

Mobile based Home Automation using Internet of Things(IoT)

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Abstract—Availability of high speed mobile networks like 3G and Long Term Evolution(LTE) coupled with cheaper and accessible smart phones, mobile industry has seen a tremendous growth in terms of providing various services and applications at the finger tips of the citizens. Internet of Things(IoT) is one of the promising technologies which can be used for connecting, controlling and managing intelligent objects which are connected to Internet through an IP address. Applications ranging from smart governance, smart education, smart agriculture, smart health care, smart homes etc can use IoT for effective delivery of services with out manual intervention in a more effective manner. This paper discusses about IoT and how it can be used for realizing smart home automation using a micro-controller based Arduino board and Android mobile app. In this paper, two prototypes namely home automation using Bluetooth in an indoor environment and home automation using Ethernet in an outdoor environment are presented.

Keywords-Internet of Things(IoT), Home Automation, Smart Cities, Arduino, Android, Bluetooth, Ethernet, Mobile App

I. INTRODUCTION

Internet of Things(IoT) deals with billions of intelligent objects which would be connected to sense & collect the data and also communicate with surrounding people using mobile, wireless and sensor technologies. Main objective of IoT is to manage and control physical objects around us in a more intelligent and meaningful manner[1] and also improve quality of life by providing cost effective living including safety, security and entertainment. Smart objects gather useful contextual data autonomously and send to remote application servers for offering context aware or location based services. The word “context” can refer to any location information, surrounding environment, people & objects that are near by etc so that adaptive and personalized services can be provided to the user.

According to CISCO, it is estimated that 50 Billion devices would be connected to the Internet by 2020[2]. Recent advancement in cloud computing and data analytics allows intelligent systems to process and analyze the data in a more efficient manner. Though there are many IoT applications, authors propose a unique mobile based home automation solution that can facilitate people to remotely control home appliances using their personal android smart phones anywhere and anytime as shown in Fig 1.

Among many IoT applications, smart homes play an important role in realizing smart cities. Smart homes can be used for remotely monitoring and controlling electrical appliances

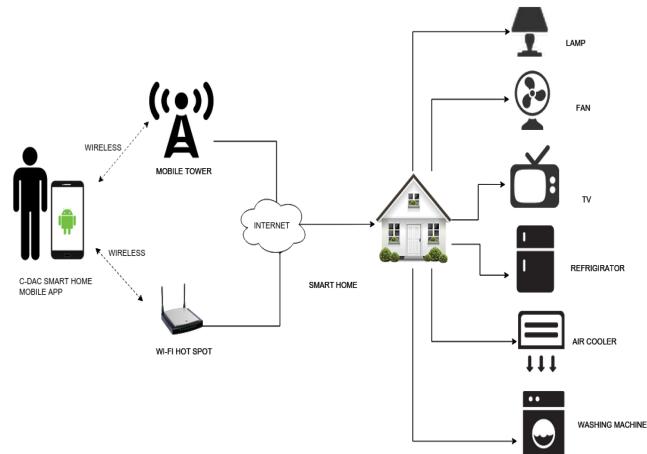


Fig. 1. Concept of Smart Home

fitted inside the home using smart & intelligent physical infrastructure. The present Government of India(GoI) has proposed to develop 100 smart cities[3] across the country which will create a huge demand for smart home automation solutions in near future. In “smart home” the word “smart” means context aware which can be realized using Information and Communication Technology (ICT) and IoT.

II. RELATED WORKS

Though the concept of smart homes is new in India, considerable amount of work has been carried out in other countries, where smart homes are already in place. Kang [4] discusses about acquisition and analysis of sensor data which are going to be used across smart homes. It proposed an architecture for extracting contextual information by analyzing the data acquired from various sensors and provide context aware services. Jeya Jeya Padmini [5] discusses about effective power utilization and conservation in smart homes using IoT. It uses cameras for recognizing human activities through image processing techniques. Andreas Kamilaris [6] discusses the need for common standards and protocols for developing sustainable IoT based applications for smart homes. Pranay P.Gaikwad [7] discusses about challenges and problems arise in smart home systems using IoT and propose possible solutions. Though similar works are carried out elsewhere, authors propose an unique architecture for IoT based home automation using low cost android phones in Indian context. In order

to meet growing needs of the people, two prototype models namely 1. Home Automation using Bluetooth and 2. Home Automation using Ethernet are presented in this paper.

III. IMPLEMENTATION DETAILS

A. Home Automation System using Bluetooth

In this paper, the concept of home automation using IoT is realised using low cost micro-controller based Arduino board[8] and an Android mobile phone. Arduino is a open source platform that can be used for prototyping any hardware and software. Arduino can be programmed to receive keyboard input or sensor data and control various electrical appliances connected to output peripherals. Since mobile phone is a wireless communication device, connectivity between Arduino and smart phone is established using Bluetooth, one of the short range wireless communication technologies that can be used for communication in an indoor environment. Operating at universally available frequency of 2.4 GHz, it can connect digital devices within a range of 10-20 meters (theoretically expandable up to 100m, by increasing transmitter power) at the speed of 256 Kbps to 1 Mbps. Since Arduino micro-controller unit does not have inbuilt bluetooth radio, an external HC-05 Bluetooth module is used for establishing wireless connectivity as shown in Fig 2. Once home appliances are connected to Arduino board, they can be easily controlled using any bluetooth enabled smart phone inside a smart home.

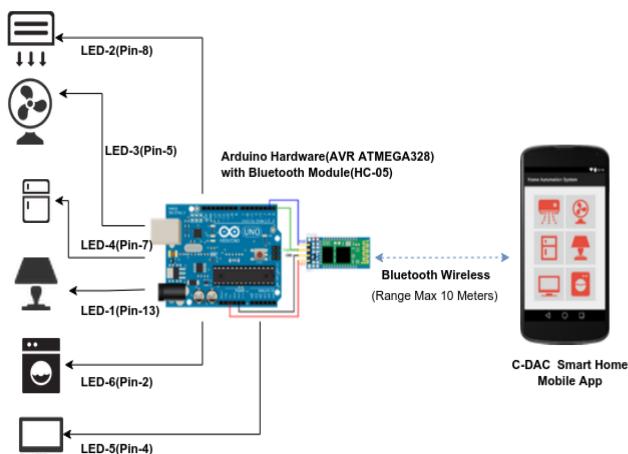


Fig. 2. Architecture for Home Automation using Bluetooth

Android based mobile application is developed using Android studio (Ver-1.5) that provides complete development environment for developing any mobile application including tools for compilation, verification, debugging and packaging[9]. Android application consists of following two activities. 1. A splash screen showing application home page and 2. Second screen consist of 6 icons corresponding to various electrical appliances namely Lamp, AC, Fan, Refrigerator, TV, Washing Machine. Status of these appliances are indicated using a Light Emitting Diode(LED). RED color indicates that an appliance is in OFF state and GREEN color indicates that an appliance is in ON state. Various steps involved in connecting Arduino board with bluetooth module

are explained below.

Step 1: Connect Bluetooth ground and VCC to Arduino ground and VCC respectively.

Step 2: Connect LEDs to Arduino pins with their cathode connected to ground pin.

Step 3: HC-05 Bluetooth module is interfaced with Arduino by connecting Bluetooth's TXD pin to Arduino's Rx and RXD pin to Tx respectively to form serial communication between the devices[10].

Whenever mobile app is launched, Arduino board gets paired to smart phone using bluetooth connectivity using serial communication protocol. MAC address of HC-05 bluetooth module is used for directly pairing with mobile app with out scanning for bluetooth devices in the vicinity, there by reducing the time.

Once connection is established, whenever a user taps an icon on the android phone as shown in Fig 3, data such as "A" or "a" will be sent. The transmitted data will be received by Arduino's bluetooth module. On Arduino board, six LED's are connected which are mapped to individual home appliances as shown in Table I.

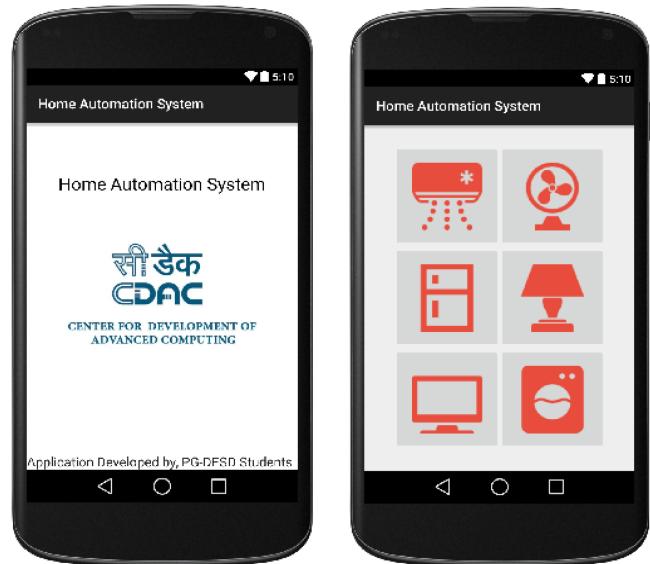


Fig. 3. Android Mobile App for Home Automation

TABLE I
LED PIN CONNECTIONS

LED PIN NUMBER	HOME APPLIANCE
LED 1 (PIN 13)	LAMP
LED 2 (PIN 8)	AC
LED 3 (PIN 5)	FAN
LED 4 (PIN 7)	REFRIGERATOR
LED 5 (PIN 4)	TELEVISION
LED 6 (PIN 2)	WASHING MACHINE

On the other side i.e. in Arduino board, data transmitted by android mobile application will be received with the help of Bluetooth module connected to the Arduino board. After receiving the data from the phone, data gets verified and

respective LED's status will be changed either to ON or OFF state as shown in Fig 4. For example, if user taps on the LAMP icon in the android phone, LED-1 connected to Pin No.13 gets switched ON and if user again taps on the same LAMP icon, LED-1 gets switched OFF. The key logic here is, Bluetooth based smart phone is acting as a client, while Arduino board is acting as a Server. Whenever Arduino board is powered ON, HC-05 Bluetooth module's RED LED starts blinking. Once Android application connection is established, RED LED becomes solid indicating that a communication channel is established.

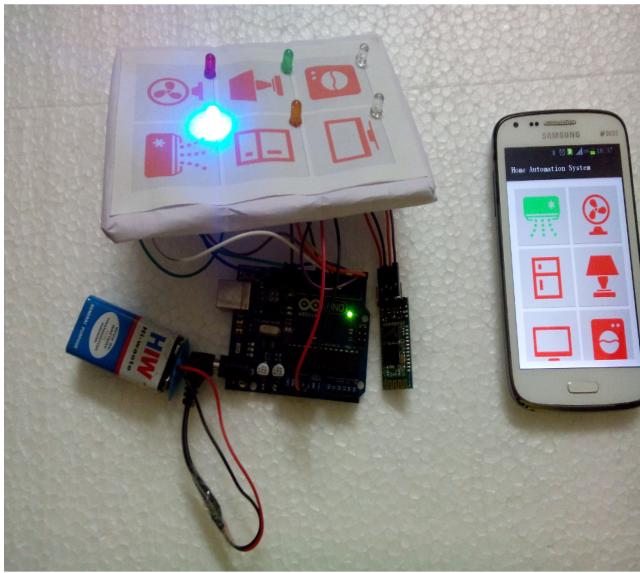


Fig. 4. Home Automation using Bluetooth

Though a prototype smart home automation system using bluetooth is realised, there are some practical challenges associated with it. This bluetooth based solution can not be used from a distant location, as it uses short range wireless communication technology which can work up to 10-20 meters only. This application can only be used by a person to control and manage appliances in an indoor environment.

B. Home Automation System using Ethernet

The main drawback of bluetooth based home automation can be overcome using Ethernet technology. In this section, Ethernet module is used for connecting Arduino board from any part of the world. Arduino's Ethernet module IP address and Port number can be used to locate remote device connected to the Internet in a smart home environment. Android mobile app can be used to control electrical appliances from a remote location. Ethernet shield is placed just above Arduino board which is connected to RJ-45 for Internet connectivity.

In this architecture, Arduino board is configured as a server. Whenever user enters IP address and Port number, request will be sent to Arduino board(server), which in turn serves a HTML web page[11] which is stored in Arduino's micro SD card. LED corresponding electrical appliance can be switched ON/OFF using Android mobile app as shown in Fig 5.

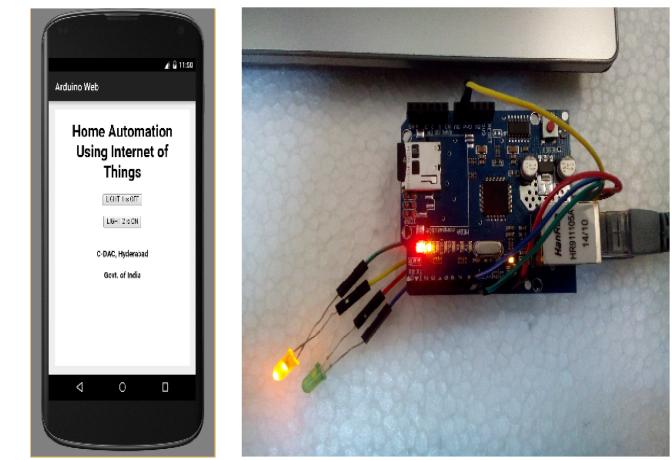
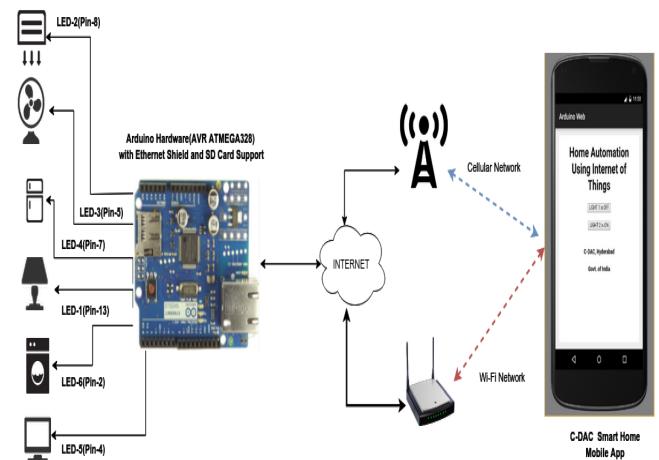


Fig. 5. Home Automation using Ethernet

IV. EXPERIMENTAL RESULTS & CHALLENGES

This paper demonstrated smart home automation concept using low cost Arduino board for controlling various electrical appliances using an Android smart phone. Since IoT is one of the upcoming technologies that can be used for home automation, there are many challenges that are associated with it. One of the major challenges in the lack of standards for integrating various sensors, applications and other existing intelligent embedded devices. Providing unique IP addresses for connected devices and privacy & security in a smart home environment is another big challenge. As IoT deals with huge amount of data collected from various sensors deployed in a smart environment, proper care should be taken in handling, storing and securing the data. In future, data analytics and visualization can be used for effective monitoring and management of IoT devices in a smart home environment.

V. CONCLUSION & FUTURE SCOPE

In this paper, a prototype smart home automation using IoT is presented. This research work will be carried forward by integrating relays to Arduino board for controlling home appliances from a remote location in a real scenario. As an extension, authors propose a generic IoT framework and use cloud computing infrastructure for connecting and managing

remote devices and also store sensor data. Authors plan to productize proposed home automation solution so that more number of people can use IoT in a smart environment.

VI. ACKNOWLEDGMENT

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