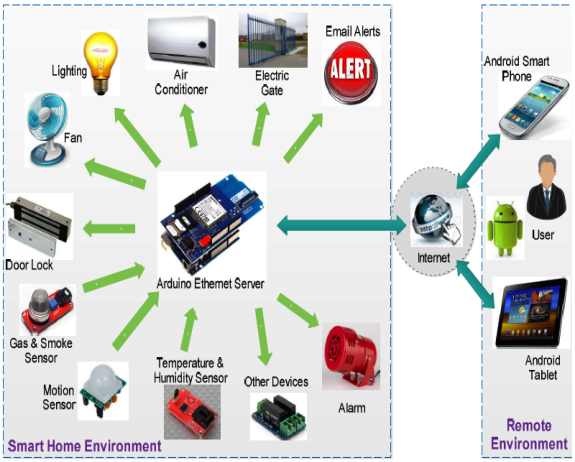

Fig.6. System Architecture of the proposed Ubiquitous Smart Home

Eclipse (running on Windows 7 development platform), which is the officially supported integrated development environment (IDE) has been used on in conjunction with the Android Development Tools (ADT) Plug-in to develop the smart home app. The screenshots of the smart home app developed is shown in Figure 6 while the processing of the smart home app is shown in Figure 7.
The designed app for the smart home system provides the following functionalities to the user: [8]

- Remote connection (via internet) to the smart home micro web-server; require server real
- IP and user authentication.
- Device control and monitoring.
- Scheduling tasks and setting automatic control of the smart home environment.
- Password change option.
- Supports voice activation for switching functions.

H. Input /Output Block
Input/output block consists of two pieces of PIR (Passive Infra-Red) motion sensor and an LM35 temperature sensor as inputs and some lamps, sockets, relay and buzzer as outputs.

PIR sensor is used to detect the presence of motion. The sensor readings are used to turn off the lights if there is no activity and turn on the lights otherwise. In addition, this sensor is also used for security systems to detect suspicious movements. If it detects any suspicious movement an alarm (buzzer) will sound. An LM35 is functioning as temperature monitoring. This sensor also serves as an input in order to execute some sockets. The socket will in on condition when the temperature exceeds a certain limit. This condition will activate a fan or Air Condition (AC) while connected to the socket. Connection circuit between microcontroller system with a PIR sensor and an LM35 sensor is shown in Fig8 and Fig. 9.
Output part consists of the relays and buzzer. Buzzer serves as a warning alarm when there is suspicious movement. Relays connected with lamps and socket. Relay circuit is shown in Fig. 10.[9]

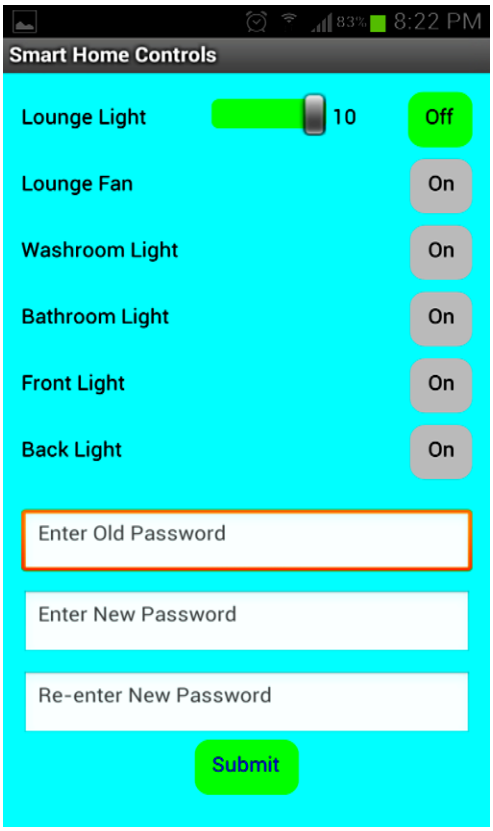

Fig.7. Screenshots of the proposed smart home app

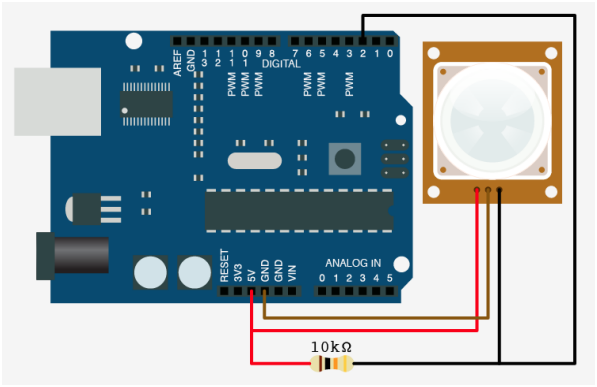

Fig.8. Connection Circuit of PIR Sensor

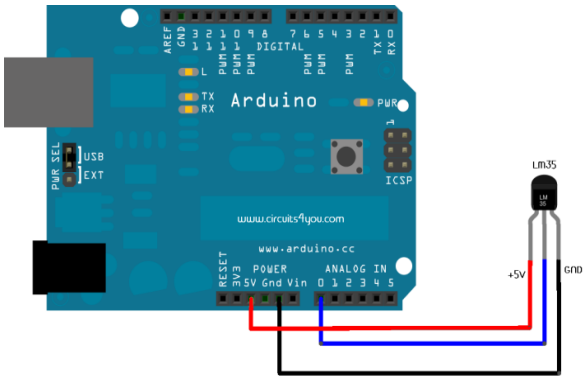

Fig.9. Connection Circuit of LM35 Sensor

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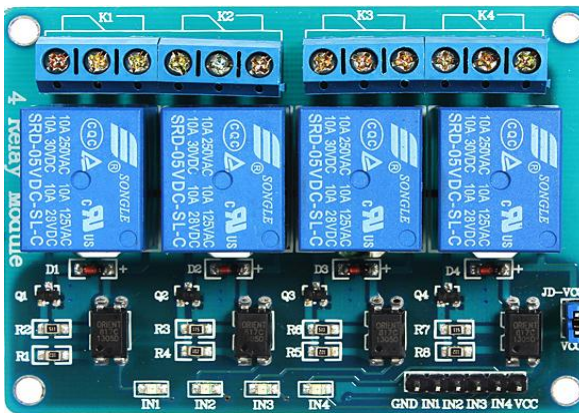

Fig.10. Relay Circuit

III. DESIGN OF SMART HOME CONTROL NETWORK

A. Central Controller

Central controller (Arduino) receiving commands used to perform. You may connect to the Internet through an Ethernet shield mounted on the Arduino. On the user side, provides a portable interface to the system as a whole through an easy-to-use application. Can either be wired mobile device of the central control unit (through the USB cable, for example), or in connection with this wirelessly. Within the home, wireless connectivity can be achieved by using the Ethernet shield on the central console. This way, you will be able to access the console, either locally or remotely through the Internet. In this case, client/server architecture is the one to choose, because the central console as a static entity that responds to requests from clients (mobile devices) (and sends notifications, as well as them eventually). Hence need for server (at the application level, any piece of code that can respond to client requests) is closely linked to the company. We'll use a simple Web server application running on Arduino that communicates via HTTP protocol with Web-based Android app. [4]

B. Block diagram

I. IBOARD

Iboard is a unique Arduino board which features a WIZnet Ethernet port, an XBee socket, nRF24L01+ module interface and an ATMega328. This board will add wireless XBee / nRF24L01+ control as well as internet

Fig.11. Arduino I Board

connectivity to your projects. It's great for anything from home automation to robot control in figure 11.[10]

II.XBEE ZIGBEE

ZigBee is an open global standard built on the IEEE 802.15.4 MAC/PHY. ZigBee defines a network layer above the 802.15.4 layers to support advanced mesh routing capabilities. The ZigBee specification is developed by a growing consortium of companies that make up the ZigBee Alliance. The Alliance is made up of over 300 members, including semiconductor, module, stack, and software developers in figure 12.[11]. XBee Series 2The difference between Series 1 (S1) and Series 2 (S2) isthat the latter enhances the power output of the antenna to 2mW. S2 also enhances the data protocol of the XBee module.S2 is similar to S1 in enabling simple and easy communication between microcontrollers and supporting point-to-point and point-to-multipoint communication. [12]

Fig.12.XBee S2

III. MAIN DIAGRAM

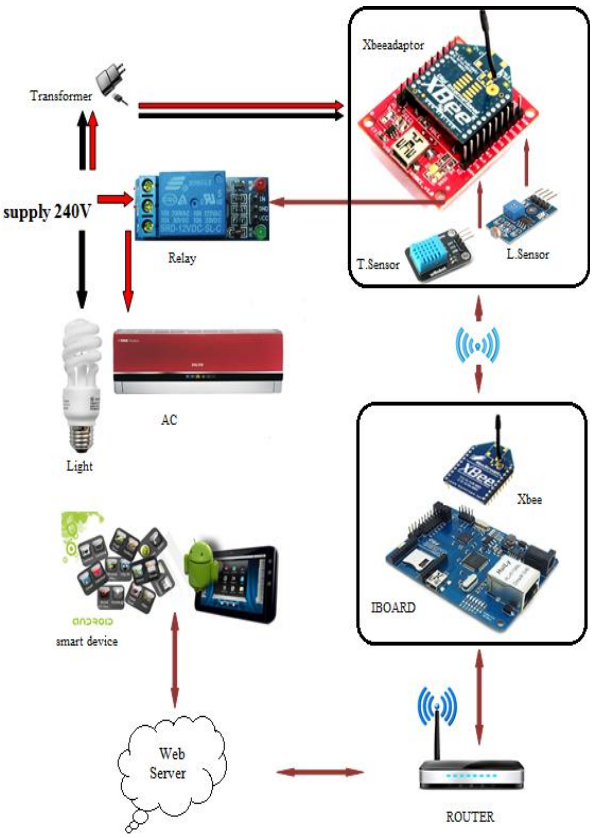

Fig.13. System architecture of Android Smart Switch system

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The entire system in this project was to make the appropriate size component is a device smaller and can fit into the existing switch housing designed. The prices also become a factor in the component selection of the components.

Figure.13, Shows the system design architecture. This system architecture has two main parts. The first part is the smart switch apparatus that is connected to the existing wiring of the electrical appliances in the house, such as a ceiling air condition and lamp in order to ge power supply. This unit will receive supplies from the lives and neutral of home supply that are connected to the power module. It is 240 VAC to convert (AC) to (DC) with 5V rectifier type DC power supply Xbees adapter. [13]

C. Procedure

1. The function of the relay module as normal switch "ON" and "OFF" will turn a lamp. An infrared detection system consists of infrared sensor as an input, while the relay module as starting Arduino XBee adapter. The XBee is a feature-rich RF module for use on a wireless sensor network. The IEEE 802.15.4 protocol greatly reduces the work of the programming f ensuring data communications. The XBee has many other features for use in a WSN beyond its networking ability. Now that you have a better understanding about the XBee's features and uses, we will look at means of interfacing the RF modem to your microcontroller and showing examples of use.[14]
2. The access point consists of IBOARD that can connect to the Internet and transmission of data to hosting server or smartphone. The hosting server is received and the data stored in database, as we described, if we want to give our Arduino the ability to communicate over the Ethernet cable, and more generally over an Ethernet network, we have to implement the required standards in the firmware. There is a library called Ethernet that can provide a great number of features. As usual, we have to include this native library itself. You can choose to do that by navigating to Sketch | Import Library, which includes almost everything you need. However, since Arduino version 0018, because of the implementation of SPI and because the Arduino Ethernet Shield communicates with the Arduino board through SPI, we have to include something more. Be careful about that.[15]
3. The data in the database to transfer on the same web page hosting server to show the data that is the switching state. The web page on hosting server can read and update data in database. Writing the Code for the Web Client For the Web-enabled light switch, we will create a simple Ruby on Rails project to manage the user interface interaction first via a web browser. We won't spend a lot of time on the user interface, though, since that will ultimately be the job of the custom Android application we will create after the web interface is functionally tested.[16]
4. The Android app was designed to show the switch is the same as the web page on hosting server. It can also read update data on the database by touching the "ON" or "OFF" and appears on the button as on the website. This smart switch device, the lamp in a house controlled manually with the infrared switches detection system or wirelessly with Android App. Writing the Code for the Android Client You might be wondering why you should go through the trouble of building a native Android client when the web application we wrote can be accessed by the Android mobile web browser. Well, if all you wanted to do was toggle light switches on and off, then I would say you don't need a native client.[16]

Building the Solution

In order for X10-managed lights and appliances to be remotely controlled, we are going to assemble a variety of separate technologies and use them in a unified way. We will do the following:

1. Test the X10 computer interface and modules with the Heyu application.
2. Create a Ruby on Rails application that provides a web-based front end to a subset of Heyu commands.
3. Create an Android mobile application that will communicate with the Rails application, turning the light on and off via a native onscreen Android toggle switch control. [16]

IV.IMPLEMENTATION OF SMART HOME CONTROL NETWORK

ZigBee networking module circuit and sensors ZigBee technology is a new type of wireless, short, low power network communication technology, which has so many technological advantages, such as low complexity, low power consumption, low cost, high efficiency and high reliability and its network coverage area is so much wide. Home metering data transmission along with energy management services shows the lowest communication bandwidth. Due to its low data requirement, simple low power RF protocol can meet this specification from M-Bus to 802.15.4 based protocols. On the contrary, the number of applications that may be deployed for home health care solutions is, in terms of bandwidth, very wide. [17]

Figure14.shows total wireless and Internet communication system architecture. Each Smart-Switch devices had their own address. The address name is the number of smart switch device to follow as the address name of the smart switch unit 1 is smart switch node 1 and the address is the number of this unit to follow until the last units are in used a house. The access point has been installed on the first floor. The smart switch devices on the first floor can be communicated to the access point with single-hop radio frequency protocol (RF). The smart switch equipment to the second floor cannot communicate directly to the access point because the signal x bee is loss due to obstructions, such as walls. The multi-hop RF protocol is used to transfer the data to smart switch equipment to the second floor of the hope that the data for other smart switch devices to reach the access point to transmit. The Iboard is connected to establish an Internet connection with a router and to enable communication with the hosting server. Can use the phone, Wi-Fi, 3G or 4G to access the Web page on hosting server using Android App.

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Software design for the development of an embedded system is to discuss this topic. The hardware must with specific software; the embedded system works are programmed. Figure .15 shows the flowchart for the smart switch node sends Status Android App. The name Smart Switch node is used, because it is also the name of the address for smart switch device. Figure .16 shows the flowchart for Android app sends status on smart switch node. Figure 17, 18 give us configuration of system control of smart home, Temperature sensor android app, Lighting sensor android app. A user in the remote home environment configure ones social network relations each other, and the resulting device profiles are exchanged by user consents. Further, Web based API interfaces helps to control and sharing remote home devices in a convenient ways. [18]

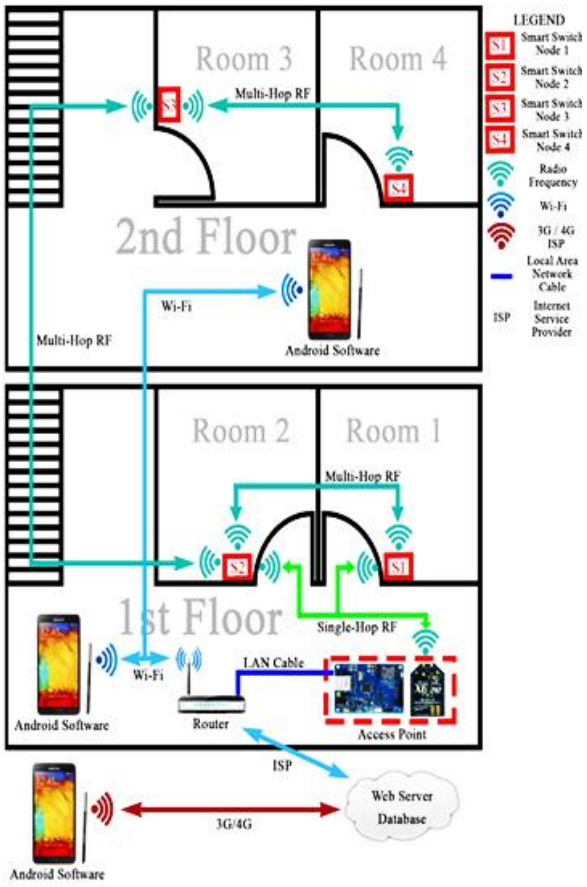

Fig.14.The name of Smart Switch Devices

V. RESULT AND SPECIFICATIONS

A. power management

Making better use of energy in the house by remote control by the technical system represented PDC regime structuring sensor remote XBee Smart house consists of a server with the wireless system where the Iboard of server logs in with Internet via Ethernet to operate synchronize each relay system or touch pad or via synchronization via the website to your Android smart home application. It gives more flexibility in controlling appliances and status report of requirements for light and heat and the atmosphere is easy to control. Where it represents the active administration of energy management, flexible and scalable according to the needs and desire.

B. Design and implementation of a smart home system

The purpose of the system is to use the integrated installation XBee mobile phone for automation without a lot of equipment and less expensive as well as what the high response system XBee communication with wireless connection and less hostess between the transceiver and the IBOARD server and XBee Series 2 Hardware and software.

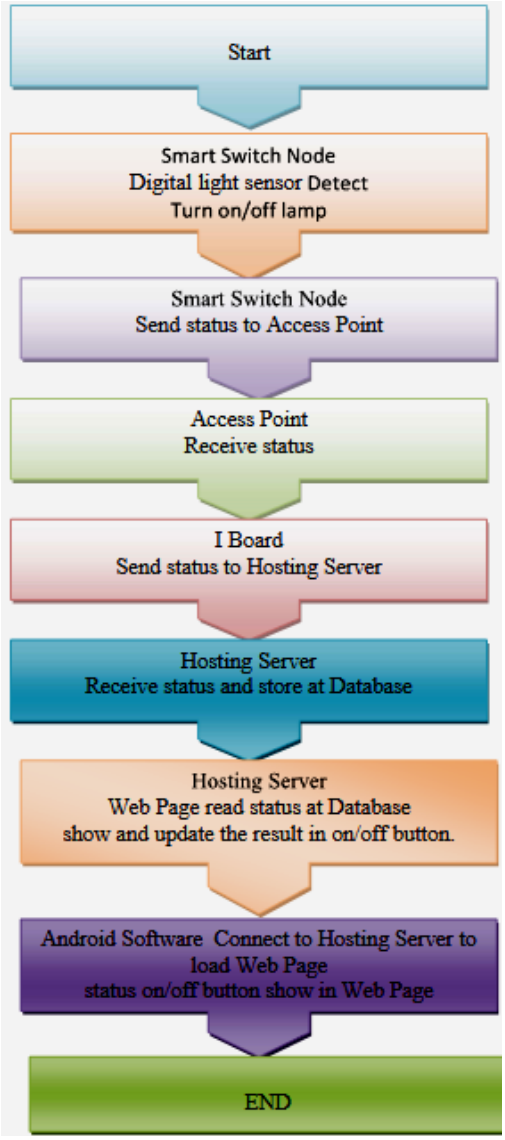

Fig.15 Flow chart for smart switch node sends status to android software

Design Arduino and Android, Arduino using Arduino C language for programming system.

Mobile phones, and the results are shown general population is encouraging. The Smart Home is a good model for any automation system based on Smart Phone and XBee wireless systems.

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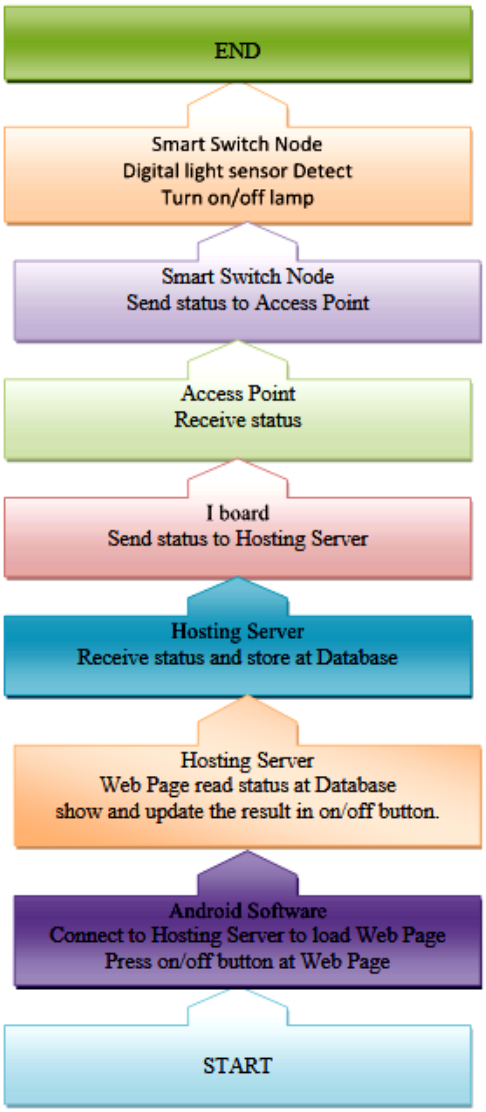

Fig. 16 Flow chart for android software send status to smart switch node

Fig.17 Temperature sensor android app

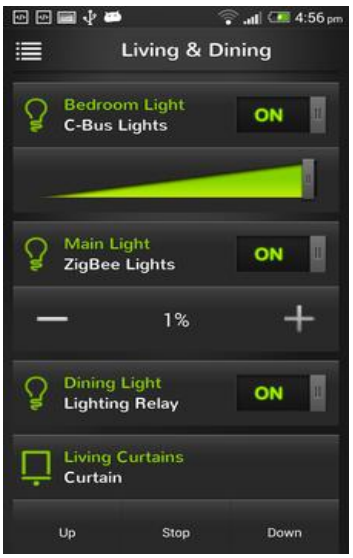

Fig .18 Lighting sensor android app

In our prototype, we use the Arduino I board to provide a shield for a WLAN connection (Android tablet to the same network that is connected wirelessly). We are programmed Arduino and Xbees make this possible, consider the following scenario:

1. The user sends commands to your Android tablet Arduino board.
2. Arduino which in turn transmits instructions Network Xbees formed router, hub coordinator and the final knot.
3. Send Xbees sensor readings equipment Arduino.
4. Arduino can design shows the algorithm is planning to propose an appropriate function depending on resources and availability.
5. Information on programming the sensor data collected Xbees appear in Android application databases for different users updated as necessary.

VI.CONCLUSION

In this paper we propose a new architecture for the monitoring and control system that uses a flexible home-based Android smartphone at a reasonable price and implemented by XBee wireless transceiver and IBOARD Arduinoas well as using android app for system control configuration. The proposed architecture is used in a quiet based web services in an interoperable application layer for communication between the remote user and the home device. All Android-based smartphone, the Wi-Fi connection is the support built, the home access device to control. If the Internet is not possible, it can be access by used the 3G mobile system mobile. Future studies will use the commands for controlling the voice applications by implementing the home server.

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