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IOT Based Smart Home Using Arduino Nano

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Abstract:- This paper aims to provide luxurious and secure life to occupant at low cost and flexible manner to monitor, control and schedule home appliances as per occupant's requirement .We propose IoT based Smart Home system using an embedded micro-web server, with IP connectivity for accessing and controlling home appliances remotely using Android based Smart phone app. The proposed system is simple standalone system which does not require a dedicated server PC and offers a brief communication protocol to monitor, control and schedule the home appliances rather than just the switching operation. To demonstrate the feasibleness and effectiveness of this system hardware prototype implemented and GUI have been prepared. Devices such as light switches, light sensor, level sensor, and temperature sensor are used to control home devices for energy saving, gas sensor to provide security have been integrated with the proposed home control system.

Keywords:- Internet of Things, Smart Home, Home Automation, Android Smartphone, Arduino, IO Adafruit server. RESTful based Web services.

I. INTRODUCTION

With the advent of information and communication technologies it is possible to control and monitor remote devices. The Internet of Things (IoTs) is the technology in which we can connect everyday objects like smart-phones, physical devices, sensors and actuators to the Internet where the devices are intelligently linked together enabling new forms of communication among things and people, and between things itself. In last couple of years dramatically advancement occurs in the field of IoT technology, since it has added a new dimension to the world of information and communication technologies [1]. Day by day devices connected to the Internet increases in huge amount. Now anyone, from anywhere and anytime can have connectivity for anything and it is expected that these connections will expand and create an entirely advanced dynamic network of Internet of Things (IoTs). The development of the Internet of Things will revolutionize a number of sectors, from automation, healthcare, energy, transportation, financial services to nanotechnology. IoTs technology can also be applied to create a new concept for smart homes to provide intelligence, comfort and to improve the quality of life of occupants.

This project is environment friendly as it helps in energy saving and making the home as smart as human being. Different devices and the appliances in the home are now being connected to the Internet so that it can be controlled and monitor remotely using the Smart phones, Tablets or Laptops. Not only devices can be controlled, but home environment can also be continuously monitored for maintaining certain desired temperature ,water level in water tank ,ambient light to switch lamp ON or OFF automatically. Hence, this will contribute to overall cost reduction and energy saving which is one of the main concerns of today. This project overcomes all disadvantages of existing technologies like Bluetooth technology, GSM technology and Wi-Fi technology and presents a low cost and flexible home monitoring and control system using an embedded micro-web server, with IP connectivity for accessing and controlling home appliances and devices remotely using Android based Smart phone app. The proposed system does not require a dedicated server PC and offers a brief communication protocol to monitor and control the home environment with more than just the switching functionality.

II. RELATED WORK

Now a day several wireless technologies available that can be use for some form of remote data transfer, sensing and control such as Bluetooth, Wi-Fi, and cellular networks have been utilized to embed various levels of intelligence in the home. In Bluetooth based home monitoring and control systems using Android Smart phones the Internet connection does not require. The devices are physically connected to a Bluetooth sub-controller which is then accessed and controlled by the Smart phone using in-built Bluetooth connectivity. However, due to limited range of operation (maximum up to 100 m) the system is unable to cope with flexibility and can only be controlled within the vicinity[2-4]. In Wi-Fi based home control system using PC based web server which manages the connected home devices where a dedicated web server, web pages and database have been developed to interconnect and manage the devices with the Internet. There are two disadvantages of these systems. Firstly, a high end personal computer has been utilized which not only increases

the energy consumption but also increases the cost of installation. Secondly, development and hosting of web pages which also add to the cost[5-6]. In GSM based home automation system to control different home appliances, different AT commands are sent to the Home Mobile for controlling different home appliances. The drawback of this system is that users are not provided with a graphical user interface and users have to remember various AT commands to control the connected devices[7-8].

Recently few researchers have also presented use of Web services, Simple Object Access Protocol (SOAP) and REpresentational State Transfer (REST) as an interoperable application layer to access home automation systems from anywhere. In home automation system over the Ethernet network based on XML SOAP standards. The drawback of using SOAP based Web service is that it adds complexity and overhead to the client and server when parsing the message, resulting in slower operation and higher Bandwidth .REST has been use Web techniques such as HTTP caching and push messaging for Web-based interaction to monitoring and controlling household appliances[9-10]. Also a Web-based graphical user interface has been developed to monitor, control and schedule home appliances.

The above mentioned systems have made significant contributions to the design and advancement of home automation systems. However, the existing works were mainly focused on switching, controlling and scheduling home appliances or connected devices rather than remotely monitoring of home environment.

III. SYSTEM DESCRIPTION

A. Feature of Proposed System

In order to overcome limitations of Bluetooth, Wi-Fi and GSM technology a standalone, flexible and low cost home controlling, monitoring and scheduling system using RESTful based Web services as an interoperable application layer has been implemented. The main components of the system are a micro Web - server based on Arduino Nano and CC3000 Wi-Fi module, hardware interface modules and the Android Smart phone app. The architecture presented in this work can be customized in different ways in order to adapt different application scenarios with minimum recoding and design i.e. whenever a new device is connected to the micro Web-server, a new thread dedicated to the new device is automatically establish in the Smart phone app. Hence, the main intention of the proposed work is not to integrate expensive components such as high end PC. This system allows authorized person to remotely monitor, control and schedule different connected devices at home using any Wi-Fi or 3G/4G connectivity in Smart phone which supports Java. The smart phone app provides a graphical user interface (GUI) to user for monitoring and controlling the devices at home through server real IP.

Description of Proposed Architecture

This section describes the proposed architecture and design of flexible and low cost home controlling and monitoring system. The architecture is divided into three layers: Home Environment, Home Gateway and Remote Environment. Remote Environment represents authorized users who can access the system on their Smart phone app using the Internet via Wi-Fi or 3G/4G network. Home Environment consists of Home Gateway and a hardware interface module. The primary function of the Home Gateway for the proposed architecture is to provide data translation services between the Internets. The main component of the Home Gateway is a micro Web - server based on Arduino Nano and CC3000 Wi-Fi module. The main task of the server is to manage, control and monitor system components, that enables hardware interface modules to successfully execute their assigned task using actuators and feed current sensor measured data on server. Hardware interface modules are directly interfaced with sensors and actuators through wires. It has the capabilities to control different relays through which different devices are connected like lightings, power plugs, HVAC (heating, ventilation, and air conditioning), systems and security system. For monitoring Home Environment the system supports sensors such as temperature sensor, light sensor, gas sensor, and level sensor.

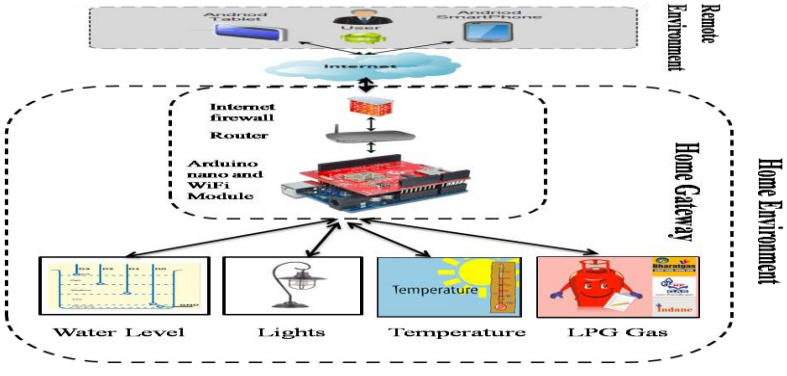


Fig 1: A Overview of Conceptual architecture

IV. SYSTEM IMPLEMENTATION

A. Software Development For Home Gateway

Software of the proposed home automation system is divided into two parts: server application software and microcontroller firmware. The server application software is a library implementation of a micro Web-server running on Arduino Nano using CC3000 Wi-Fi Module. This Wi-Fi Module has the capability to be used both, as a client or a server. To successfully communicate between remote user and the Home Gateway, configuration stage and sensor/actuator control stage layers have been implemented on the Arduino Nano. The <Adafruit_CC3000.h> library is used to receive data on Arduino Nano and creates output messages in JavaScript Object Notation (JSON) format. Figure 3 shows the flowchart of connection establishment between the Arduino Nano and the Internet. The Home Gateway is connected to Internet over TCP/IP. Since Arduino Nano using CC3000 Wi-Fi Module already supports a TCP/IP stack, we have focused on implementing software to connect it to the remote user. The Home Gateway once started enters the configuration stage. During the configuration stage the Wi-Fi Module establishes connection with Local Area Network (LAN) using Dynamic Host Configuration Protocol (DHCP). Once the Home Gateway has been initialized, it continuously sends data to IO Adafruit server and receives data from server i.e. commands from the remote user. Upon successful reception of commands as strings from the Smart phone app, it is decoded and appropriate control action is taken. These actions can be either actuation or sensing. The current status of home environment can observe on IO Adafruit server by login to server using Smart phone app.

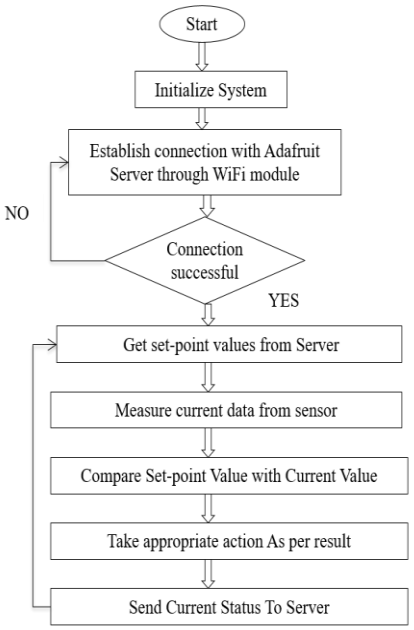


Fig 2: Home Gateway flow chart for the connection Establishment with the Internet

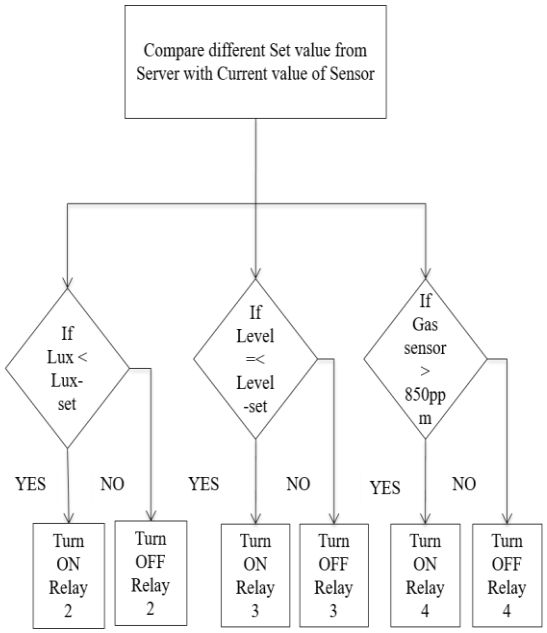


Fig 3: Flow chart for Decision Making

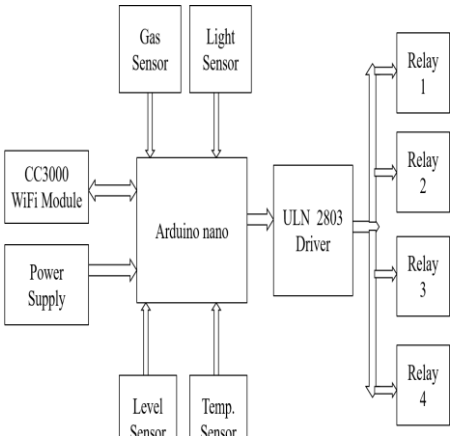
B. Home Gateway Application Framework

The access to Web services has to be easy, direct, open and interoperable. That is, the provided communication means and programming interfaces (APIs) shall be easy to implement on every platform and developing environment [26]. The most open and interoperable way to provide access to remote services or to enable applications to communicate with each other is to utilize Web services. There are two classes of Web services: Simple Object Access Protocol (SOAP) and Representational State Transfer (REST). RESTful is a much more lightweight mechanism than SOAP offering functionality similar to SOAP based Web services.

Therefore, in our approach we have used the RESTful based Web service utilizing standard operation such as GET and POST requests that return JavaScript Object Notation (JSON) responses to communicate between the remote user and the micro Web server. JSON is a lightweight data-interchange format. It is easy for human beings to read and write. It is also simpler for machines to parse and generate messages than using XML.

C. Hardware Implementation Block Diagram and Home Automation Devices

The overall implementation block diagram of the discussed home monitoring and controlling system using Android based smart phone from anywhere is illustrated in Fig 4 and prototype of system in Fig 5.



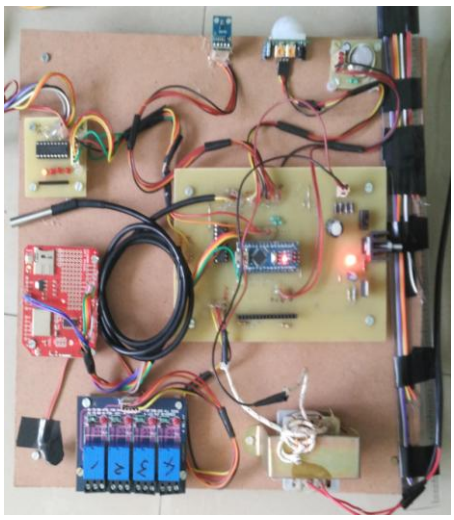


Fig 4: System Block Diagram

Fig 5: Hardware Implementation of System

The Arduino Nano and CC3000 WiFi Module were used to implement the micro Web-server for the Home gateway. First of all Home gateway forms connection with Internet. The Arduino Nano is an open-source microcontroller that uses ATMEGA 328, an Atmel AVR processor which can be programmed by the computer in Arduino IDE. Arduino IDE is open-source software which makes it easy to write code and upload it to the board via USB port. Arduino Nano also has on-board 8 analog pins and 14 digital pins for input and output operations, supporting SPI and I2C which can be used to interface with other devices. The CC3000 WiFi Module acts as a bridge to connect the Home Gateway to the local proxy. Various devices are integrated with Arduino using relays to demonstrate the switching capability, temperature sensor was used for temperature monitoring , LPG gas sensor is used detect gas leakage, light sensor is used to light intensity which is used to automatically ON or OFF the light, Level sensor gives the current level of water in water tank. The hardware architecture presented is flexible and allows other home appliances and devices to be seamlessly integrated with minimal changes.

D. Smartphone Application and Features

There are several platforms for developing Smartphone application such as Windows Mobile, Symbian, iOS and Android. Since most of the Smart phones support Android OS, therefore, we decided to develop and implement the application in JAVA programming language using the Android Software Development Kit (SDK). The most important feature of our Smartphone app is to hide several processes from the user while allowing full interaction with the application. By using the several software packages, we were able to customize the application to include a variety of user interface elements such as text boxes, choice groups, lists and command buttons.

Fig 6: Screenshot of Graphical User Interface

In this project Graphical User Interface (GUI) is provided to user, with the help of it user can set Level of water in water tank, threshold of Lux to turn ON or OFF Lamp automatically, user can monitor home environment remotely and control home appliances as per requirement. The GUI's screenshot is shown in Figure 6. The Smart phone app for home monitor, control and scheduling applications provides the following functionalities to the user: 1) Remote connection to the Home Gateway. 2) Device control. 3) Device Monitoring. 4) Managing schedule. To successfully connect to the Home server, the user has to configure the IP via Dynamic Host Configuration Protocol (DHCP) and the Port number of the micro Web-server in the app and login to IO Adafruit server . Then the user has to synchronize the app with the Web-server (see Figure 6.) to retrieve the actuators and sensors those are connected to the Arduino Nano and what they are used for.

Arduino Nano sends data to server and receives the data from server. Arduino Nano sends following JSON message to IO Adafruit server to send data https://io.adafruit.com/api/MyFeeds/ myProject /send.json?x-aiokey=a2cfff6a844b4288838b12845e77&temp=528369&luxset=539131&levelset=539130&lpgalarm=539141&lpg=528371&level=588943&lux=528370&device1=528376

Arduino Nano sends following JSON message to server to receive data from IO Adafruit server https://io.adafruit.com/api/ MyFeeds/ myProject /receive.json?x-aio-key= a2cfff6a844b4288838b12845e77 The JSON message indicates the IP address of the remote home server, the Arduino I/O ports where the device is connected and the device type. Arduino checks status of device connected to it and also compare with latest value from server and turn ON or OFF as per remote command string, the user has to just press the device icon in the app to turn it ON or OFF.

V. CONCLUSION

The prototype of the discussed home monitoring and controlling system has implemented and used to control the home using Android based smart phone app from anywhere at reduced cost. The proposed architecture utilizes RESTful based Web services as an interoperable application layer for communicating between the remote user and the home devices. Any Android based Smart phone with WiFi or mobile cellular networks such as 3G or 4G can be used to access the system.

This project can be used to save money and natural resources so it is beneficial for occupant as well as society. Future works will focus on creating a wireless network between the home server and the home devices using Zigbee and implementation of voice commands for controlling the application via voice.

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