International Journal of Trend in Research and Development, Volume 3(2), ISSN: 2394-9333
www.ijtrd.com

Internet of Things (IoT) – Ubiquitous Home Control and Monitoring System Using Android based Smart Phone

Mithun Prasad R[1], Kesavamoorthy M [2], Gunasekaran S[3] and Prof. B.M.Prabhu[4],
[1, 2, 3] Students, [4]Assistant Professor, [1,2,3,4]Department of Electrical and Electronics Engineering,
Angel College of Engineering and Technology, Tiruppur, Tamilnadu, India.

Abstract: Now-a-days the remote Home Automation seems to be a lot of important and appealing. It improves the worth of our lives by automating numerous electrical appliances. In this project we've conferred a low value and versatile home management and monitoring system using an embedded based web server, with ip connectivity for accessing and controlling the devices and appliances remotely through android plat formed smart phone. This method doesn't need adedicated server computer with respect to similar systems and offers a unique communication protocol to monitor and manage the house surroundings with quite simple switching functionality. To demonstrate the feasibleness and effectiveness of this method, devices like lightweight switches, power plug, temperature sensing element and current sensing element are integrated with the projected home system.

Keyword *- Internet of Things (IoT), Smart Home, Home Automation, Android Smartphone, Arduino.*

I. INTRODUCTION

Every day the fashionable people expect new device and new technology to alter their day to day life. The innovators and researchers are always attempting to search out new things to satisfy the people however the method continues to be infinite. Within the Nineteen Nineties, web connectivity began to proliferate in enterprise and shopper markets, however was still restricted in its use because of the low performance of the network interconnects. Within the 2000s web connectivity became the norm for many applications but nowadays it's expected as a part of many enterprises, industrial and shopper product to provide access to data or information. Still, these devices are primarily things on the web that need a lot of human interaction and monitoring through apps and interfaces. The term "Internet of Things" has defined to explain the variety of technologies and analysis disciplines that enable the web to achieve out into the important world of physical objects. Extending the web will provides connection, communication, and internal networking between devices and physical objects, or Things, may be a growing trend that's typically mentioned as internet of Things. This sometimes referred as the internet of Objects. It represents of subsequent evolution the web, taking a large leap in its ability to analyse and distribute the data that we can change into information, knowledge and ultimately, wisdom.

Now anyone, from anytime and anyplace will have connectivity for the entire world and it's expected that these connections can extend and build a completely advanced dynamic network. IoT technology may also be applied to form a brand new idea and wide development area for sensible homes to produce intelligence, comfort and to boost the standard of life. Trendy advances in physical science and communications Technologies leads to have an improvement in the performance of computers, sensors and networking. These changes will definitely increase in rise to the development of many home automation technologies and systems. Consistent with this, home automation may be helpful to those who need to Access their home appliances while away from their home and might implausibly improve the lives of disabled persons.

II. OVERVIEW OF INTERNET OF THINGS

In the digital world, especially the computer communication starts with sharing data between machine to machine, and it moves to machine to infrastructure, then machine to environment, and machine to people but now internet is everything. The people also want to communicate with all non-living things through internet such as home appliances, furniture's, stationeries, cloths etc. The people already have a lot of technologies to interact with living things but IoT enables to communicate with non-living things with comfort manner. IoT is a convergence of several technologies like ubiquitous, pervasive computing, Ambient Intelligence, Sensors, Actuators, Communications technologies, Internet Technologies, Embedded systems etc... See Fig.1

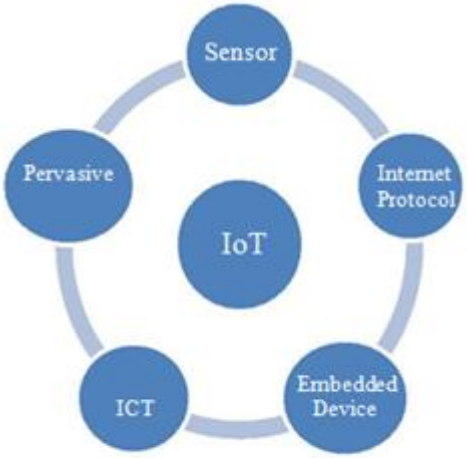

Fig.1 Architecture of Internet of Things (IoT)

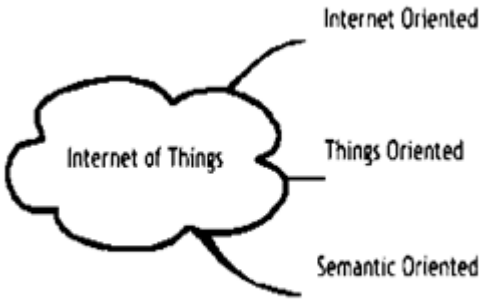

Fig.2 Functional Classification of Internet of Things

In the architecture, embedded system, sensors and actuators are the physical components which are directly interacting with the users. The users manipulate the data through these components. ICT, pervasive computing, Internet protocols used to create communication among the devices and manage

high end user interactions. According to the IoT architecture the components are further classified into three functional units See Fig.2

In the IoT architecture, "Internet Oriented" represents internet and its technologies and it act as a middleware between user and intelligent things and so it's called as intelligent middleware. Intelligent middleware will allow the creation of a dynamic map of the real/physical world within the digital/virtual space by using a high temporal and spatial resolution and combining the characteristics of ubiquitous sensor networks and other identifiable "things".

Things Oriented" is known as "Intelligent Things" which represents sensors and actuators which is respond it to stimuli from the environment in a consistent manner. This phase sense and react based on the environment and user actions such as When white light is shone on a red object the dye absorbs nearly all the light except the red, which is reflected. At an abstract level, the coloured surface is an interface for the object, and the light arriving at object can be a message sent to the thing, and accordingly its reflection is the response from the thing. The consistency in responses received from the interfaces for each message, enables things to interact with their surroundings. Hence to make the virtual world comprehensible, there needs to be consistency in messages and it responses. This is enabled through standard interfaces, which is in turn to facilitate interoperability. Simply this phase focuses the functionalities and communications among sensor/actuators, embedded devices and any other smart phones.

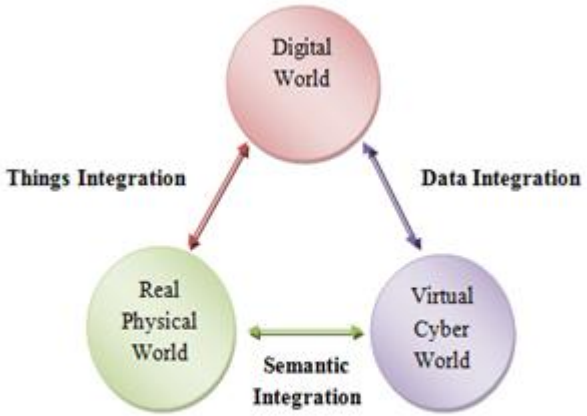

Fig.3 Functional Integration of Internet of Things

"Semantic Oriented" is known as "Intelligent Process" which represents knowledge based and decision making processes.

III. PROPOSED SYSTEM AND ITS ARCHITECTURE

A. Features of the Proposed System

In order to overcome the mentioned issues of flexibility and functionality in the literature survey, we have presented a report, standalone, flexible and low cost home controlling and monitoring system using REST ful based Web services as an interoperable application layer. The system consists of a micro Web - server based on Arduino Ethernet, hardware interface modules and the Android compatible Smart phone app. The architecture presented in this work can be customized in different ways in order to accommodate different application with minimum recoding and design i.e. each time a new device is added to the micro Web-server, a new thread dedicated to the device is automatically created in the Smart phone app. Hence, the aim of this project is not to incorporate expensive components such as high end personal computers. This project allows authorized home owners to remotely control and monitor connected devices at home using any Wi-Fi or 3G/4G enabled Smart phone which supports Java. The smart phone app provides a graphical user interface for accessing and controlling the devices at home through server real IP.

B. Proposed Architecture

In this section we have described 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 See Fig.4. Remote Environment represents authorized users who can access the system on their Smart phone app using the Internet via Wi-Fi or 2G/3G/4G networks. 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 Ethernet. The main task of the server is to manage, control and monitor system components, that enables hardware interface modules to successfully execute their assigned work using actuators and to report server with triggered events via sensors.

Fig.4 An overview of the Architecture

Hardware interface modules are directly interfaced with sensors and actuators through wires. It has the capabilities to control energy management systems like lightings, power plugs, HVAC systems and security systems such as door locks, and gates. For monitoring Home Environment the system supports sensors such as temperature, humidity and current.

C. System Implementation

As mentioned, the proposed smart home control and monitoring system consists of three main modules: the micro Web server, hardware interface module and the software package (Smart phone app). To demonstrate the feasibility and effectiveness of this system, devices such as light switches, power plug, temperature sensor and current sensor have been integrated with the proposed home control system. This section describes the system implementation details.

IV. SOFTWARE DEVELOPMENT FOR HOME GATE

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 Uno using the Ethernet shield. This Ethernet shield 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 Uno.

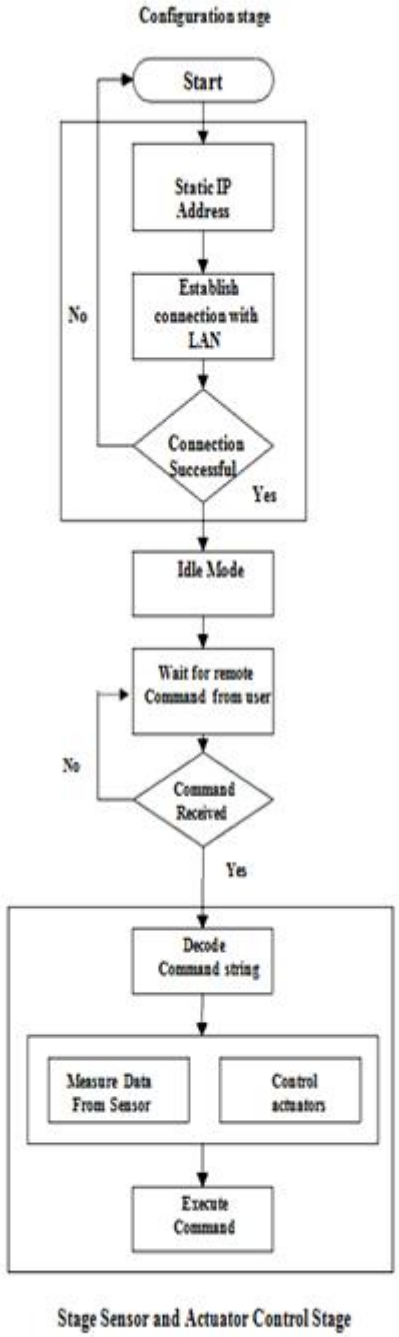

Fig.5 Home gateway flow chart for the connection establishment with the Internet

The <Ethernet> libraries are used to receive data on Arduino Uno and create output messages in JavaScript Object Notation (JSON) format. Fig.5 shows the flowchart of connection establishment between the Arduino Uno and the Internet. The Home Gateway is connected to Internet over TCP/IP. Since Arduino Ethernet shield 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 Ethernet module establishes connection with Local Area Network using a static IP address. To optimize the process of connection, we have used static IP address rather than acquiring an IP via Dynamic Host Configuration Protocol. Once the Home Gateway has been initialized, it enters into an idle state until any command is received from the remote user. Upon successful reception of commands as strings from the Smart phone app, it's decoded and appropriate control action is taken. These actions can be either actuation or sensing.

V. HOME GATEWAY APPLICATION FRAMEWORK

The access to Web services has to be easy, direct, open and interoperable. This means, the providing communication and programming interfaces shall be easy to implement on every platform and developing environment. 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). REST ful is a much more lightweight mechanism than SOAP offering functionality similar to SOAP based Web services. Therefore, in our approach we have used the REST ful 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.

VI. SMARTPHONE APPLICATION AND FEATURES

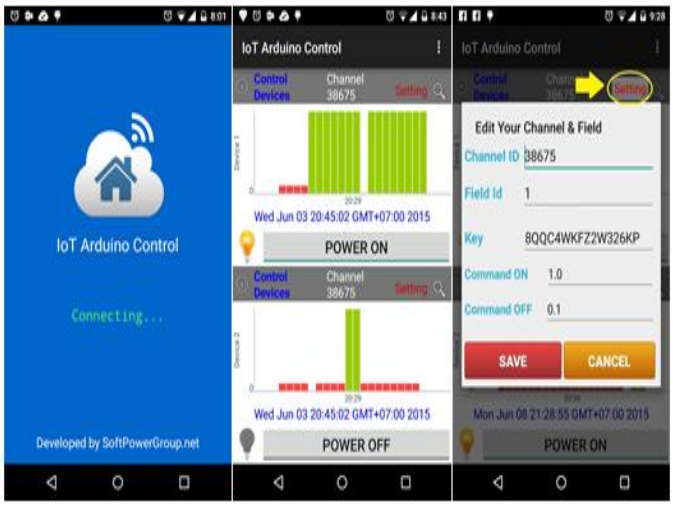

Fig.6 Screenshots for Graphical user interface for the home control system

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 illustrates some designs for the graphical user interface.

The Smart phone app for home control and monitoring 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 address and the Port number of the micro Web-server in the app (See Fig.6.a). Then the user has to synchronize the app with the Web-server (See Fig.6.b) to retrieve the actuators and sensors those are connected to the Arduino Uno and what they are used.

While performing synchronization, the Smart phone app sends the following to the Arduino: http://arduinoip/?out = all and to acknowledge the command, the Web-server replies with the following JSON message:

{"ip" : "117.17.80.199", "devices" :[{ "type" : "light", "name" : "Light 1", "out" : "4"},{ "type" : "light", "name" : "Light 2", "out" : "5"},{ "type" : "temperature", "name" : "Temp", "out" : "3"},{ "type" : "plug", "name" : "Power Plug", "out" : "6"},{ "type" : "door", "name" : "Front Door", "out" : "7"},{ "type" : "gate", "name" : "Main Gate", "out" : "8"},{ "type" : "wattmeter", "name" : "Main Switch Board", "out" : "2"}]}

The JSON message indicates the IP address of the remote home server, the Arduino I/O ports where the device is connected to and type of the device. To connect the new device and add it to the app, the user has to only program the home server. Each time a new device is programmed in the server, a new thread dedicated to the device is automatically created in the app (See Fig.6.c) e.g. Light 1 and Light 2. After synchronizing the app with the home server, the user has to just press the device icon in the app to turn it ON or OFF. The Smart phone app sends the following to the home server: http://arduinoip/?out=1&status=1. The out indicates the I/O port on the Arduino and the status can be either 1 (ON) or 0 (OFF). (See Fig.6.d) shows the temperature display on the app. The Manage schedule items (See Fig.6.e) lists and manages the current devices which can be scheduled to operate at a specific time.

VII. HARDWARE IMPLEMENTATION AND HOME AUTOMATION DEVICES

For the proof of this concept, low cost and minimal electronics hardware is used to setup the test bench. The overall implementation diagram is illustrated in Fig.7. The Arduino Uno and Ethernet shield were used to implement the micro Web-server for the Home gateway. Home gateway connects to the Internet according to the details provided in Software development for home gateway. 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 and an LM35 temperature sensor was used for temperature monitoring while a non-invasive 30A current sensor was utilized for power monitoring. The hardware architecture presented is flexible and allows other home appliances and devices to be seamlessly integrated with minimal changes.

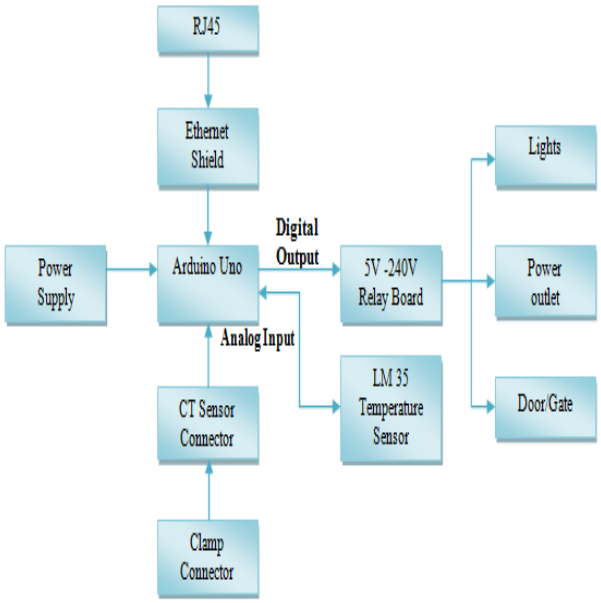

Fig.7 Hardware Architecture and Implementation

CONCLUSION

A Smart Home technology integrates the electrical devices in a home with one another. In this paper, we've given a low price and versatile home management and monitoring system using android plat formed smart phone. The projected design utilizes REST full based net services as a practical application layer for act between the remote user and the home devices. Android plat formed smart phone with inbuilt Wi-Fi are often used to access and manage the devices at home. Once a Wi-Fi connection isn't available, mobile cellular networks like 2G or 3G or 4G are often used to access the devices. We have a tendency to conjointly offer notification to the user regarding any error happens within the devices and send mail or SMS to the service supplier regarding the issues. In our project we have a tendency to eliminate most of the human interaction by providing intelligent system. Development of such sensible Home came through with the help of internet of Things technologies. By using this system we can truly manage to make low price, flexible sensible homes to regulate its environmental factors and to resolve the issues with energy saving technology.

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