Remote Home Automation

A PROJECT REPORT

submitted by

Anindya Maiti (08BCE042)

in partial fulfillment for the award

of

B. Tech

degree in

Computer Science and Engineering

School of Computing Science and Engineering

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DECLARATION

I hereby declare that the project entitled **"Remote Home Automation"** submitted by me to the School of Computing Science and Engineering, VIT University, Vellore-14 in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology in Computer Science and Engineering** is a record of bonafide work carried out by me under the supervision of **Prof. S. Sivanesan.** I further declare that the work reported in this project has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma of this institute or of any other institute or university.

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CERTIFICATE

The project report entitled "**Remote Home Automation**" is prepared and submitted by **Anindya Maiti (Register No: 08BCE042).** It has been found satisfactory in terms of scope, quality and presentation as partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology in Computer Science and Engineering** in VIT University, India.

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Prof. S. Sivanesan
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Examined by:

Internal Examiner **External Examiner**

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LIST OF ABBREVIATIONS

Abbreviation	Expansion
HAaaS	Home Automation as a Service
HVAC	Heating, Ventilation and Air Conditioning
LAN	Local Area Network
Wi-Fi	Wireless Fidelity
IEEE	Institute of Electrical and Electronics Engineers
HA	Home Automation
DIY	Do It Yourself
SaaS	Software as a Service
PaaS	Platform as a Service
IaaS	Infrastructure as a Service
API	Application Programming Interface
QoS	Quality of Service
RFID	Radio-Frequency Identification
HSDPA	High-Speed Downlink Packet Access
ISP	Internet Service Provider
AC	Alternating Current
UMTS	Universal Mobile Telecommunications System
MIMO	Multiple-Input and Multiple-Output
OFDM	Orthogonal Frequency Division Multiplexing
ICH	I/O Controller Hub
SPDIF	Sony/Philips Digital Interconnect Format
AEC	Acoustic Echo Cancellation
BF	Beam Forming

NS	Noise Suppression
PLL	Phase-Locked Loop
BOM	Bill of Materials
CODEC	Compressor-Decompressor
IoT	Internet of Things
SMS	Short Message Service
PC	Personal Computer
MPEG	Moving Picture Experts Group
MP3	MPEG Audio Layer III
USB	Universal Serial Bus
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
SSL	Secure Socket Layer
RSVP-TE	Resource Reservation Protocol - Traffic Engineering
IP	Internet Protocol
WMI	Windows Management Instrumentation
WMIC	Windows Management Instrumentation Command-line
OS	Operating System
ID	Identification
WMA	Windows Media Audio
WMV	Windows Media Video
ASF	Advanced Streaming Format
AVI	Audio Video Interleave
AAC	Advanced Audio Coding
FLAC	Free Lossless Audio Codec

MIDI	Musical Instrument Digital Interface
WAMP	Windows, Apache, MySQL and PHP
WPA2	Wi-Fi Protected Access II
CCMP	Counter Cipher Mode with Block Chaining Message Authentication Code Protocol
CPV	Cost per View
ID3	IDentify an MP3
PRTG	Paessler Router Traffic Grapher
SNMP	Simple Network Management Protocol
CAPTCHA	Completely Automated Public Turing test to tell Computers and Humans Apart
VLC	VideoLAN Client
IrDA	Infrared Data Association
SCS	Sistema Cablaggio Semplificato
VSCP	Very Simple Control Protocol
HomePNA	Home Phoneline Networking Alliance

ABSTRACT

Smart homes have been recognized as the next forefront of the networking revolution, where consumer technology and Internet infrastructure intersect to change the way we lead our lives. Internet connections for home users are becoming faster and cheaper. Home Automation web services are increasing day by day, while the next step is the creation of Home Automation Services. The area of residential e-services constitutes the next phase of Internet evolution. These e-services include, among others, shared Internet access, energy management, home automation, safety alerts, security, home health care, etc. This project presents a novel architecture for remote home automation networks services platform via high speed Internet connections ensuring QoS support.

While there are many ways to classify home networks, the most important distinction is that different technologies are designed for different services: data, entertainment (audio/video), and control. Home data networks, like those in an office environment, provide high-speed connectivity for computers. Entertainment networks allow the streaming of audio and video from one location to another within the home. And home control networks let devices such as thermostats, light switches, security systems, and home appliances talk to each other and to the Internet. At the highest level, a residential gateway makes the networked home possible by providing a central point of connectivity or an ad-hoc network between in-home devices and a wide area Internet access network.

Home Automation networks are networks that consist of home nodes, which are devices, capable of using the communication and interaction resources in order to provide services to the user. Expanding power and influence of the Internet, together with the mobile device technology, high speed connections and real-time remote management, are creating a vast array of web based services also called HAaaS. As HAaaS meet noticeable development, the need for a model that will support numerous such networks as well as Internet, mobile connectivity, high speed connectivity, and between the home under control and the user-side, comes into sight.

Chapter 1
Introduction

1.1 Aim

Design, implementation and operation of a cloud controlled ad-hoc wireless home automation system.

1.2 Motivation

Convenience, Hospitality, Safety, Security and Savings. Smart homes are becoming increasingly prevalent. As we bring more lifestyle enhancing technology into our everyday lives and high speed internet becomes available to almost every household, the possibilities for more control and convenience have multiplied when it comes to home automation. Here are the foremost reasons why cloud based home automation is imperative.

A. *Total Control of the Environment*: A cloud based smart house allows us to take total control of the environment. Security is just one area among many. Home automation systems allow we to personalize different rooms and spaces for light, temperature, music and mood. We can schedule changes by pre-programming and leave the details to the system.

B. *Remote Control*: Control any aspect of the home that is connected to the automation system from a remote location. For example, if we're on holiday or at work, we can control the security and alarm system, monitor the house, adjust the multimedia system to tape new shows when programs change, or turn on the lights before we get home. Once we get home, we can access and watch the video in any room in the house.

C. *Energy Conservation*: Home automation allows home owners and property management managers to closely monitor energy and water usage. With energy management software, any device that is connected to the network can be monitored and detailed reports generated according to time, hour, day or month. We can also request reports for each device and room or area so energy consumption levels are easy to identify, and informed choices can be made about conserving energy. Moisture sensors can be incorporated into we system so when we go on holiday, the lawn is only watered when it's needed. Lights can be set to automatically switch off at a time, or if there is no one detected in the space, saving energy expenditure.

D. *Great Security Options*: There is no better way to have a comprehensive and user friendly security system than cloud based home automation. Smart home systems commonly feature voice or video intercom for front doors and gates, movement censors, activated lighting, and security cameras for different rooms. In apartment buildings it's also common to have door release and elevator control options. Sensors can range from movement sensors, to temperature sensors,

photoelectric beams, and even reed switches, which send we a reminder when outside gate or garage door is left open for more than say, 10 or 20 minutes.

E. *Integration and Convenience*: Any home or building works best as a whole instead of a collection of separate component parts, and cloud based home automation allows users to make use of the latest technology in security, lighting, temperature control, and energy conservation on a single platform. It creates a central point of control with user-friendly software. After setting the preferences, we can leave it all to the system. Remote control of devices adds to convenience - we can change settings while in the next room, in another city, or on another continent.

F. *Information Gathering*: Home automation systems are also potentially informational gathering devices. They are particularly useful for large apartments or houses where residents or building managers have a strong need to conduct monitoring and collect information for security, energy, and the management of public spaces in a shared building. Even smaller residences can benefit enormously from having information on their energy and water use.

1.3 Objective

The objective of this project is to devise our own cloud services which can be used in residences across the world to control and monitor home appliances remotely. Additionally, we deliver value added services to the automation system, like a cloud based audio player synchronized across the home automation network, and a cloud controlled intrusion detection and burglary prevention system.

1.4 Related Work

- **Heating, Ventilation and Air Conditioning (HVAC)** solutions can include temperature and humidity control, fresh air, heating and natural cooling. Home automation solutions are varied and could include an internet-controlled thermostat, by allowing the homeowner to control the building's heating and air conditioning systems remotely, or it could be linked to windows to allow automated opening and closing to allow hot air out and cool air in to allow for cooling of the thermal mass of the house structure. Many systems are designed to not only provide convenience but to also allow for better energy efficiency.

- **Lighting control** systems can be used to control household electric lights. Examples include:

    - Extinguish all the lights of the house at a predetermined time and date range.

    - Use of motion detectors to automatically extinguish the lights in a room after occupants have left and turn on the lights if occupants enter a room.

    - Turn the light on or off with the use of a remote wireless device.

        - Control the brightness of the lights according to the level of ambient light available or other criteria.

        - Change the ambient color of a room via the lights used (mood control).

- **Audio Visual** systems include audio and video switching and distribution. Multiple audio or video sources can be selected and distributed to one or more rooms and can be linked with lighting and blinds to provide mood settings.

- Control and integration of **Security Systems** and also the potential for central locking of all perimeter doors and windows. With Home Automation, the consumer can select and watch cameras live from an Internet source to their home or business. Security systems can include motion sensors that will detect any kind of unauthorized movement and notify the user through the security system or via cell phone. This category also includes control and distribution of security cameras.

    - Detection of possible intrusion

        - Sensors of detection of movement.

        - Sensors of magnetic contact of door/window.

        - Sensors of glass breaking.

        - Sensors of pressure changes.

    - Simulation of presence.

    - Detection of fire, gas leaks, water leaks.

    - Medical alert. Teleassistance.

    - Precise and safe closing of blinds.

- An **Intercom** S**ystem** allows communication via a microphone and loud speaker between multiple rooms. Integration of the intercom to the telephone, or of the video door entry system to the television set, allowing the residents to view the door camera automatically.

- **Domotic** refers to intelligent houses meaning the use of the automation technologies and computer science applied to the home. Domotics includes completely automated systems that control entertainment, heating, broadband, lighting and security from one of many types of digital computer control devices, panels and mobile handset. Domotics is used to improve the quality of life increasing comfort, security and the same time obtaining costs and energy savings. The term covers a range of application:

    - Domotics is the discipline that investigates how to realize an intelligent home environment.

- Digital Home as a spectrum of services including home automation, multimedia, telecommunications, e-commerce, etc. through wired and wireless networks.

- Household devices, appliances, entertainment centers, temperature and lighting control units that behave intelligently.

- Under the domotics umbrella fall home security systems, whole-house audio or video systems, lights, gates and household LAN.

- Domotics and home automation means that systems talk to each other so that the result is convenience, energy efficiency, and safety.

- Control of home robots, using if necessary domotic electric beacon.

- Home robot communication (using Wi-Fi) with the domotic network and other home robots.

- Home assistive technologies.

- **Other Systems** that can be automated are:

  - Coffeemaker or tea maker.

  - Garage door.

  - Pet feeding and watering.

  - Plant watering.

  - Pool pump(s) and heater, hot tub and spa.

  - Sump Pump.

1.5 System Requirements

1.5.1 *Hardware Requirements*: Hardware is the core of the home automation system. It is what carries out commands and actually gets stuff done. This section covers both the control hardware and the HA hardware that makes up my system.

- *The Control Unit*: While there are a proliferation of plug-in controllers and timers out there, we really need to have a dedicated computer to run control software and accept inputs from complex devices. Additionally, having a dedicated computer allows to link the system to the cloud, giving the users access to virtually limitless quantities of data. A home control unit doesn't have to be good. In fact, complexity can be a liability - the more complex the machine, the more things there are to go wrong.

- *The Interface*: In order for control unit to send commands, we'll need an interface. These either connect to the computer via USB or through a serial cable. Interfaces serve two purposes - they connect the computer to the home's power lines, and they receive radio signals from modules, allowing them to communicate with the control unit.

- *Communication Protocol*: The information exchanged between devices on the home automation network or other communications medium is governed by rules or conventions that can be set out in a technical specification called a communication protocol standard. The nature of the communication, the actual data exchanged and any state-dependent behaviors are defined by the specification.

- *Lamp Modules*: Lamp modules allow controlling incandescent light bulbs. The module is plugged into an outlet, and then the lamp or light fixture is plugged into the module. Lamp modules can be dimmed, but they can only handle a certain load, so they shouldn't be used for appliances.

- *Appliance Modules*: Appliance modules act just like lamp modules, except they handle bigger loads, and they aren't dimmable. They are basically a remote controlled relay, so they make a distinctive "clunk" when triggered. The same issues with local control apply.

- *Wall Switches*: Wall Switch modules replace an existing wall switch. Since they use the same switch cover and wiring as the old switch, they are relatively unobtrusive and easy to install. As modules go, these are some of the most versatile - they allow built in light fixtures in a home to be controlled remotely, while leaving local control uncompromised. There are a lot of variations on the basic design - 3 way switches, switches with dimmers built in, etc.

- *Motion Sensors*: The motion sensors act slightly differently from other modules. They are wireless, so rather than sending signals through the power lines, they send them through the air, where they are received and relayed by the interface. This allows to place the sensors wherever desired - some are even waterproof.

- *Remote Switches*: Like motion sensors, remote switches transmit wireless signals through the air. It's a great alternative to drilling holes and running wires if a new switch is needed to install.

- *Universal Modules*: Universal modules are great for tinkerers and DIYers. They have two contacts that are switched when the module receives a command. The contacts can handle up to 24V, and they can operate as normally open or normally closed. Additionally, the module can switch the contacts for 5 seconds, or leave them switched on until an off command is received. Universal modules

can be used to automate everything from electronic drapes to garage door openers or even to control a furnace.

- *Other Hardware*: In addition to the basic control hardware, it's often useful to add other hardware, like sensors, cameras, etc. into the HA system.

- *Cloud Servers*: Cloud Servers are highly capable computers which act as the common remote gateway for all users of a HAaaS. Users use the cloud services hosted on these servers to control and monitor their home appliances remotely. Additional cloud hardware resources like a SMS modem is controlled by theses cloud servers.

1.5.2 *Software Requirements*: Software is arguably the most important part of any home automation system. It serves as the backbone for everything else, and as such it has to be reliable, feature-rich, and well supported.

- *The Control Software*.

- *The Ubiquitous Interface*.

- *Cloud Services.*

1.6 Report Organization

This report consists of six chapters. Aptly named, the Introduction introduces the reader to the key concepts of home automation, cloud computing and the combination of both. Chapter 2 gives an outline of the proposed system by defining HAaaS and explains how to actualize it.

Chapter 3 briefly analyzes the proposed system and then confers the hardware and software architecture. The four modules of this project are mentioned along with their functional and non-functional requirements.

Chapter 4 presents the implementation accompanied by tools used and screenshots. Chapter 5 validates the usability of the project by testing each module. The test results and the performance of each module are mentioned in the 6th Chapter.

Chapter 2
Overview of the Proposed System

2.1 Cloud Computing

Cloud computing is the delivery of computing as a service rather than a product, whereby shared resources, software, and information are provided to computers and other devices as a utility (like the electricity grid) over a network (typically the Internet). Cloud computing provides computation, software applications, data access, data management and storage resources without requiring cloud users to know the location and other details of the computing infrastructure. End users access cloud based applications through a web browser or a light weight desktop or mobile app while the business software and data are stored on servers at a remote location. Cloud application providers strive to give the same or better service and performance than if the software programs were installed locally on end-user computers. The services offered by existent cloud providers can be broadly categorized as Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS).

2.2 Home Automation

Home automation is the automation of the home, housework or household activity. Home automation may include centralized control of lighting, HVAC (heating, ventilation and air conditioning), appliances, and other systems, to provide improved convenience, comfort, energy efficiency and security. Home automation for the elderly and disabled can provide increased quality of life for persons who might otherwise require caregivers or institutional care. A home automation system integrates electrical devices in a house with each other. The techniques employed in home automation include those in building automation as well as the control of domestic activities, such as home entertainment systems, houseplant and yard watering, pet feeding, changing the ambiance "scenes" for different events (such as dinners or parties), and the use of domestic robots. Devices may be connected through a computer network to allow control by a personal computer, and may allow remote access from the internet.

Through the integration of information technologies with the home environment, systems and appliances are able to communicate in an integrated manner which results in convenience, energy efficiency, and safety benefits. The classification of home automation models are elucidated below:

2.2.1 *Individual Control devices*: As the most primitive form of home automation implementation, these appliances (like washing machine, hair dryer, etc.) feature an independent control for themselves.

2.2.2 *Distributed Control Systems*: The most significant characteristic of this type of systems is that the controllers are not central in location, but are

distributed throughout the system and the entire system of controllers is connected by networks for communication and monitoring.

2.2.3 *Centrally Controlled Systems*: These systems are controlled by residential computers so as to regulate appliances like heaters, air conditioners, refrigerators, window shutters, cooking systems, etc. Regardless of their current location, residents may connect to the control system from anywhere via the Internet or telephone.

2.2.4 *Cloud Controlled Systems*: These systems are made up of embedded devices which are connected to cloud services via the Internet. Similar to centrally controlled systems, residents may connect to the control systems from anywhere, through the cloud, via the Internet.

2.3 Home Automation as a Service

Home automation, as a model of pervasive computing, is progressively becoming substantial for people homed in developed societies. With the proliferation in the usage of household electronic and electrical appliances, numerous data and multifarious controls levy cumbersome burden on residential home automation control units, making it expensive and difficult for the users to autonomously install, control and monitor the home automation system. In this project, we deliver the concept of Home Automation as a Service (HAaaS) based on cloud computing, which assists in shrinking residential computing workload and therefore making home automation more convenient, flexible, energy efficient and less expensive. Furthermore, cloud based HAaaS would readily endow the users the ability to remotely control and monitor their home automation system in real-time, from anywhere, via the Internet. We also present the design, implementation and operation of a cloud connected ad-hoc wireless home automation system as a working example of multi-user HAaaS and thereby infer that HAaaS is indeed fructuous.

2.4 Proposed System

Prevalent techniques used in home automation include control of lighting, heating, ventilation, air conditioning, appliances, multi-media home entertainment, security surveillance and other systems. With the vast number of the household electronic and electrical appliances used in modern homes, the undertaking of home automation systems has become extensive and hefty. Home Automation as a Service (HAaaS) can simplify this scenario by connecting each sub-system of a home automation system directly to the cloud, and thus not only reduce the setup and maintenance cost by eliminating the need of specialized gateway and web server in each household, but also enable HAaaS providers to deliver advanced automation services to the home automation system. Multi-user HAaaS must be necessarily based on the standard cloud computing model, in which services are made available to the general public over the Internet as long as they use the specified web application programming interface (API). To endorse the expediency of HAaaS, we designed and actualized a cloud connected ad-hoc wireless home automation system as a virtuous case in point of HAaaS and tested the Quality of Service (QoS) of different sub-systems working simultaneously. We also devised our own cloud so as to empower

the employment of specialized shared resources and demonstrate the upright functioning of the entire ecosystem while calling attention to the advantages of HAaaS over traditional home automation systems.

Chapter 3
Analysis & Design

3.1 Brief Introduction

HAaaS refers to the cloud services provided over the Internet together with the household appliances that are automated through those services. We regard HAaaS as a development of PaaS, where computer hardware, operating systems, data storage and network bandwidth are outsourced, while application and data are managed by the HAaaS provider. HAaaS users are in control of their automated home appliances and systems by using the cloud services. To realize the amalgamation of cloud and home automation, the bridge to link cloud services with home automation systems needs to be efficient and effective.

3.2 System Analysis

The impingement of building automation on people's lifestyles is as far reaching as that of industrial automation on manufacturing and its benefits stretches over all sections of a society. Building automation is realized by embedding small-scale microcomputers inside various appliances, all of which interact with the user and communicate with other appliances. Home automation is a domain within building automation, focused towards certain automation requirements that are consistent with the domestic lifestyles of the residents. While several systems (such as illumination control, heating and ventilation control, control of doors and window shutters, security surveillance systems, etc.) deployed in building automation are also used in home automation, added functions in home automation can comprise of control of home entertainment systems, plant watering, pet feeding, changing the ambiance and the use of domestic robots. Cutting-edge systems can sense the presence and identity of a person and possibly set personalized illumination, temperature and music. Further refined systems may maintain a portfolio of merchandises, recording their usage through radio-frequency identification (RFID) tags, and formulate a shopping list to order replacements.

3.2.1 Functional Modules:

3.2.1.1 *Power Management System*: One fundamental objective of home automation systems is to control home appliances remotely. In this project, we control and monitor a home power management system (a vital part of most home automation systems) from virtually anywhere using a central cloud based service. The design, implementation and operation of the centralized cloud connected ad-hoc wireless home automation system are conferred and the benefits of cloud based home automation systems compared to mere Internet based home automation systems are also cited in this report.

3.2.1.2 *Cloud Audio Player*: In this project, we implemented a cloud based audio player synchronized across the home automation network in all (or selected) rooms of a house, thus delivering a brilliant music listening experience across a household. We also deployed specially fabricated strategies and protocols to synchronize the playing of an audio file from the cloud using minimal network bandwidth, in order to maintain a virtuous quality of service (QoS) for other components of the home automation network.

3.2.1.3 *Intrusion Detection and Burglary Prevention System*: Security surveillance partakes in significant number of home automation systems, deploying digital cameras and sensors to monitor and report intrusion events and thereby reducing damages caused by burglary. Our cloud connected ad-hoc wireless home automation system has en suite intrusion detection and burglary prevention stratagems. Along with an improved infrared camera, each node of our home automation system has devised intelligent algorithms for intrusion detection and subsequently reports any event to a location-aware cloud service in real-time.

3.2.1.4 *Location-Aware Advertising in Home Automation Systems*: With internet marketing being a driving force behind the growing internet economy, innovative and efficient ways to reach target markets are being pursued. In this project we designed and implemented an advertising framework which uses cloud connected home automation systems as the advertising platform. Moreover, en suite location awareness of the home automation system aids in effective geomarketing.

3.2.2 Non-Functional Requirements:

3.2.2.1 *Performance Requirements*: The home automation system needs to comply with certain performance requirement for each modules working simultaneously:

- Power Management Timeout: 1 second (local)
  20 seconds (remote)
- Audio Streaming Bitrate: 256 kilobit/s
- Intrusion Alert/ Notification Timeout: 15 seconds
- Location Detection Accuracy: ±100 meters

3.2.2.2 *Safety Requirements*: Like every electronic devices, the home automation devices should comply with these safety requirements:

- No wireless interference with other devices.

- Electrical shock proof.

- Short circuit detection / fire prevention.

3.2.2.3 *Security Requirements*: Connecting home automation network to the cloud calls for additional security protocols. To ensure sure and encrypted communication between devices or between a device and the cloud, modern technologies like HTTPS and WPA2 need to be deployed.

3.3 Design of the Proposed System

According to the design of the project, we replaced the traditional electrical switch board of each room with our cloud connected board where each board is a node of the home automation system, as a result creating a cloud connected ad-hoc wireless network among all the boards in a household.

3.3.1 System Architectural Design

3.3.1.1 *Hardware Architecture*: The hardware design of our home automation system makes it low cost, flexible and easy to install. We configured one board to act as an Internet gateway of the entire ad-hoc network by connecting it to a public HSDPA network of a national Internet Service Provider (ISP) with down-link speed of 7.2 Megabit/s and up-link speed of 1.8 Megabit/s.

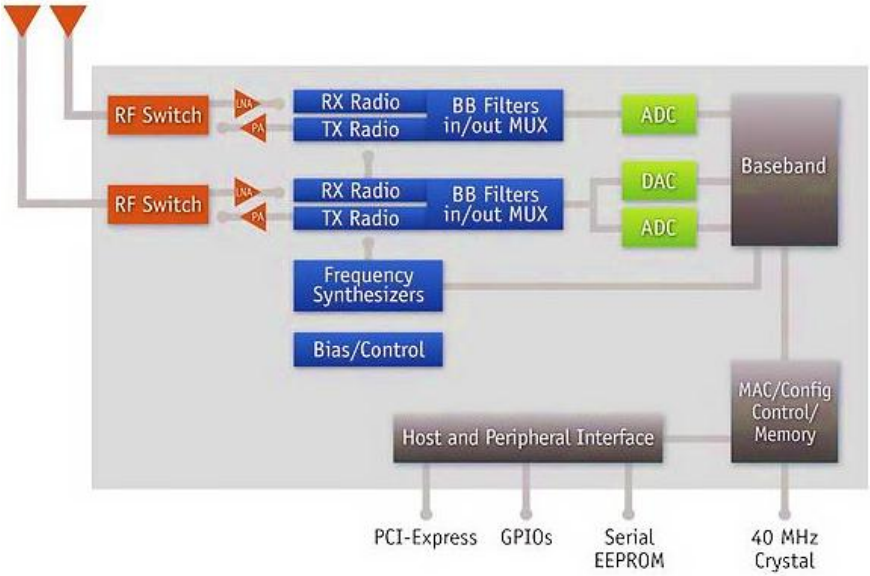

Fig. 3.1 Architecture of the 802.11n radio.

The home appliances are plugged into the AC power outputs which are governed by solid state relays controlled by a microcontroller. The microcontroller in turn is controlled by a low cost microprocessor which also controls the network radios of both 802.11n and UMTS (if configured) over a common bus.

Figure 3.3, 3.4 shows the internal and external photographs of the board in use. The touchscreen on the exterior of the board can be used as a local controller of the power management system, which delivers faster response time than a remote controller. The operating configuration and the hardware architecture of the 802.11n radio chip (Qualcomm Atheros XSPAN-AR9287) are provided in Table 3.1 and Figure 3.1, respectively. The wireless network is secured by Wi-Fi Protected Access II (WPA2) and encrypted with Counter Mode with Cipher Block Chaining Message Authentication Code Protocol (CCMP) encryption protocol.

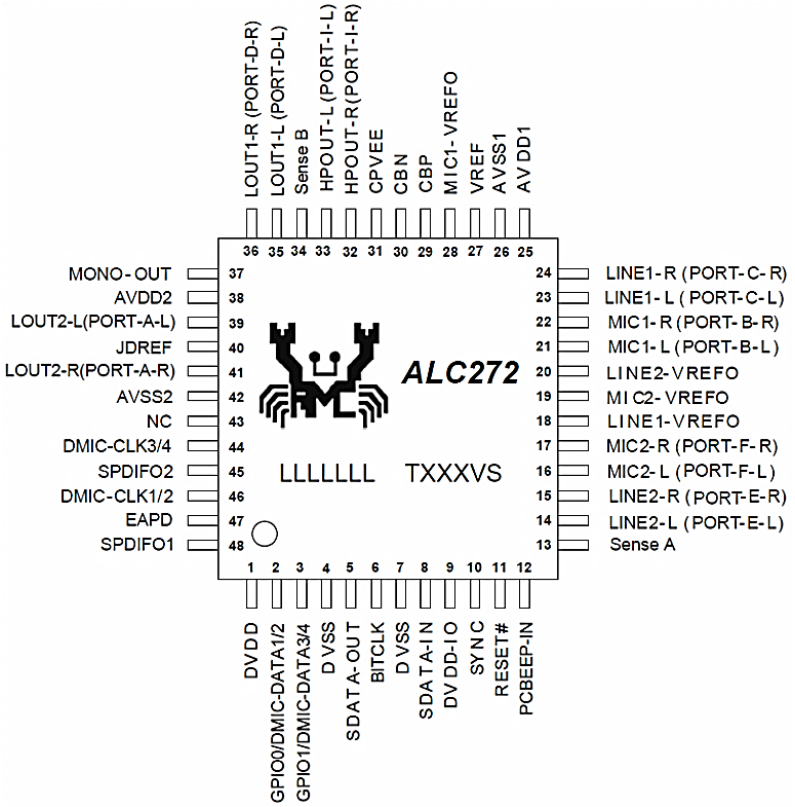

Fig. 3.2 Pin assignments of the ALC272 CODEC.

The board is also equipped with an improved infrared camera in each node. The improvement is made by fitting an additional wide-angle (also known as fisheye) lens to the camera, so as to have a full 180° view of observation. Since the board is installed on a wall, the camera acquires a complete view of a room. And since we replaced the electrical switch board of every room with our board, we get a complete view of the entire house. An application running on each board detects intrusion by the technique of motion detection, captured in the camera.

We also installed supplementary audio hardware to the cloud based home automation system. For audio playback we

coupled a High Definition Audio Codec, Realtek ALC272, to the Southbridge, Intel ICH6-M (82801FBM). Featuring dual stereo digital-to-analog converters, dual stereo analog-to-digital converters, legacy analog input to analog output mixing, single stereophonic digital microphone converter, and dual independent Sony/Philips Digital Interconnect Format (SPDIF) output converters, the ALC272 provides a fully integrated audio solution.

Fig. 3.3 External snapshots of an operational cloud connected board (node).

Fig. 3.4 Internal snapshots of the same board.

The ALC272 supports simultaneous analog microphone recording and up to 4 channel digital microphone array recording, and features Acoustic Echo Cancellation (AEC), Beam Forming (BF), and Noise Suppression (NS) for voice applications. The ALC272 CODEC's power efficient design reduces power consumption when the audio function is not

being used and offers jack detection wake-up when the system is in power down state so as to minimize power consumption without sacrificing audio features. The ALC272 CODEC's digital interface circuitry operates on a 3.3V power supply. An integrated 50mW/20ohm headset audio amplifier for Front-Out and Surround-Out, a 14.318MHz to 24.576MHz phase-locked loop (PLL), and a PCBEEP generator cut bill of materials (BOM) cost. We also installed a set of auxiliary stereo speakers inside the board, with the option to plug in external speakers over a standard 3.5mm audio port.

Table 3.1 Operating configuration of the 802.11n radio.

802.11n		
Frequency	5 GHz	
Bandwidth	40 MHz	
Data rate	150 Mbit/s per stream	
MIMO streams	2	
Modulation	OFDM	
Approximate indoor range	60m	200ft
Approximate outdoor range	200m	650ft

3.3.1.2 *Software Architecture:* Each board comes installed with Windows Embedded 6.0. We installed audio software to play audio files from the cloud. On the front end, the software application provides control to music playback along with details of currently playing track. The controls are Play, Stop, Previous Track and Next Track. The details include Title, Album, Artist, Year and Album Art. On the back end, the software first decides a protocol on which the audio file is to be streamed and then plays the streaming audio file in synchronization with other boards.

Power management software controls the attached appliances and an application running on each board detects intrusion by the technique of motion detection, captured in the infrared camera. In case of an intrusion event, the application communicates with the cloud in order to notify the user.

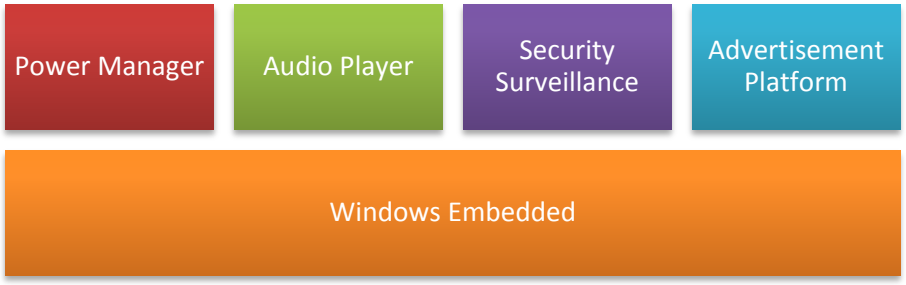

Fig. 3.5 Software architecture.

3.3.1.3 *Cloud Architecture:* To construct our cloud, we deployed an Intel Xeon and Windows Server 2008 R2 based system. A SMS modem connected to the cloud server is used for opt-in notifications to the users, in case of technical complications like blackout or network failure.

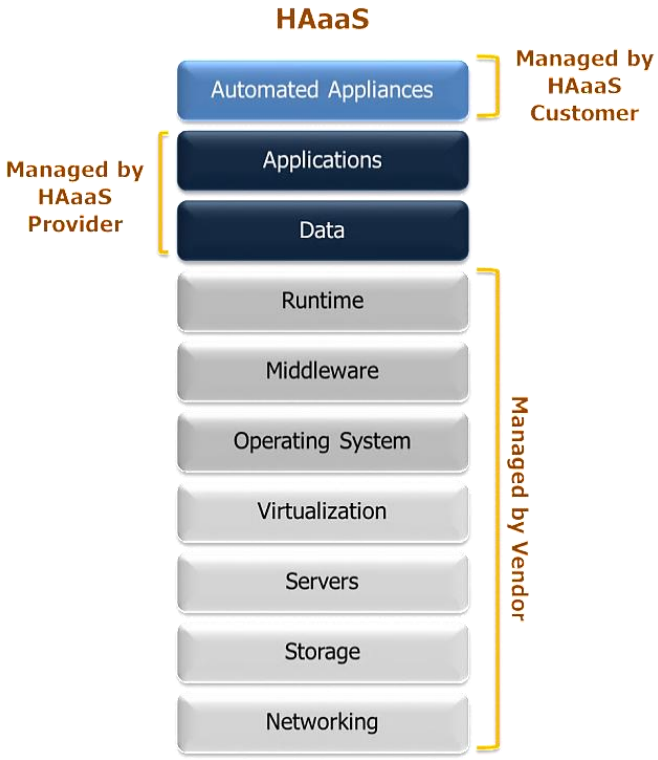

Fig. 3.6 HAaaS architecture.

To connect of cloud and home automation, the bridge to link cloud services with home automation systems needs to be efficient and effective. The link is essentially the Internet and the following are the two main approaches to linking:

- *Internet Gateway*: Conventionally, smart homes use an Internet gateway to connect to the Internet, where the Internet gateway is largely a dedicated computer unit which allows coupled devices to access the Internet. In HAaaS, home automation systems and appliances may also be connected to the cloud through such an Internet

gateway. Figure 3.7 shows how different household appliances can be connected to the cloud by linking to a residential Internet gateway.

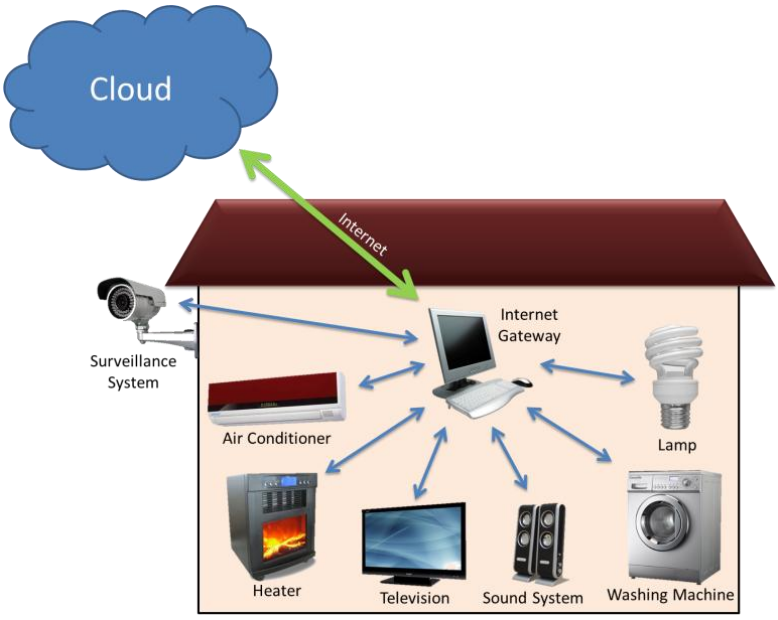

Fig. 3.7 Internet Gateway based HAaaS.

- *Internet of Things*: The Internet of Things (IoT) refers to distinctively recognizable objects (things) and their virtual representations in an Internet-like structure. In HAaaS, individual home automation systems and appliances may be directly connected to the cloud as distinct objects and as a result avoid protocol conversions.

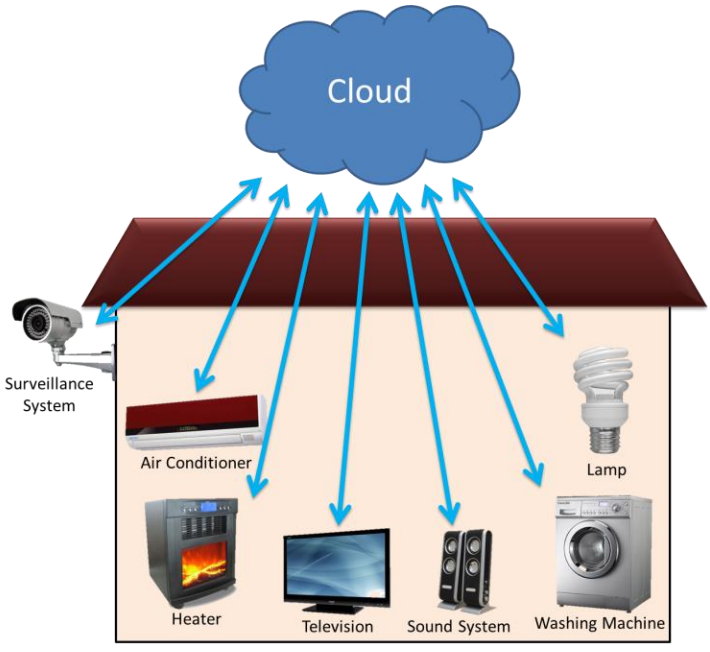

Fig. 3.8 Internet of Things based HAaaS.

3.3.1.4 Discussion of Alternative Designs

There are several other standards of HA currently available in the market. Some of them are mentioned below:

- Device interconnection:
  - Bluetooth
  - IEEE 1394 interface (FireWire)
  - IrDA
  - Universal Serial Bus (USB)
  - ZigBee
- Control and automation nets:
  - BACnet
  - SCS BUS with OpenWebNet
  - C-Bus (protocol)
  - CEBus
  - ECHONET
  - EnOcean
  - EHS
  - INSTEON
  - KNX (European Installation Bus)
  - LonWorks
  - ONE-NET
  - S-Bus
  - Universal Powerline Bus
  - VSCP
  - X10
  - XPL Protocol
  - Z-Wave
  - ZigBee
- Data nets:
  - Ethernet
  - Homeplug
  - HomePNA

There have been many attempts to standardize the forms of hardware, electronic and communication interfaces needed to construct a home automation system. Some standards use additional communication and control wiring, some embed signals in the existing power circuit of the house, some use radio frequency (RF) signals, and some use a combination of

several methods. Control wiring is hardest to retrofit into an existing house. Some appliances include USB that is used to control it and connect it to a domotics network. Bridges translate information from one standard to another, e.g., from X10 to European Installation Bus.

3.3.2 Component Description

3.3.2.1 Power Management

A home power management system controls electrical and electronic appliances such as lamps, heaters, ovens, computers and computer peripherals, geysers, etcetera. It essentially turns on the appliances when required or commanded and turns off the appliances when inactive or commanded. When the control of appliances is made automated, the necessity of monitoring becomes equally important. Presently, the services offered in our cloud are:

- Real-time Status Monitoring:
  - AC power supply status.
  - Network Connectivity status.
- Toggling a specific appliance on or off.
- Power Scheduling.
- SMS notifications:
  - AC power supply disruption notification.
  - Broken network connection notification.

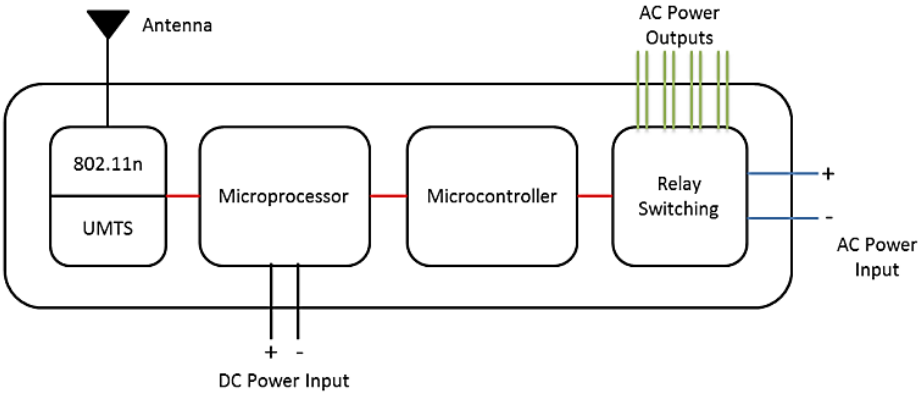

Fig. 3.9 Internal hardware architecture of every board (node).

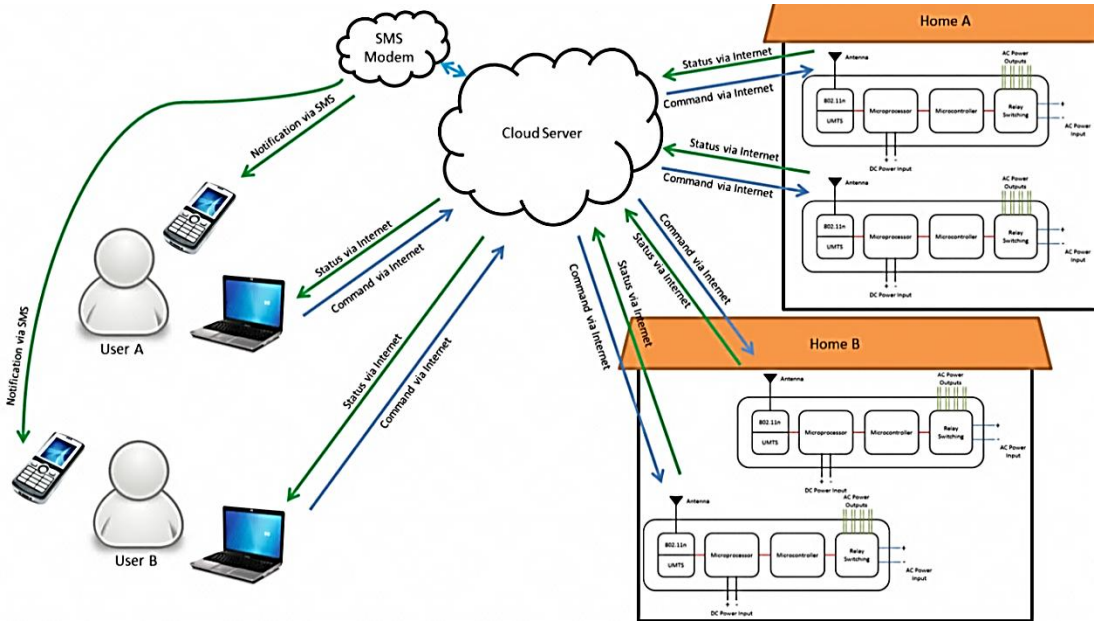

Fig. 3.10 Schematic diagram of how two users can use the same cloud services to control and monitor their home appliances remotely.

3.3.2.2 Cloud Audio Player

A cloud audio player is essentially an audio streaming service where audio file are stored in the cloud and a user can stream and listen to a song amongst the list of audio files previously stored. In addition, many existent cloud audio players give an option to upload and store user's personal audio file in the cloud. Our application of the cloud based audio player is synchronized across the home automation network in all (or selected) rooms of a house, thus delivering a brilliant music listening experience across a household.

Building the home automation network on 802.11n standard provides us surplus bandwidth to stream audio files within the network. But independently streaming an audio file to all boards (nodes) in a house would require a superior and costlier gateway modem than the low cost UMTS Release 5 modem we installed. So, we deployed a few strategies to minimize the gateway bandwidth usage and thereby maintaining a good QoS for the entire home automation system. The strategies are adaptive and use mutable protocols to play the audio files in synchronization. Presently, the audio services offered in our cloud are:

- Uploading audio files in MPEG-1 or MPEG-2 Audio Layer III (MP3) format, up to 10 GB per user.

- Smart music playlist.

- 256 kilobit/s audio streaming.
- Controls:
  - Play
  - Stop
  - Previous Track
  - Next Track
- 4-bit independent volume control of each board.
- Details:
  - Title
  - Album
  - Artist
  - Year
  - Album Art
  - Runtime

3.3.2.3 Intrusion Detection and Burglary Prevention

Security surveillance partakes in significant number of home automation systems, deploying digital cameras and sensors to monitor and report intrusion events and thereby reducing damages caused by burglary. Our cloud connected ad-hoc wireless home automation system has en suite intrusion detection and burglary prevention stratagems. Along with an improved infrared camera, each node of our home automation system has devised intelligent algorithms for intrusion detection and subsequently reports any event to a location-aware cloud service in real-time.

In case of an intrusion event, another cloud service alerts the user with a SMS conversation. The user can then monitor the intrusion from anywhere, on any Internet enable device by accessing the cloud's web interface. If the intrusion is genuine, the user is provided with options to stealthily alert neighbors (who are using our home automation system), play alarm sounds or even report to the police. Using these

techniques, burglary can be evaded effectively. Presently, the security services offered in our cloud are:

- Real-time Monitoring of all rooms.
- Toggling the security surveillance on or off.
- Automatic storing and updating geolocation of each board.
- SMS notifications and user's confirmation in case of intrusion detection.
- In case of genuine intrusion, as confirmed by the user:
    - Stealthily alert neighbors, who are also using our home automation system, using SMS, email or by playing low sound alarms in their home.
    - Inform local police.
    - Play loud alarm sound.

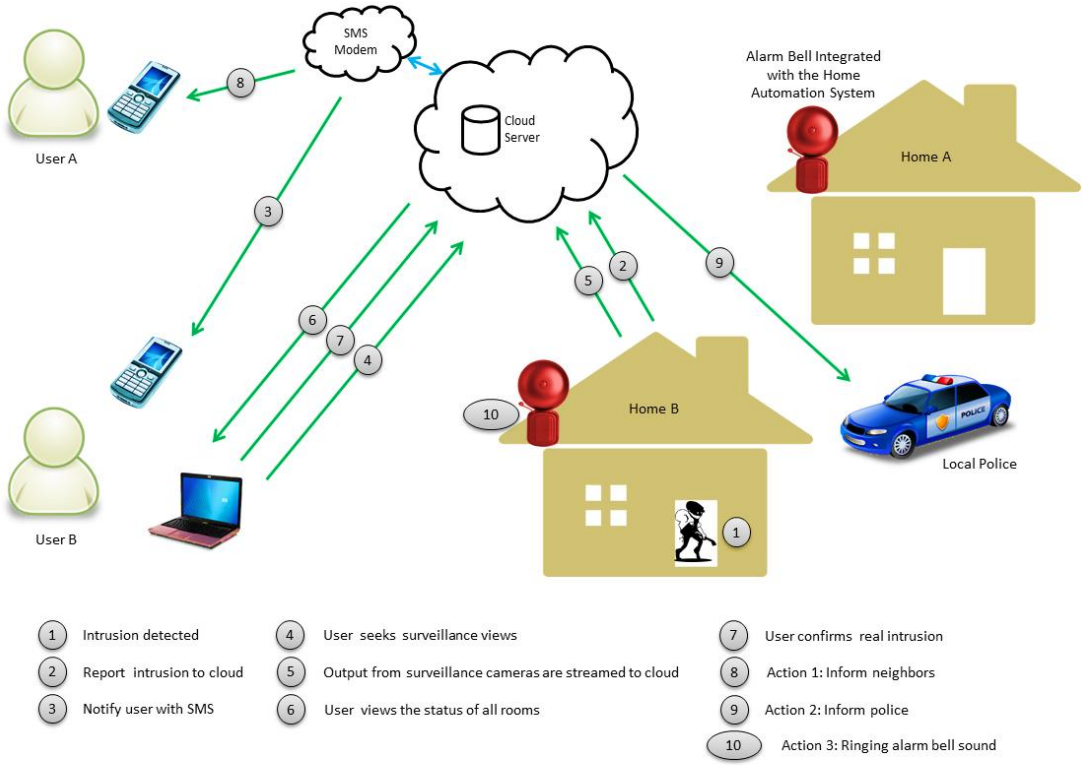

Fig. 3.11 Schematic diagram of how a user (B) is notified about an intrusion event and how he takes action to prevent burglary by alerting neighbor (user A), informing local police or ringing loud alarm bell sound.

3.3.2.4 Location-Aware Advertising in Home Automation Systems

Internet advertising is referred to the form of promotion of products or services over the Internet which conveys marketing deals appealing to targeted customers. The major advantage of online advertising is the instantaneous publication of information and content that is not restricted by geography or time. Another benefit is the efficiency of advertiser's investment by personalization and customization of advertisement messages. Cloud based home automation systems depend on Home Automation as a Service (HAaaS) providers. Traditionally, HAaaS provider may offer a paid subscription or may offer a free service with advertisements. Here, in this paper we present the design and implementation of an advertising framework which can be used by HAaaS providers to advertise in their cloud connected home automation systems.

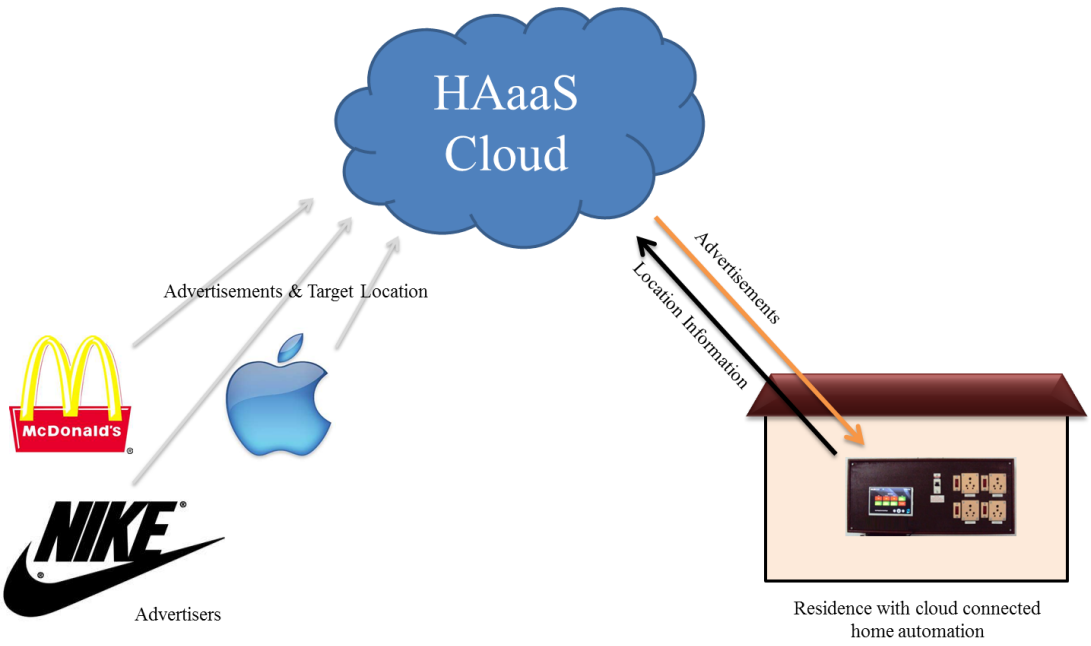

Fig. 3.12 Schematic diagram of how advertisers can advertise on home automation systems through the HAaaS cloud.

The advertisement system has an upload site, where client advertiser corporations upload their advertisement messages to the HAaaS cloud along with information of their geographical target. The advertiser corporations are charged on Cost per View (CPV), where advertisers pay for each unique view of an advertisement.

In the home automation system, each node is equipped with a software based location detection system. The cloud stores the geolocation of each board (node) of all independent home automation networks in latitude and longitude. This

geolocation information is stored in the cloud and is update on a regular basis. Each node connects to a cloud API to download the advertisement messages targeted for the last detected location of the board. The advertisements are displayed on the touchscreen of the board which also serves as the control panel for the home automation system. The advertisements are displayed only on certain user interaction events. For example, an infrared camera is used to detect if some is present in the room, and thus increase the effectiveness of the displayed advertisements.

3.3.2.5 Controlling & Monitoring through Internet

The cloud services can be accessed from anywhere in the world on any Internet enable device over an enforced Hypertext Transfer Protocol Secure (HTTPS) connection, encrypted by Secure Sockets Layer (SSL) version 3.0. The web interface of the cloud requires password based user authentication. A user is entitled to add any number of board (nodes) to his account, which can also be removed if necessary. After authentication, the user is redirected to the home page where controlling options and status of individual boards (nodes) are displayed.

Chapter 4
Implementation

4.1 Tools Used

4.1.1 Client Board Tools:

- **WMIC** for AC power status detection (Appendix A).
- **Adobe Flex Builder** to create software for motion detection (Appendix B).
- **JCreator** to build Java based GUI.
- **Connectify** is used for ad-hoc network management.
- Command-line **VLC** is used to play streaming audio files (Appendix C) in background.
- **Windows Embedded 6** as the operating system.
- **Geosense** is used to detect location of the board.

4.1.2 Cloud Tools:

- **WAMP** is used to host cloud services and web based control and monitor.
- **getID3()** is used to read ID3 tags of user uploaded MP3 files (Appendix D).
- **Windows Server 2008 R2** as the server operating system.
- **Ozeki NG - SMS Gateway** is used for SMS notification management through PHP.

4.2 Software Implementation

4.2.1 User Interface Design

The cloud's web interface is used to control and monitor the home automation devices. The web interface consists of these key pages:

- Sign In

- Sign Up
- Home
- Power Management & Power Scheduling
- Cloud Audio Player & MP3 Upload
- Settings
- Deactivate Account

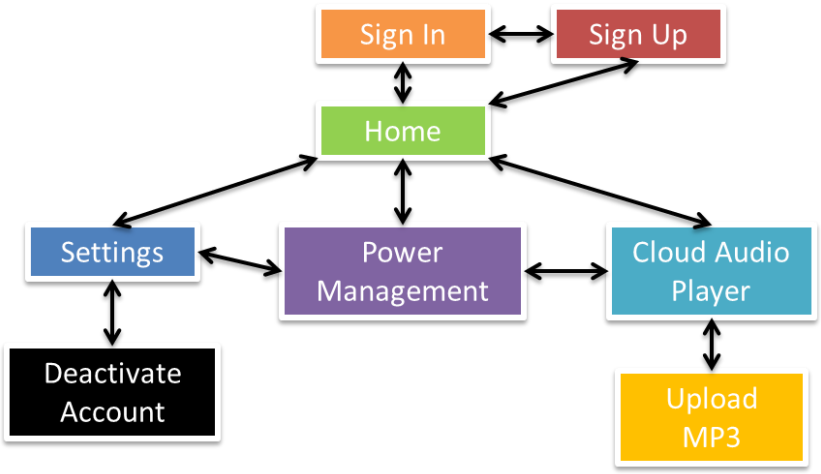

Fig. 4.1 User interface diagram of the cloud's web interface

4.2.2 Description of the User Interface

A. *Sign In Page*: The users of HAaaS have to authenticate themselves in order to proceed to their account.

B. *Sign Up Page*: New users of HAaaS can open an account by providing personal and authentication details followed by a CAPTCHA verification.

C. *Home Page*: After authentication is completed successfully, the user is redirected to this page. The page acts as a dashboard to all the other pages.

D. *Power Management Page*: Integrated with the home page, this page offers information about the status of different cloud connected boards added to the account. The page also provides the control to the home appliances and an option to add additional boards.

E. *Cloud Audio Player page*: This page displays the user uploaded MP3 files' information. Users can choose to play a file among the

list. The page also provides other controls like next song, previous song, delete song, etc.

F. *Deactivate Account*: This page allows the HAaaS user to deactivate his/her account if he/she wish to do so. This can be due to dissatisfaction with the product/service or other personal causes.

G. *Upload MP3*: This page allows the user to add new music files to their account. The file uploaded must be a must be an audio file in MP3 container.

H. *Power Schedules Page*: Displays the previously added schedules and provides an option to add a new.

4.2.3 Screen Images

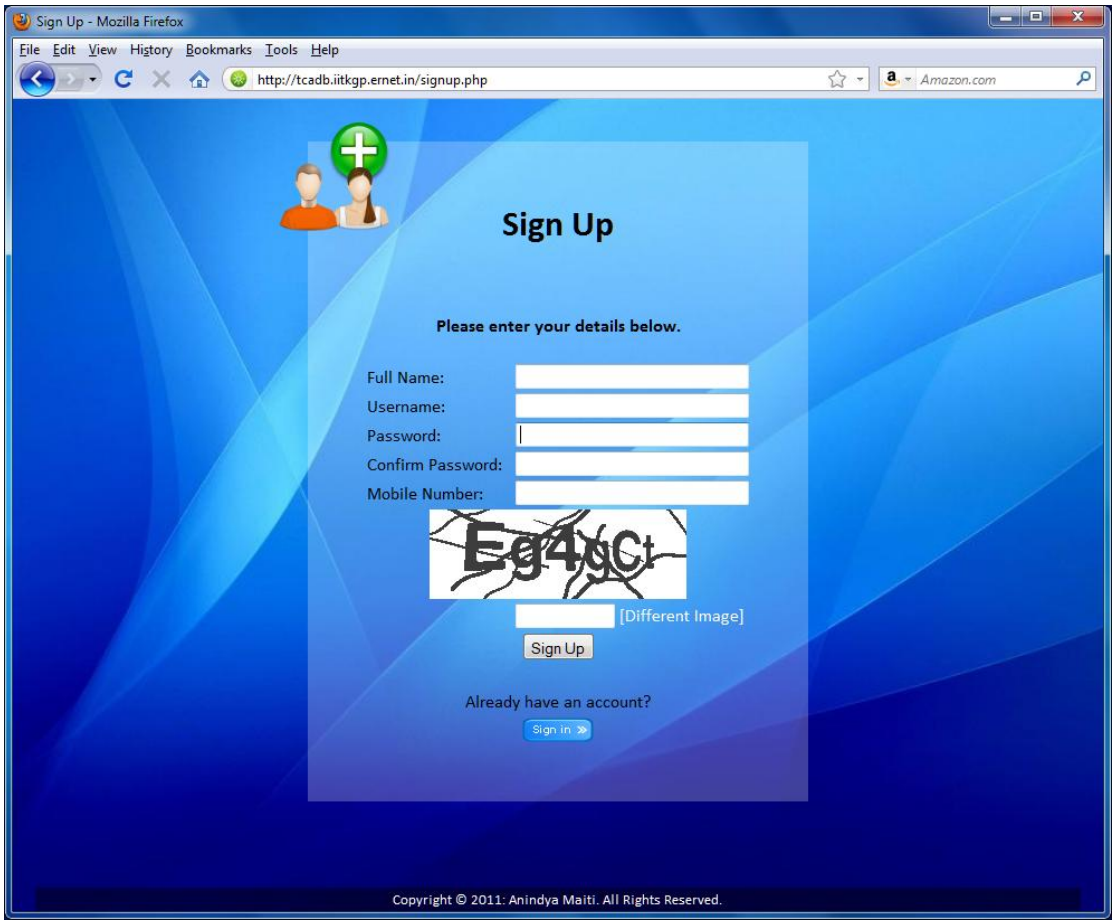

Fig. 4.2 Sign Up Page

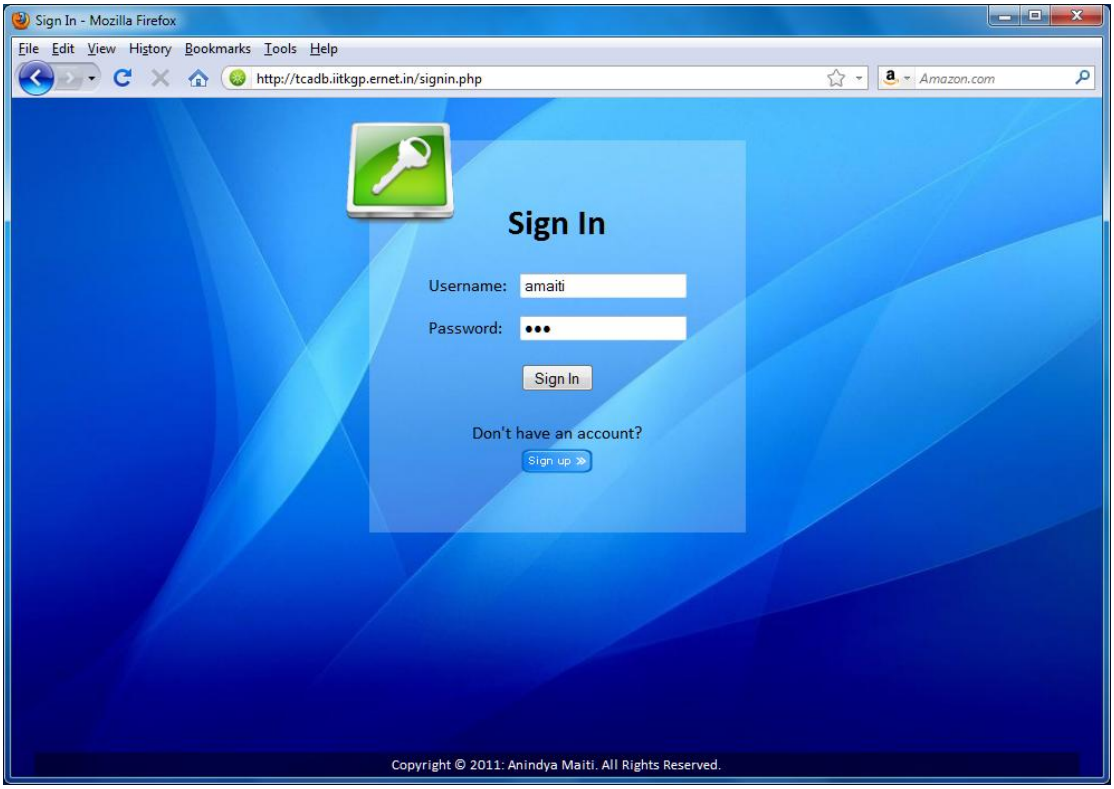

Fig. 4.3 Sign In Page

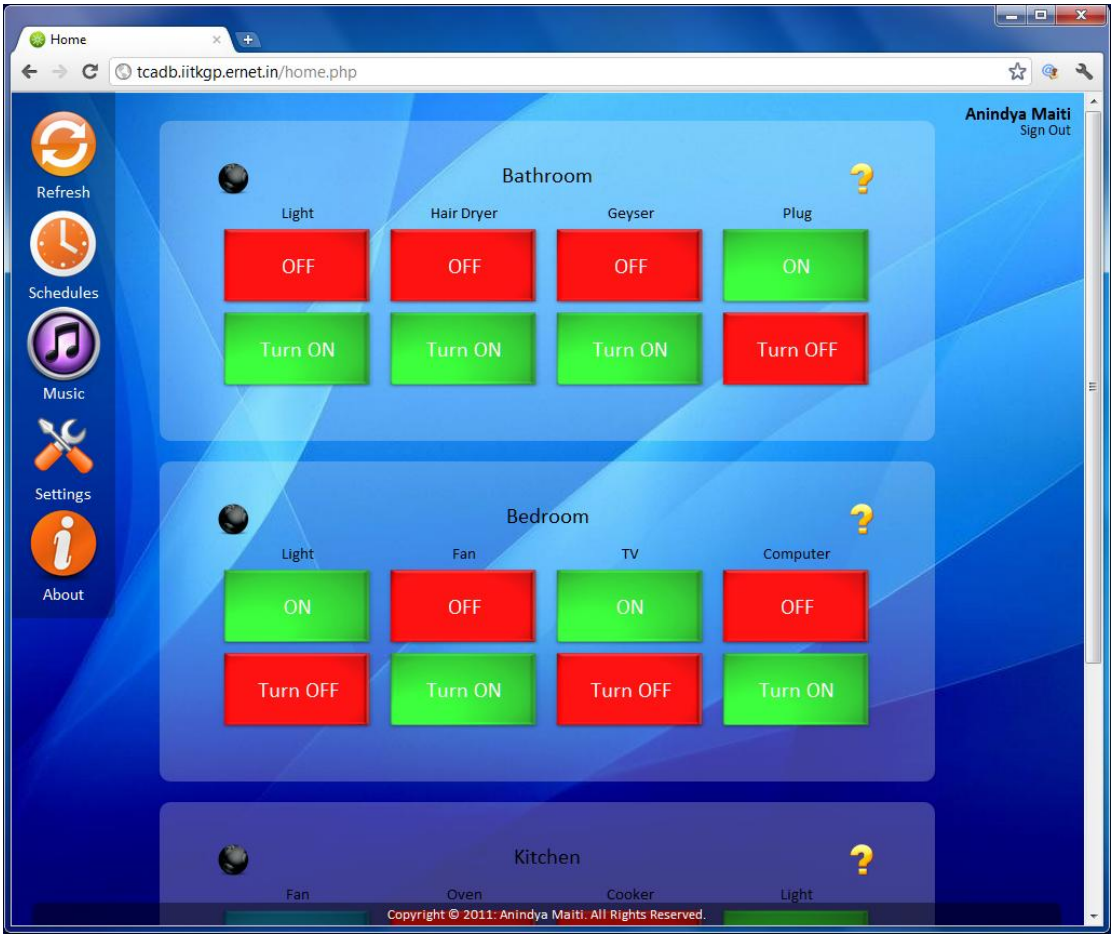

Fig. 4.4 Power Management Home Page

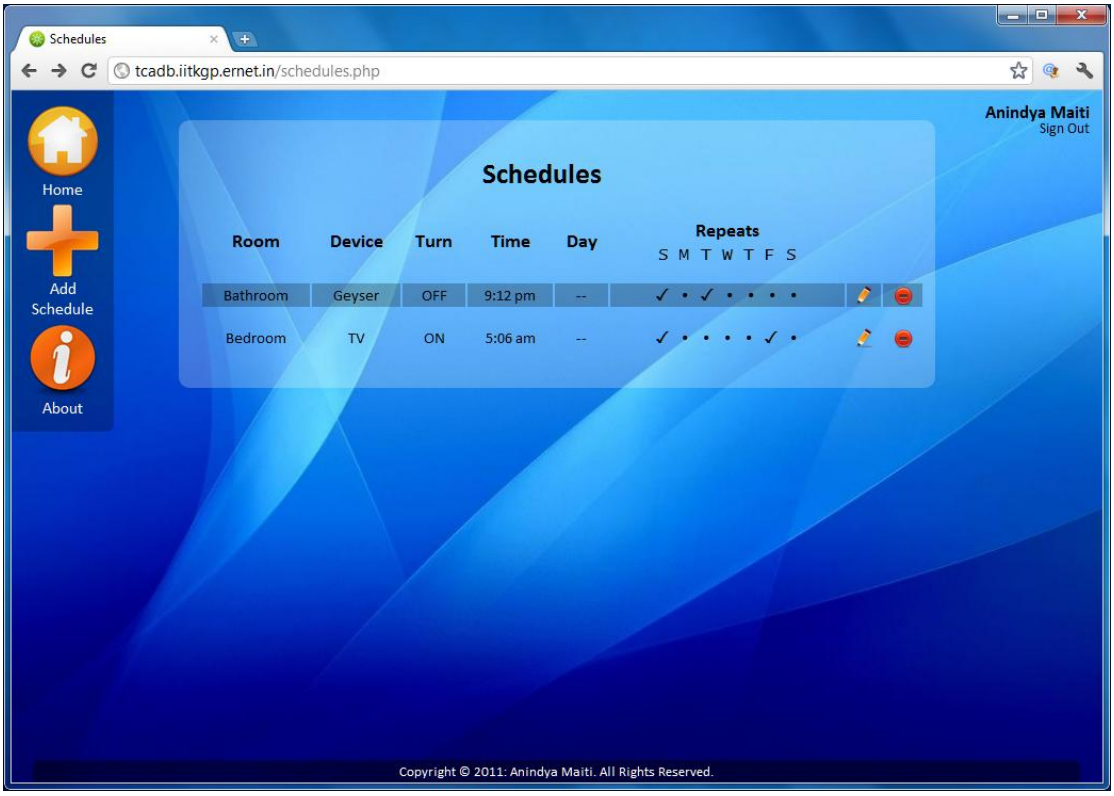

Fig. 4.5 Power Scheduling Page

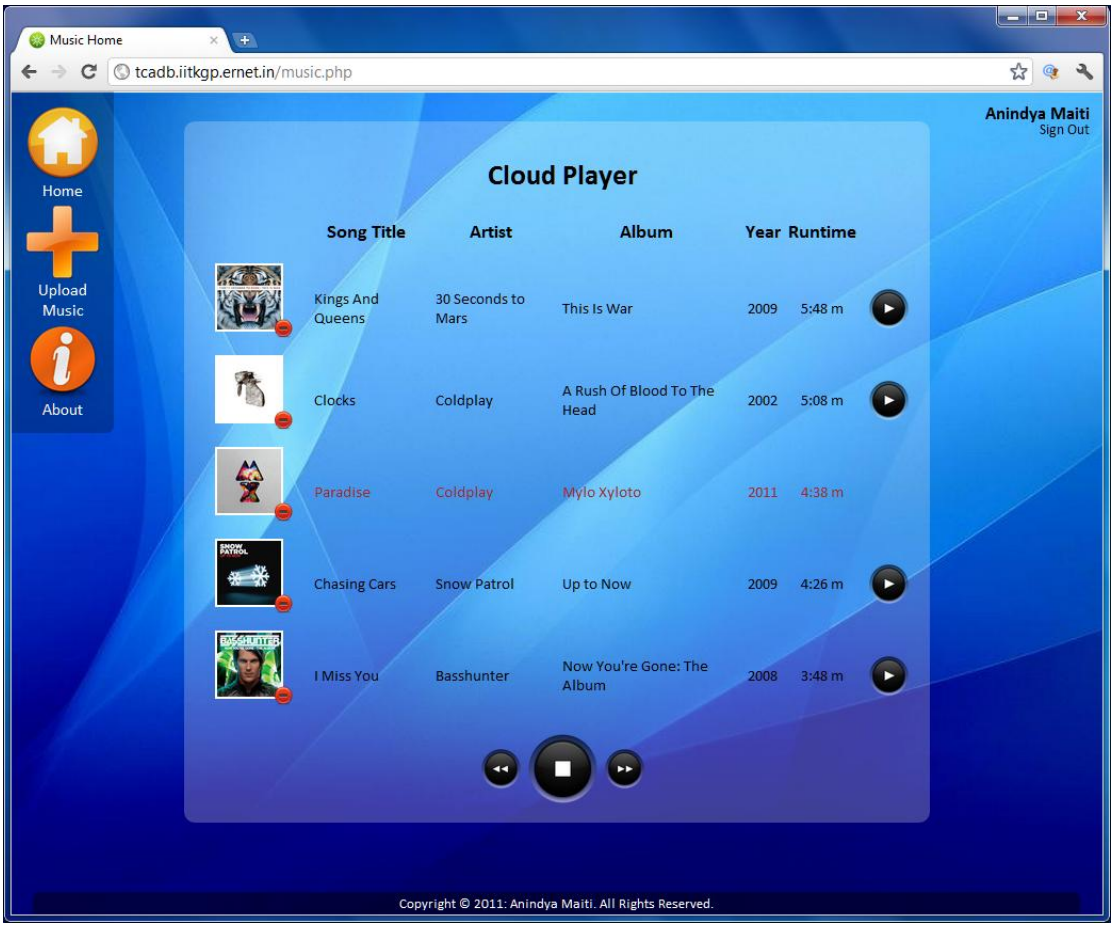

Fig. 4.6 Cloud Audio Player

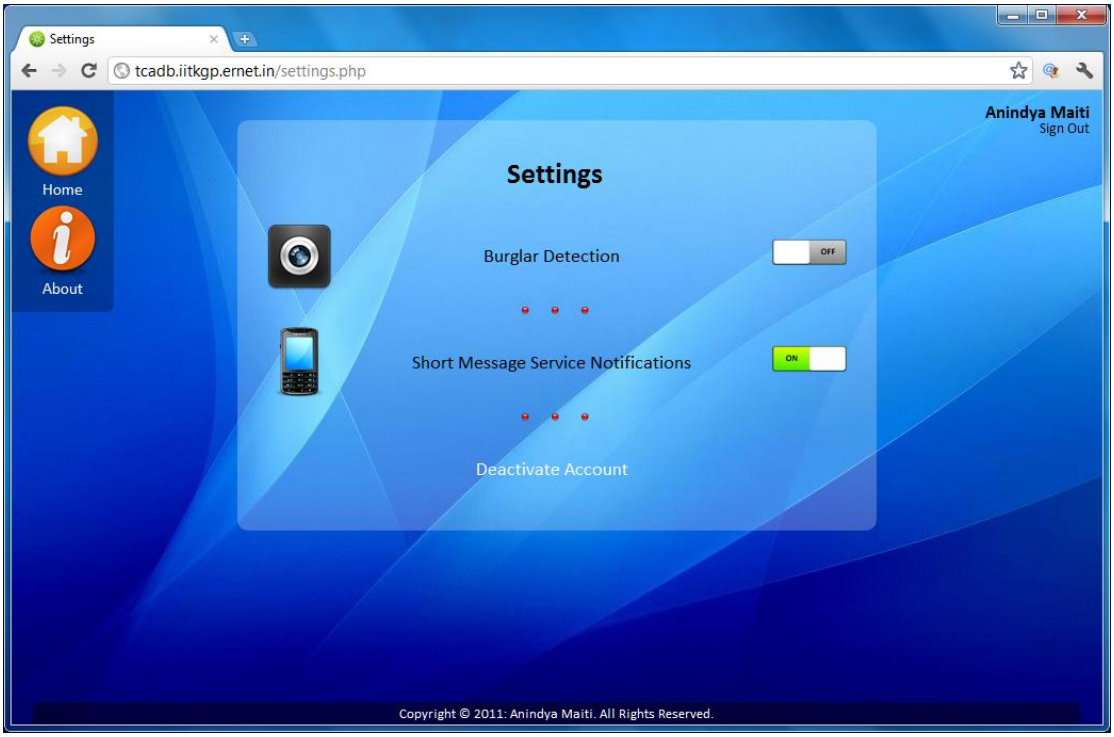

Fig. 4.7 Settings Page

4. 3 Hardware Implementation

Fig. 4.8 Camera fitted with Fish-Eye lens.

Fig. 4.9 SMS modem connected to the cloud server.

4. 4 Testing

4.4.1 Test Approach

As with any real-time process, the process of home automation should comply with good operability and integrity. So, benchmark tests of the network gateway were conducted.

4.4.2 Test Plan

Features to Be Tested:

- Power Management Timeout.
- Uninterrupted Audio Streaming at 256kbps.
- Intrusion Alert/ Notification Timeout.
- Location Detection Accuracy

4.4.3 Testing Tools and Environment

PRTG Network Monitor was used to tests of the network gateway bandwidth. PRTG Network Monitor is the powerful and comprehensive network monitoring solution from Paessler AG. It monitors the network using a whole range of technologies and assures the availability of network components and measures traffic and usage. PRTG saves costs by avoiding outages, optimizing connections, saving time and controlling service level agreements (SLAs).

PRTG Network Monitor runs on a Windows machine within the network, collecting various statistics from the machines, software, and devices designated. PRTG comes with an easy-to-use web interface with point-and-click configuration. RTG can collect data for

almost anything of interest on the network. It supports multiple protocols for collecting this data:

- SNMP and WMI
- Packet Sniffing
- NetFlow, jFlow, and sFlow

Geosense Demo Client application was used to test the accuracy of location detection. Geosense is a Windows Sensor that provides the Location and Sensors platform in Windows with accurate and reasonably ubiquitous positioning information without requiring or the assistance of GPS hardware, enabling more practical location-based applications and scenarios on Windows. Although not required, it works best on computers with a Wi-Fi adapter.

Chapter 5
Results & Discussion

5.1 Results

The benchmark test result graphs generated by PRTG Network Monitor are below:

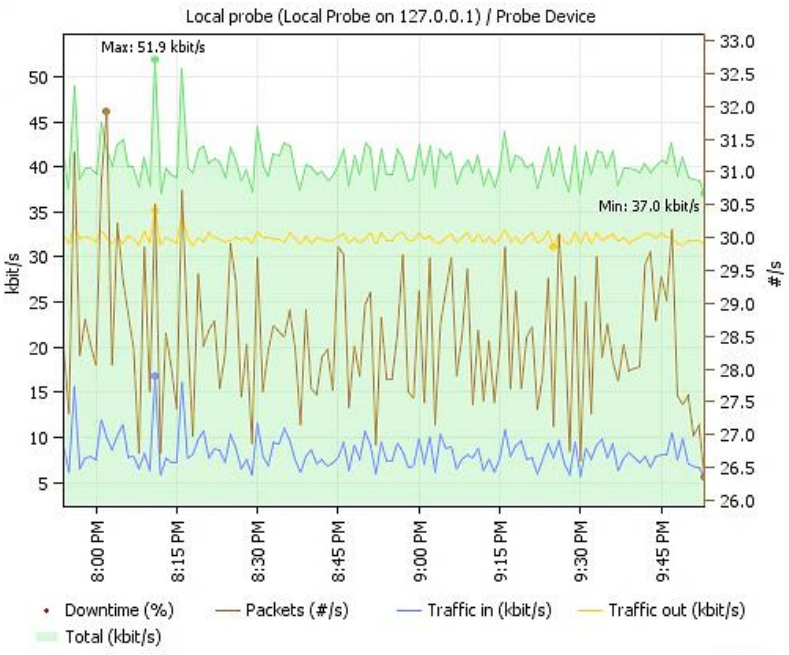

Fig. 5.1 A graph showing gateway bandwidth usage in power management for duration of 2 hours.

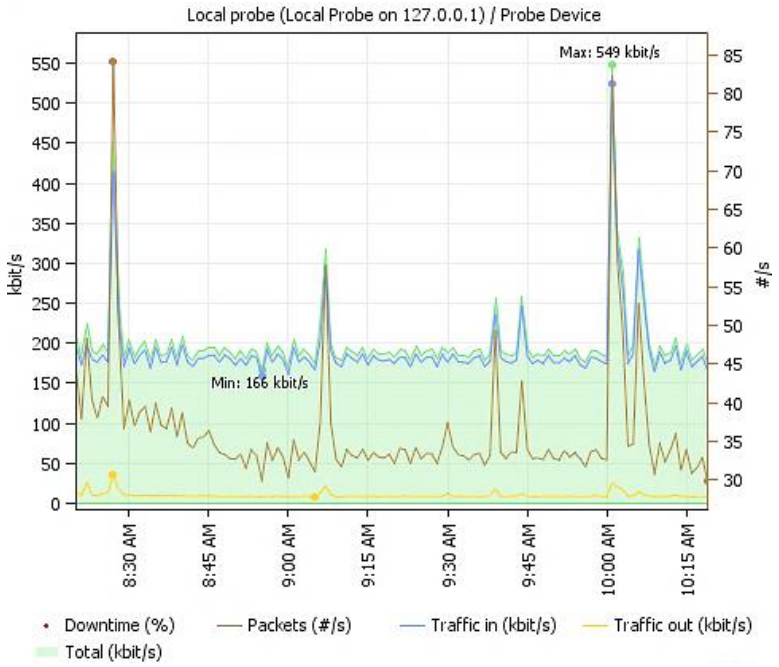

Fig. 5.2 A graph showing gateway bandwidth usage by audio player for duration of 2 hours.

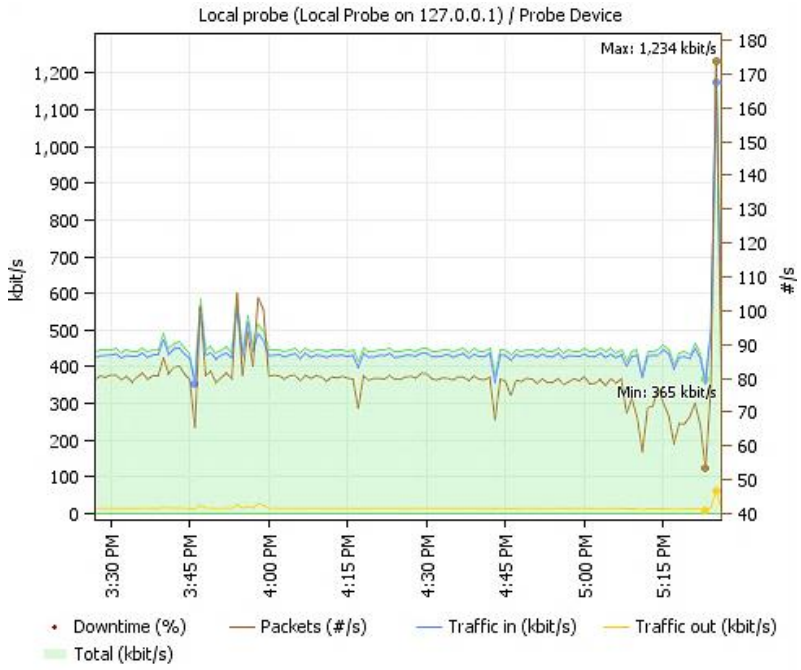

Fig. 5.3 A graph showing gateway bandwidth usage by security surveillance system for duration of 2 hours.

The location detected by the Geosense Demo Client is show in the map below:

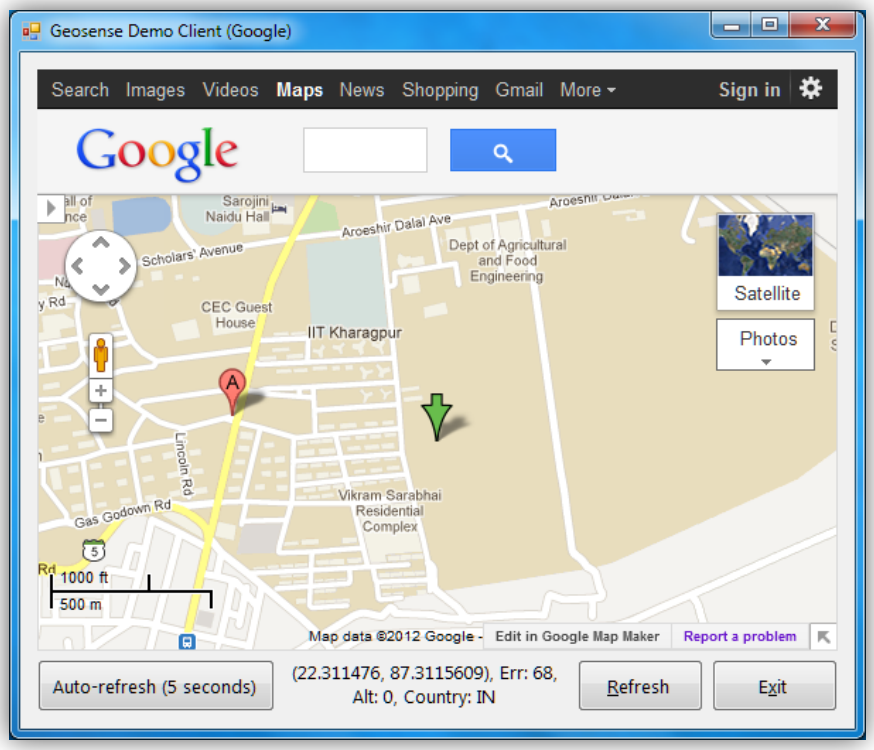

Fig. 5.4 The green arrow showing the location detected.

5.2 Performance Analysis

After analyzing the graphs we perceive that on an average, less than 20% of the gateway bandwidth is in use, while using 5 boards simultaneously. This leaves out

enough bandwidth to set up Resource Reservation Protocol - Traffic Engineering (RSVP-TE) across the IP network, which is anticipated to give real-time controlling and monitoring authority to the users.

Also, the location detected was inside 50 meters of the radius from the origin which is well within our requirement.

Chapter 6
Conclusion & Future Works

The use of cloud services in home automation derives many benefits extending from cost reduction to value added services. For further work on the cloud based home automation network, we plan to add a few more a multi-level cloud audio player and many more.

On improving the security surveillance system, we plan to add more social integration through social networking sites like Facebook and Google+. With the help of these online social networks, we can easily contact and notify a user's friends in case of an intrusion event and thus make burglary prevention more effective.

We are also developing a socially interactive cloud audio player for home automation systems wherein users can share music on friend's home automation network.

Apart from services, we plan to device a mechanism to improve the effectiveness of Smart Grids. Already functional in many cities, Smart Grids are a promising answer to a sustainable future. We can make these Smart Grids more efficient than the current model, by processing more specific real-time electricity usage data from the cloud, without causing detriment to user privacy. Moreover, the boards (nodes) used in our power management system can act as smart meters as well as load balancer, at little to no extra hardware cost.

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Appendix A
Windows Management Instrumentation Command-line

The Windows Management Instrumentation Command-line (WMIC) is a command-line and scripting interface that simplifies the use of Windows Management Instrumentation (WMI) and systems managed through WMI. WMIC is based on aliases. Aliases make the primary data provided by WMI available without having to understand WMI-specific concepts. WMI data and many WMI features are also accessible through WMI without aliases.

Table A.1 WMIC Verbs

Verb	Sample Command	Description
Assoc	group where name= 'administrators' assoc	Shows all the associations that the Administrators group has with the system. For example, Administrators group members and the drives that they own appear in the list of properties displayed.
	os assoc	Displays information about the OS and installed patches and hotfixes.
Create	environment create name="progloc", username="wkst01\ ethanw",variablevalue= "%programfiles%\prog01"	Adds a variable named Progloc and sets its value to a folder below the Program Files folder. For example, the sample command is adding this variable to the Ethanw user account on the WKST01 workgroup computer.
Delete	environment where(name= "progloc") delete	Deletes the Progloc environment variable. To avoid unintended deletions when testing a WMIC command that uses the Delete verb, use the /interactive:on global switch. User will then be prompted to confirm each deletion.
Get	partition get bootpartition, description, deviceid, bootable	Returns the boot-partition Boolean (true or false), description string, and device ID properties of the partition alias.
Set	path WIN32_USERACCOUNT where(name="user01") set disabled="true"	Disables the User01 user account on a member server or workstation.

To view all of the processes that are currently running on the computer, type **PROCESS** in the WMIC utility. To list a specific process, type a command such as **PROCESS WHERE (Description="explorer.exe")**. To receive specific properties

for the processes, type a command such as **PROCESS GET Name, Handle, PageFaults**. Without using aliases, we can use the same options with the **CLASS** command. For example, **CLASS Win32_Process GET Name, Handle, PageFaults**. However, we must determine the name of the class from other sources. To do the equivalent of the alias **Where** clause, we must use **PATH Win32_Process.Description="explorer.exe"**.

WMIC is used in this project to detect the AC power status and update the cloud servers with the same. The code snippet used is below:

```
@echo off

:: Variables to translate the returned BatteryStatus integer to a
descriptive text
::SET BatteryStatus.1=discharging
::SET BatteryStatus.2=The system has access to AC so no battery is being
discharged. However, the battery is not necessarily charging.
::SET BatteryStatus.3=fully charged
::SET BatteryStatus.4=low
::SET BatteryStatus.5=critical
::SET BatteryStatus.6=charging
::SET BatteryStatus.7=charging and high
::SET BatteryStatus.8=charging and low
::SET BatteryStatus.9=charging and critical
::SET BatteryStatus.10=UNDEFINED
::SET BatteryStatus.11=partially charged

:: Read the battery status
FOR /F "tokens=*" %%A IN ('WMIC Path Win32_Battery Get BatteryStatus
/Format:List ^| FIND "="') DO SET %%A

> C:\wamp\www\batt.txt ECHO %BatteryStatus%
```

The AC power status is checked by running the above script periodically and the current status is stored in **batt.txt**.

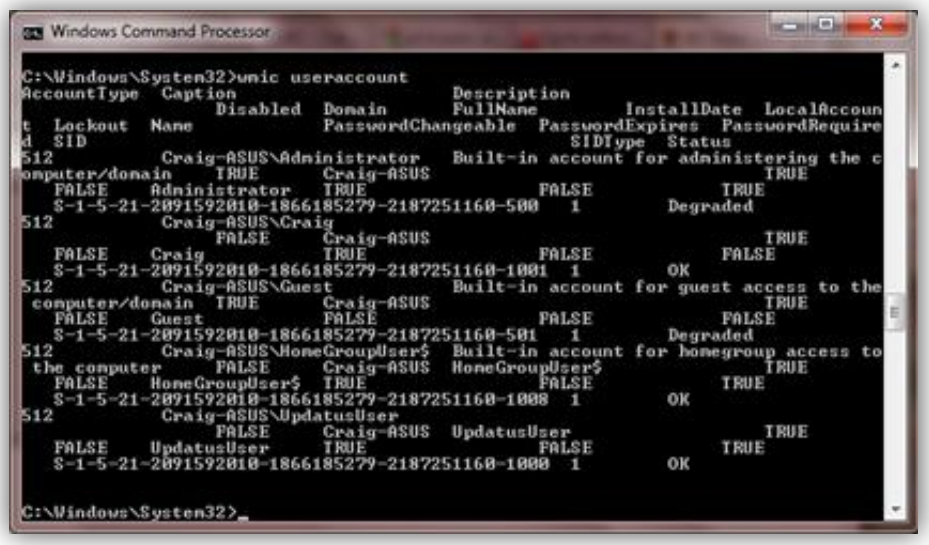

Fig. A.1 An example of WMIC command usage.

Appendix B
Motion Detection using Adobe Flex

Flex is a powerful, open source application framework that allows to easily build mobile applications for iOS, Android, and BlackBerry Tablet OS devices, as well as traditional applications for browser and desktop using the same programming model, tool, and code base.

We used Adobe Flex in this project to detect motion and update the cloud servers with the same in case of intrusion detection.

Fig. B.1 The Flex application showing the percentage of motion detected.

The code snippet used is below:

```
<?xml version="1.0" encoding="utf-8"?>
<mx:Application xmlns:mx="http://www.adobe.com/2006/mxml"
	xmlns:utils="com.dougmccune.utils.*"
xmlns:controls="com.dougmccune.controls.*"
	verticalGap="0" viewSourceURL="srcview/index.html">
	<mx:HTTPService id="httpService" resultFormat="text"
result="xresult(event);" fault="xfault(event);"/>

	<mx:Script>
		<![CDATA[

			import mx.controls.Image;
			import mx.core.UIComponent;
			import mx.controls.Alert;

			import mx.rpc.events.ResultEvent;
```

```
                import mx.rpc.events.FaultEvent;

                    public var i:Number = 0;
                    public var datee1:Date = new Date();

                    private function xfault(evt:FaultEvent):void {

            }

            private function xresult(evt:ResultEvent):void {

            }

//if motion is greater than this we take a snapshot and add it to the tile
container
                    private var threshold:Number = .05;

                    private function motionHandler(event:Event):void {
                          if(detector.percentChange > threshold) {

                                if(tile.numChildren > 0) {
                                      httpService.url =
"http://localhost/bug.php";

      httpService.send({d1:datee1.getTime().toString()});

                                      i = 0;

                                      tile.removeAllChildren();
                                }

                                var image:Image = new Image();
                                image.source = new
Bitmap(detector.lastSnapshot.clone());
                                image.width =  45;
                                image.height = 35;

                                tile.addChild(image);

                                if(i == 0)
                                datee1 = new Date();

                                bar.setStyle("trackColors",
[0xff0000,0xff0000]);
                          }
                          else {
                                bar.clearStyle("trackColors");
                          }
                    }
            ]]>
      </mx:Script>
      <!-- the magic motion detector -->
      <utils:SimpleMotionDetector id="detector"  sampleRate="100"
            source="{cam}" change="motionHandler(event);
bar.setProgress(detector.percentChange, 1)" />

      <!-- a custom VideoDisplay to show a webcam -->
      <controls:WebCamDisplay id="cam" />

      <mx:ProgressBar mode="manual" minimum="0" maximum="1" id="bar"
trackHeight="30"
            labelPlacement="center" label="Motion: %3%%"
width="{cam.width}" />

      <mx:Tile id="tile" width="100%" horizontalGap="0" verticalGap="0"
creationPolicy="queued" />

</mx:Application>
```

Appendix C
VLC: The Command Line Interface

VLC uses a modular structure. The core mainly manages communication between modules. All the multimedia processing is done by modules. There are input modules, demultiplexers, decoders, video output modules and so on. Here are some of the commands used in the project:

1. To receive an unicast UDP stream (sent by VLS or VLC's stream output), start VLC with:

```
% vlc -vvv udp:[@:server_port]
```

2. To receive an multicast UDP stream (sent by VLS or VLC's stream output), start VLC with:

```
% vlc -vvv udp:@multicast_address[:server_port]
```

3. To receive a HTTP stream, start VLC with:

```
% vlc -vvv http://www.example.org/your_file.mpg
```

4. To receive a RTSP stream, start VLC with:

```
% vlc -vvv rtsp://www.example.org/your_stream
```

For more information please visit: *http://wiki.videolan.org/VLC_command-line_help*

Appendix D
getID3()

getID3() is a PHP script that extracts useful information (such as ID3 tags, bitrate, playtime, etc.) from MP3s & other multimedia file formats (Ogg, WMA, WMV, ASF, WAV, AVI, AAC, VQF, FLAC, MusePack, Real, QuickTime, Monkey's Audio, MIDI and more).

We used getID3() in this project to read ID3 information of the user uploaded MP3 files and update the cloud servers with the same in case of intrusion detection. The code snippet used is below:

```
<?php
    require_once('getid3/getid3/getid3.php');
    $connect=mysql_connect("localhost","root","show.00x");
    mysql_select_db("cloudautomation",$connect);
    $query=mysql_query("select * from user where
username='$_SESSION[username]'");
    $row = mysql_fetch_assoc($query);
    echo "<center><table id=\"musictable\" width=\"700\">";
    if ($row['musiccount']>=0)
    {
        echo "<tr><td colspan=\"7\"><center><h2>Cloud
Player</h2></center></td></tr>";
        echo "<tr><td><center></center></td><td><center><b>Song
Title</center></td><td><center><b>Artist</center></td><td><center><b>Album</
center></td><td><center><b>Year</center></td><td><center><b> Runtime
</center></td></tr>";
        echo
"<tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr>";
        for($i=0;$i<=$row['musiccount'];$i++)
        {
            $playquery=mysql_query("select * from MP3 where
username='$_SESSION[username]'");
            $playrow = mysql_fetch_assoc($playquery);
            if($playrow['fileno']!=$i)
            {
                echo "<tr><td id=\"musiccol\"><img
src=\"getcover.php?username=".$_SESSION['username']."&mp3no=".$i."\"
height=\"60px\" width=\"60px\" style=\"border: 2px white solid;\"/>
                <a
href=\"removemusic.php?fileno=".$i."&username=".$_SESSION['username']."\"><i
mg id=\"musicremove\" src=\"images/minus.png\" height=\"20px\"
width=\"20px\"/></a></td>";
            }
            else
            {
                echo "<tr style=\"color:brown;\"><td id=\"musiccol\"><img
src=\"getcover.php?username=".$_SESSION['username']."&mp3no=".$i."\"
height=\"60px\" width=\"60px\" style=\"border: 2px white solid;\"/>
                <a
href=\"removemusic.php?fileno=".$i."&username=".$_SESSION['username']."\"><i
mg id=\"musicremove\" src=\"images/minus.png\" height=\"20px\"
width=\"20px\"/></a></td>";
            }
            require_once('getid3/getid3/getid3.php');

            $getID3 = new getID3;
            $ThisFileInfo = $getID3-
>analyze("C:/WAMP/www/music/".$_SESSION['username']."/".$i.".mp3");
```

```
            getid3_lib::CopyTagsToComments($ThisFileInfo);

            echo "<td
id=\"musiccol\">".@$ThisFileInfo['tags']['id3v2']['title'][0]."</td>";
            echo "<td
id=\"musiccol\">".@$ThisFileInfo['comments']['artist'][0]."</td>";
            echo "<td
id=\"musiccol\">".@$ThisFileInfo['comments']['album'][0]."</td>";
            echo "<td
id=\"musiccol\"><center>".@$ThisFileInfo['comments']['year'][0]."</center></
td>";
            echo "<td
id=\"musiccol\"><center>".@$ThisFileInfo['playtime_string']."
m</center></td>";

            if($playrow['fileno']!=$i)
                echo "<td id=\"musiccol\"><center><a
href=\"play.php?username=".$_SESSION['username']."&fileno=$i\"><img
src=\"images/play2.png\" height=\"40px\"
width=\"40px\"/></a></center></td></tr>";
        }
        echo "<tr><td></td></tr><tr><td></td></tr>";
        echo "<td colspan=\"7\" id=\"musiccol\"><center>
        <a href=\"prev.php?username=".$_SESSION['username']."\"><img
style=\"padding-bottom:15px;\" src=\"images/prev.png\" height=\"40px\"
width=\"40px\"/></a>
        <a href=\"stop.php?username=".$_SESSION['username']."\"><img
src=\"images/stop1.png\" height=\"70px\" width=\"70px\"/></a>
        <a href=\"next.php?username=".$_SESSION['username']."\"><img
style=\"padding-bottom:15px;\" src=\"images/next.png\" height=\"40px\"
width=\"40px\"/></a>
        </center></td></tr>";
    }
    else
    {
        echo "<tr><td><center><a style=\"color:blue;\"
href=\"musicupload.php\">Start Uploading</a> Music to Your Cloud
Storage</center></td></tr>";
    }
    echo "</table></center>";

?>
```

The code snippet used to retrieve album art is below:

```
<?php
    require_once('getid3/getid3/getid3.php');

    $getID3 = new getID3;
    $getID3->option_tag_id3v2 = true; # Don't know what this does yet
    $getID3-
>analyze("C:/WAMP/www/music/".$_GET['username']."/".$_GET['mp3no'].".mp3");

    if (isset($getID3->info['id3v2']['APIC'][0]['data']))
    {
        $cover = $getID3->info['id3v2']['APIC'][0]['data'];
    }
    elseif (isset($getID3->info['id3v2']['PIC'][0]['data']))
    {
        $cover = $getID3->info['id3v2']['PIC'][0]['data'];
    }
    else
    {
        $cover = null;
    }
    if (isset($getID3->info['id3v2']['APIC'][0]['image_mime']))
    {
```

```
        $mimetype = $getID3->info['id3v2']['APIC'][0]['image_mime'];
    }
    else
    {
        $mimetype = 'image/jpeg';
    }

    if (!is_null($cover))
    {
        header("Content-Type: " . $mimetype);

        if (isset($getID3->info['id3v2']['APIC'][0]['image_bytes']))
        {
            header("Content-Length: " . $getID3-
>info['id3v2']['APIC'][0]['image_bytes']);
        }

        echo($cover);
    }
?>
```

getID3() is supported by GNU Public License. For more information please visit: *http://getid3.sourceforge.net/*

Appendix E
Sample Codes

home.php - Displays the home page.

```
<?php session_start();
if(!isset($_SESSION['username']))
    header('Location: signin.php');
echo     "<a     id=\"welcome\">".$_SESSION['name']."</a><a     id=\"logout\"
href=\"logout.php\">Sign Out</a>";
echo "<a id=\"footer\"><center>Copyright © 2011: Anindya Maiti. All Rights
Reserved.</a>";
?>
<meta http-equiv="refresh" content="10"; url="home.php">
<html>
    <title>Home</title>
    <head>
    <link rel="shortcut icon" href="images/favicon.ico" type="image/x-icon"
/>
    <link href="style.css" rel="stylesheet" type="text/css">
    <?php

    $connect=mysql_connect("localhost","root","show.00x");
    mysql_select_db("cloudautomation",$connect);
    $query=mysql_query("select        *        from        board        where
username='$_SESSION[username]'");
    ?>
    <div id="leftmenu">
    <table>
    <tr><td><a  href="home.php"><img  src="images/refresh.png"  height="70px"
width="70px"/><br><center>Refresh</center></a></td></tr>
    <tr><td><a        href="schedules.php"><img        src="images/clock.png"
height="70px" width="70px"/><br><center>Schedules</center></a></td></tr>
    <tr><td><a  href="music.php"><img  src="images/itune.png"  height="70px"
width="70px"/><br><center>Music</center></a></td></tr>
    <tr><td><a       href="settings.php"><img       src="images/settings.png"
height="70px" width="70px"/><br><center>Settings</center></a></td></tr>
    <tr><td><a  href="about.php"><img  src="images/about.png"  height="70px"
width="70px"/><br><center>About</center></a></td></tr>
    </table>
    </div>
    <?php
    $boardcount=0;
    while ($row = mysql_fetch_assoc($query))
    {
        $boardcount++;
        echo "<br>";
        echo             "<center><table            id=\"statetable\"><tr><td
colspan=\"4\"><center>";

        if($row['status']>=0)
            echo      "<img      align=\"left\"      src=\"images/conn.png\"
height=\"30px\" width=\"30px\"/>";
        else
            echo     "<img     align=\"left\"     src=\"images/disconn.png\"
height=\"30px\" width=\"30px\"/>";

        echo $row['boardname'];

        if($row['power']==1)
            echo    "<img    align=\"right\"    src=\"images/greenplug.png\"
height=\"30px\" width=\"30px\"/></center>";
```

```
        else if($row['power']==0)
            echo     "<img     align=\"right\"     src=\"images/redplug.png\"
height=\"30px\" width=\"30px\"/></center>";
        else
            echo     "<img     align=\"right\"     src=\"images/question.png\"
height=\"30px\" width=\"30px\"/></center>";

        echo "</td></tr><tr><td></td></tr>";
        echo                          "<tr                          style=\"font-
size:15;\"><td><center>".$row['switch1name']."</center></td><td><center>".$r
ow['switch2name']."</center></td><td><center>".$row['switch3name']."</center
></td><td><center>".$row['switch4name']."</center></td></tr><tr>";
        for($i=1;$i<=4;$i++)
        {
            if($row['switch'.$i]==0)
            {
                echo   "<td   width=150   height=   75   style=\"color:white;
background-image:url('images/red.png');  background-size:  150px  75px;  z-
index=5;\"><center>OFF</center></td>";
            }
            if($row['switch'.$i]==1)
            {
                echo   "<td   width=150   height=   75   style=\"color:white;
background-image:url('images/cyan.png');  background-size:  150px  75px;  z-
index=5;\"><center>Turning ON</center></td>";
            }
            if($row['switch'.$i]==2)
            {
                echo   "<td   width=150   height=   75   style=\"color:white;
background-image:url('images/green.png');  background-size:  150px  75px;  z-
index=5;\"><center>ON</center></td>";
            }
            if($row['switch'.$i]==3)
            {
                echo   "<td   width=150   height=   75   style=\"color:white;
background-image:url('images/violet.png');  background-size:  150px  75px;  z-
index=5;\"><center>Turning OFF</center></td>";
            }
        }
        echo "</tr><tr>";
        for($i=1;$i<=4;$i++)
        {
            if($row['switch'.$i]==0)
            {
                echo      "<td      height=      75      style=\"background-
image:url('images/green.png');     background-size:     150px     75px;     z-
index=6;\"><center><a
href=\"changestate.php?switchno=".$i."&newstate=1&boardid=".$row['boardid'].
"\">Turn ON</a></center></td>";
            }
            elseif($row['switch'.$i]==2)
            {
                echo      "<td      height=      75      style=\"background-
image:url('images/red.png');     background-size:     150px     75px;     z-
index=6;\"><center><a
href=\"changestate.php?switchno=".$i."&newstate=3&boardid=".$row['boardid'].
"\">Turn OFF</a></center></td>";
            }
            else
            {
                echo "<td></td>";
            }
        }
        echo "</tr></table></center>";
    }
    $boardcount++;
```

```
    echo "<center><table id=\"newboard\"><tr><td colspan=\"4\" style=\"font-
size:20;\"><center><a   href=\"addboard.php?boardno=$boardcount\">Add   Board
$boardcount</a></center></td></tr>";
    mysql_close($connect);
    ?>
    <br><br><br><br>
    </head>
</html>
```

schedules.php - Displays the previously added schedules and provides an option to add a new.

```
<?php session_start();
if(!isset($_SESSION['username']))
    header('Location: signin.php');
echo     "<a     id=\"welcome\">".$_SESSION['name']."</a><a     id=\"logout\"
href=\"logout.php\">Sign Out</a>";
echo "<a id=\"footer\"><center>Copyright © 2011: Anindya Maiti. All Rights
Reserved.</a>";
?>

<html>
    <title>Schedules</title>
    <head>
    <link  rel="shortcut  icon"  href="images/favicon.ico"  type="image/x-icon"
/>
    <link href="style.css" rel="stylesheet" type="text/css">
    <?php
    $count = 0;
    $connect=mysql_connect("localhost","root","show.00x");
    mysql_select_db("cloudautomation",$connect);
    $query1     =     mysql_query("select     *     from     board     where
username='$_SESSION[username]'");
    while($row1 = mysql_fetch_assoc($query1))
    {
        $query2    =    mysql_query("select    *    from    schedule    where
boardid='$row1[boardid]'");

        while($row2 = mysql_fetch_assoc($query2))
        {
            $count++;
        }
    }
    echo "<center><table id=\"musictable\" width=\"710\">";
    if($count==0)
    {
        echo    "<tr><td><center>You    didn't    make    any    schedule.    <a
href=\"addschedule.php\">Make one now!</center></td></tr></table>";
    }
    else
    {
        echo                                                          "<tr><td
colspan=\"7\"><center><h2>Schedules</h2></center></td></tr>";
        echo     "<tr><td     rowspan=\"2\"><center><b>Room</center></td><td
rowspan=\"2\"><center><b>Device</center></td><td
rowspan=\"2\"><center><b>Turn</center></td>
        <td                    rowspan=\"2\"><center><b>Time</center></td><td
rowspan=\"2\"><center><b>Day</center></td><td><center><b>Repeats</center></t
d></tr>";
        echo  "<tr><td><center  style=\"font-family:Lucida  Console;  font-
size:91%;\">S  M  T  W  T  F  S</center></td></tr>";
        echo
"<tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr>";
        $count = 0;
        $query1    =    mysql_query("select    *    from    board    where
username='$_SESSION[username]'");
```

```
        while($row1 = mysql_fetch_assoc($query1))
        {
            $query2   =   mysql_query("select   *   from   schedule   where
boardid='$row1[boardid]'");

            while($row2 = mysql_fetch_assoc($query2))
            {
                $name;
                if($row2['switchno']==1)
                {
                    $name = $row1['switch1name'];
                }
                else if($row2['switchno']==2)
                {
                    $name = $row1['switch2name'];
                }
                else if($row2['switchno']==3)
                {
                    $name = $row1['switch3name'];
                }
                else if($row2['switchno']==4)
                {
                    $name = $row1['switch4name'];
                }
                $count++;
                if($count%2)
                    echo     "<tr     id=\"musiccol\"     style=\"background-
color:rgba(0,0,0,0.25);\"><td><center>".$row1['boardname']."</center></td><t
d><center>".$name."</center></td>";
                else
                    echo                                                    "<tr
id=\"musiccol\"><td><center>".$row1['boardname']."</center></td><td><center>
".$name."</center></td>";

                if($row2['norepeatstate']!=2147483647)
                {
                    if($row2['norepeatstate']==0)
                        echo "<td><center>OFF</center></td>";
                    else
                        echo "<td><center>ON</center></td>";

                    echo "<td><center>".$row2['hour'].":";
                    if($row2['minute']<10)
                        echo "0";
                    echo $row2['minute']." ".$row2['ampm']."</center></td>";

if(date("l",time()+19800)==date("l",$row2['norepeattime']))
                        echo   "<td><center>Today</center></td><td><center>--
</center></td>";
                    else
if(date("l",time()+19800+86400)==date("l",$row2['norepeattime']))
                        echo
"<td><center>Tomorrow</center></td><td><center>--</center></td>";
                    else
                        echo
"<td><center>".date("l",$row2['norepeattime'])."</center></td><td><center>--
</center></td>";
                }
                else
                {
                    global $state;
                    if($row2['sunday']==2)
                        $state = "ON";
                    if($row2['monday']==2)
                        $state = "ON";
                    if($row2['tuesday']==2)
                        $state = "ON";
                    if($row2['wednesday']==2)
```

```
                        $state = "ON";
                    if($row2['thursday']==2)
                        $state = "ON";
                    if($row2['friday']==2)
                        $state = "ON";
                    if($row2['saturday']==2)
                        $state = "ON";

                    if($state!="ON")
                        $state = "OFF";

                    echo "<td><center>".$state."</center></td>";
                    echo "<td><center>".$row2['hour'].":";
                    if($row2['minute']<10)
                        echo "0";
                    echo $row2['minute']." ".$row2['ampm']."</center></td>";
                    echo "<td><center>--</center></td>";
                    echo  "<td><center  style=\"font-family:monospace;  font-
size:104%;\">";

                    if($row2['sunday']!=3)
                        echo " &#10003  ";
                    else
                        echo " &#8226  ";
                    if($row2['monday']!=3)
                        echo " &#10003  ";
                    else
                        echo " &#8226  ";
                    if($row2['tuesday']!=3)
                        echo " &#10003  ";
                    else
                        echo " &#8226  ";
                    if($row2['wednesday']!=3)
                        echo " &#10003  ";
                    else
                        echo " &#8226  ";
                    if($row2['thursday']!=3)
                        echo " &#10003  ";
                    else
                        echo " &#8226  ";
                    if($row2['friday']!=3)
                        echo " &#10003  ";
                    else
                        echo " &#8226  ";
                    if($row2['saturday']!=3)
                        echo " &#10003  ";
                    else
                        echo " &#8226  ";
                }
                echo                                                "<td><center><a
href=\"removemusic.php?fileno=".$row2['counter']."&username=".$_SESSION['use
rname']."\"><img           src=\"images/edit.png\"           height=\"18px\"
width=\"18px\"/></a></center></td>";
                echo                                                "<td><center><a
href=\"removemusic.php?fileno=".$row2['counter']."&username=".$_SESSION['use
rname']."\"><img           src=\"images/minus.png\"           height=\"20px\"
width=\"20px\"/></a></center></td>";
                echo "</center></td></tr>";
                echo
"<tr><td></td></tr><tr><td></td></tr><tr><td></td></tr><tr><td></td></tr>";
            }
        }
        echo "<tr><td></td></tr><tr><td></td></tr>";
        echo "</table>";
    }
    ?>
    </head>
    <body>
```

```
    <div id="leftmenu">
    <table>
    <tr><td><a   href="home.php"><img   src="images/home.png"   height="70px"
width="70px"/><br><center>Home</center></a></td></tr>
    <tr><td><a        href="addschedule.php"><img        src="images/add.png"
height="70px"
width="70px"/><br><center>Add<br>Schedule</center></a></td></tr>
    <tr><td><a  href="about.php"><img  src="images/about.png"  height="70px"
width="70px"/><br><center>About</center></a></td></tr>
    </table>
    </div>
    </body>
</html>
```

Appendix F
Published Papers

Accepted and Published Papers:

1. Anindya Maiti and S. Sivanesan, “Cloud Controlled Intrusion Detection and Burglary Prevention Stratagems in Home Automation Systems”, 2nd Baltic Conference on Future Internet Communications (BCFIC), April 2012, Vilnius, Republic of Lithuania.
2. Anindya Maiti and S. Sivanesan, “Controlling and Monitoring of Wireless Home Power Management Systems through Public Cloud Services”, IEEE International Conference on Electro/Information Technology (IEEE-EIT) 2012, May 2012, Indianapolis, IN, USA.

Accepted and In Press Papers:

1. Anindya Maiti and S. Sivanesan, “Advertising in Location-Aware Cloud Based Home Automation Systems”, 9th International Conference on Remote Engineering and Virtual Instrumentation (REV), July 2012, Bilbao, Spain.
2. Anindya Maiti and S. Sivanesan, “Integrating a Cloud Audio Player in Home Automation Systems”, 9th International Conference on Remote Engineering and Virtual Instrumentation (REV), July 2012, Bilbao, Spain.