FINAL PROJECT REPORT
ON
Energy Efficient Smart Home System

Submitted in partial fulfilment of the requirement for the credits of

Internet of Things in

Electrical Engineering

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TABLE OF CONTENTS

Chapter 1: Introduction

The "Internet of things" (IoT) is becoming an increasingly growing topic of conversation both in the industries and in the academia research department. It's a concept that not only has the potential to impact how we live but also how we work. This is the concept of basically connecting any device with an on and off switch to the Internet (and/or to each other). This includes everything from cell phones, coffee makers, washing machines, headphones, lamps, wearable devices and almost anything else one can think of.

It's not hard to see how and why the IoT is such a hot topic today; it certainly opens the door to a lot of opportunities but also to many challenges. And hence we picked up one the challenge to automate our home system. Smart home devices are becoming very crucial part of our life, as our dependency is increasing more and more on technologies like internet, wireless sensors, automation etc. Hence, it becomes inevitable to ignore the need to ponder upon the home devices that can talk to each other and communicate at ease.

"Connectivity and interactivity are driving the way families live and manage their homes. So while we are expected to be in more places due to business travel, children's school schedules and social activities, our new smart systems provide cutting edge connectivity to the households, even when one is far away. And when the house is occupied, the high level of automation enables more convenience, control and safety from any part of one's property. It all adds up to fewer worries and increased enjoyment of life, which is something we would all welcome"

So, the basic logic behind our project of smart home is to design an automation system, which can provide us with updates about the active or turned on devices in the house to smartly manage them and reduce the energy consumption. Also, add security to home by detecting the presence of any unauthorized person in home by shooting an email to the registered user.

Chapter 2: History

Early home automation began with labour-saving machines. Self-contained electric or gas powered home appliances became viable in the 1900s with the introduction of electric power distribution and led to the introduction of washing machines (1904), water heaters (1889), refrigerators, sewing machines, dishwashers, and clothes dryers.
The first smart homes were ideas, not actual structures. For decades, science fiction has explored the idea of home automation. Prolific writers, such as Ray Bradbury, imagined a future where homes were interactive, and seemingly ran themselves. Current trends in home automation include remote mobile control, automated lights, automated thermostat adjustment, scheduling appliances, mobile/email/text notifications, and remote video surveillance.

Chapter 3: Market Research

The home automation system market is driven by factors such as the significantly growing IoT market, cost reduction measures enabled by home automation systems, presence of a large number of manufacturers expanding their product portfolios, and the increasing importance of home monitoring from remote locations
According to the new market research report "Home Automation System Market by Protocol and Technology (Network and Wireless), Product (Lighting, Security and Access Control, HVAC and Entertainment Control), Software and Algorithm (Behavioral and Proactive), and Geography - Global Forecast to 2022"**,** the home automation system market was valued at USD 39.93 Billion in 2016 and is expected to reach USD 79.57 Billion by 2022, at a CAGR of 11.3% during the forecast period.

Chapter 4: Project Objective

- Control, monitoring and automation of home devices like light bulb, air conditioners, etc using website and home terminal.
- Reduction in the wastage of energy.
- Enhancing the security of the home.

Chapter 5: Application

a) Controlled multiple lights using web interface and home equipment.
b) Periodically sent the status of the temperature, user presence, motion and home appliances via WiFi to the cloud.
c) Reduced the wastage of energy by alerting (E-mail) the user in the case they leave an appliance switched on.
d) Enhanced security of home when user is not present by sending an alert via Email.
e) By using a home automation system, we can save a lot of time to operate home appliances from anywhere (without wasting time to move from office to home for just unlocking door for family members to enter the home).

Chapter 6: Design

Our System has three main blocks:

a) **Home Unit:** It is responsible to activate/deactivate the appliances. It sends the temperature of the house, number of users present, motion and the status of the appliances to the cloud.
b) **Cloud Control Unit:** It is responsible for keeping track of the device status in cloud and provides a user interactive Graphical User Interface (GUI) to control the home devices. It also sends out an alert e-mail to the user in certain situations.
c) **User Equipment:** User Equipment (UE) is connected to the Home unit. We can make our home more secure by identifying the presence of unauthorized person and sending an alert to user.

6.1: Hardware

a) **Micro-controller (CC2650):** The CC2650 LaunchPad is a complete development platform specially built by Texas Instrument for IoT applications. A free CCS Full License is provided when using the CC2650 LaunchPad.

b) **WiFi module ESP8266:** The ESP8266 is a low-cost Wi-Fi chip with full TCP/IP stack and MCU (microcontroller unit) capability produced by Shanghai-based Chinese manufacturer, Espressif Systems. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using AT commands. It supports following communication protocols: UART, SPI, I2C, I2S. It also has an inbuilt 10bit ADC.

c) **IR Sensor:** An Infrared (IR) sensor is used to detect obstacles in front of the robot or to differentiate between colours depending on the configuration of the sensor.

d) **PIR motion:** PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low-power, easy to use and don't wear out. For that reason, they are commonly found in appliances and gadgets used in homes or businesses.

e) **Temperature Sensor:** The Si7021 I2C Humidity and Temperature Sensor is a monolithic CMOS IC integrating humidity and temperature sensor elements, an analog-to-digital converter, signal processing, calibration data, and an I2C Interface. The patented use of industry-standard, low-K polymeric dielectrics for sensing humidity enables the construction of low-power, monolithic CMOS Sensor ICs with low drift and hysteresis, and excellent long term stability.

f) **Mechanical Relay load (control home devices):** A relay is an electrically operated switch. Many relays use an electromagnet to mechanically operate a switch, but other operating principles are also used, such as solid-state relays. Relays are used where it is necessary to control a circuit by a separate low-power signal, or where several circuits must be controlled by one signal.

6.2: Software

Node JS : Node.js is an open-source, cross-platform JavaScript run-time environment for executing JavaScript code server-side. Historically, JavaScript was used primarily for client-side scripting, in which scripts written in JavaScript are embedded in a webpage's HTML, to be run client-side by a JavaScript engine in the user's web browser.

Express Framework : Express.js, or simply Express, is a web application framework for Node.js, released as free and open-source software under the MIT License. It is designed for building web applications and APIs. It is in fact the standard server framework for Node.js.

Node Package Manager (NPM) : NPM is a package manager for the JavaScript programming language. It is the default package manager for the JavaScript runtime environment Node.js.

MongoDB (Non-relational DB): MongoDB is a free and open-source crossplatform document-oriented database program. Classified as a NoSQL database program, MongoDB uses JSON-like documents with schemas. MongoDB is developed by

MongoDB Inc., and is published under a combination of the GNU Affero General Public License and the Apache License.

Heroku: Heroku is a cloud platform as a service (PaaS) supporting several programming languages that is used as a web application deployment model. Heroku, one of the first cloud platforms, has been in development since June 2007, when it supported only the Ruby programming language, but now supports Java, Node.js, Scala, Clojure, Python, PHP, and Go.

mLab (AWS): mLab is a fully managed cloud database service that hosts MongoDB databases. mLab runs on cloud providers Amazon, Google, and Microsoft Azure, and has partnered with platform-as-a-service providers.

Front End Technologies: HTML, CSS, JAVASCRIPT, BOOTSTRAP, JQUERY

Chapter 7: Architecture

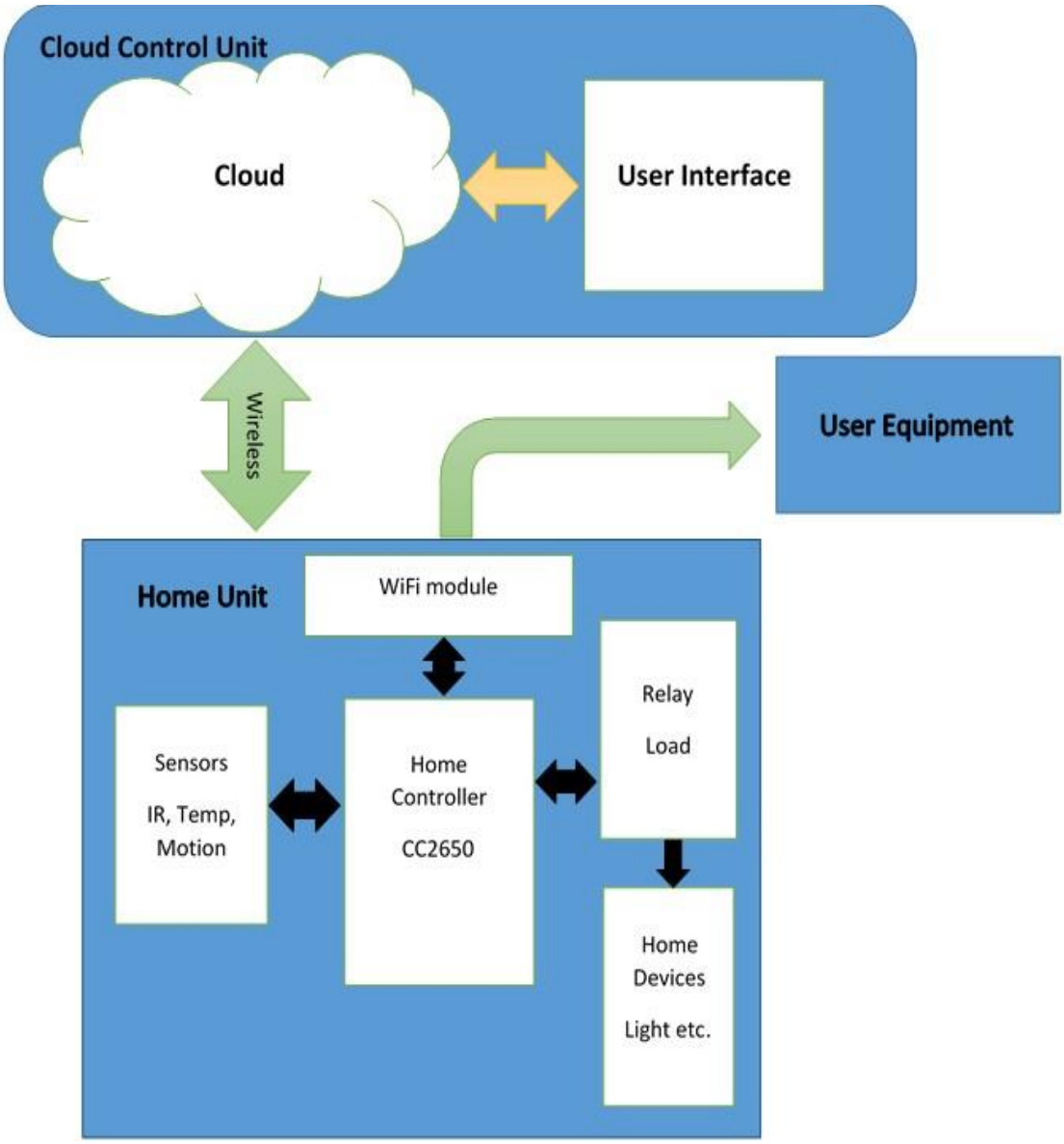

Figure 1: Architecture of the system

Chapter 8: Implementation

8.1: Hardware Implementation

The above mentioned technologies were integrated and implemented in such a way that they worked cohesively. The IR sensors connected to the LaunchPad were used as a physical switch to turn ON or OFF the appliances. When the state of the appliance was changed using the IR sensors the status was sent to the server of our website through the WiFi module. A temperature sensor was also used to read the current temperature value in the house which was then sent to the cloud server. The WiFi module also acted as an Access point to which the user's wearable device was connected. The combination of the data from the motion sensor and connection of the user wearable device to the WiFi module was used to detect the presence and absence of the user. If the user leaves the house (the system gets to know this when the user's wearable device gets disconnected from the WiFi module) and he forgets to turn OFF an appliance, then the user gets an E-mail saying that he forgot to switch off the appliance. The second scenario is that if the user device is not connected to the WiFi module and the motion sensor detects motion, it sends out an E-mail saying that someone not authorized is in the house (probably a burglar).
For all the sensors to act properly and coherently, features of RTOS like HWI, SWI, Tasks were used. The below flowchart shows how these features were scheduled to achieve the above mentioned functionalities.

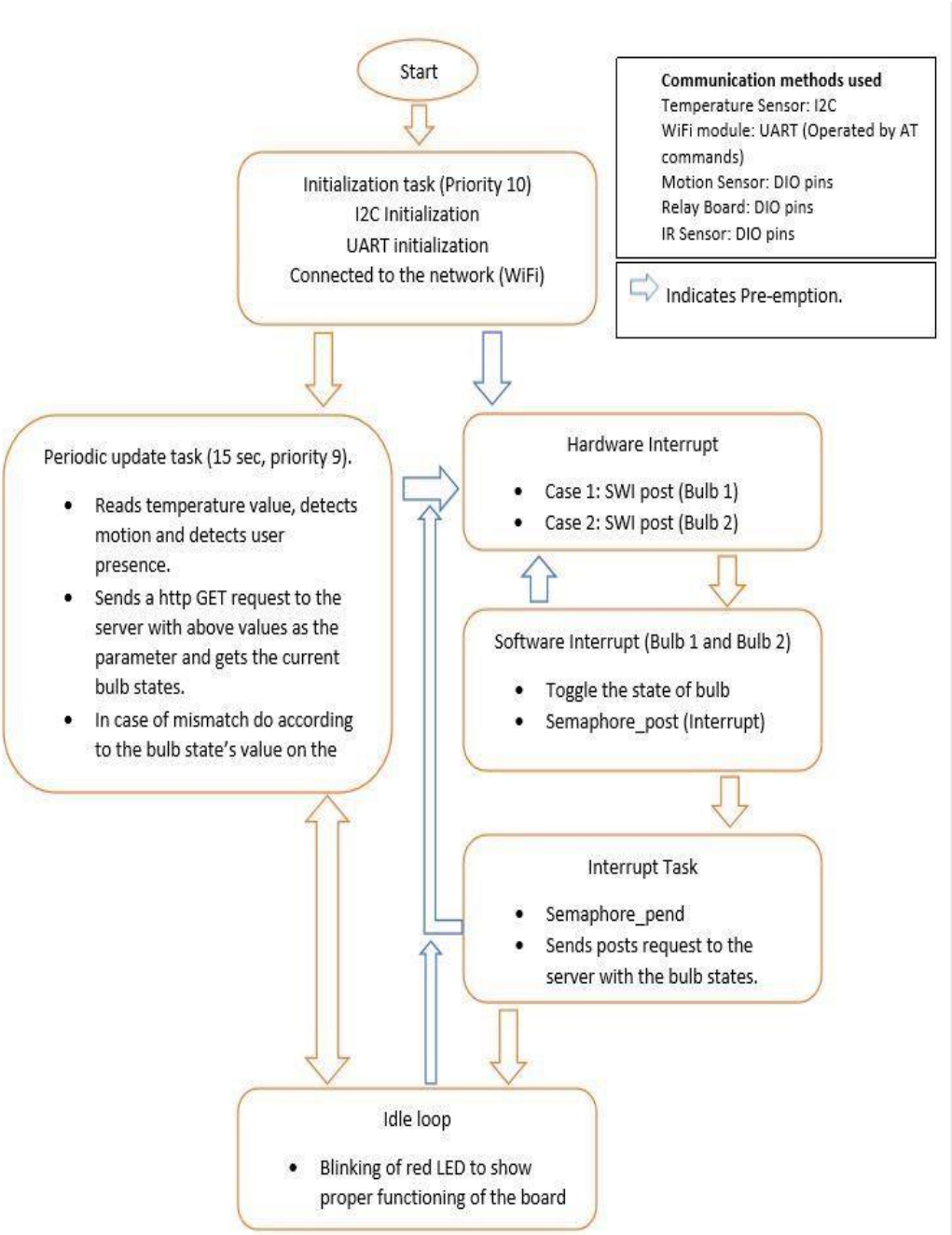

Figure 2: Scheduling of threads

8.2: Software Implementation

The following node package managers (NPM) were used to create the backend of our website:

1. **Express Framework**: This was used in order to respond to the GET and POST requests coming from the home unit as well as from the front end of the website.
2. **Node mailer**: This NPM was used in order to send the alert E-mails to the user.
3. **Passport**: This NPM was used for the username password authentication.
4. **Mongoose**: This NPM was used to interact with the MongoDB database.
5. **Request**: This NPM was used to make requests to APIs. We have made request to yahoo weather API to get the current temperature of the region.
6. **Express Session**: This NPM was used to maintain the user session and keep the user logged in unless he/she logs themselves out.

In order to display the data coming from the home unit, we made use of embedded JavaScript (ejs) pages as HTML delivers only static content.

The backend was written in Node JavaScript and the development environment used was cloud9. The actual deployment of the website was done on Heroku cloud and we made use of MongoDB which was hosted on mLABS.

Chapter 9: Results, Conclusion and Future Scope

9.1: Results and Conclusion

The project was successfully built and presented on 7th December 2017 under the esteemed guidance of Professor Jornet and his teaching assistant Amit. For demonstration purpose two light bulbs were used which were controlled using our website and a yahoo API was used to fetch the temperature. In real time environment the bulbs can be replaced by any home appliance and installation of product is fairly simple without any complex connections.

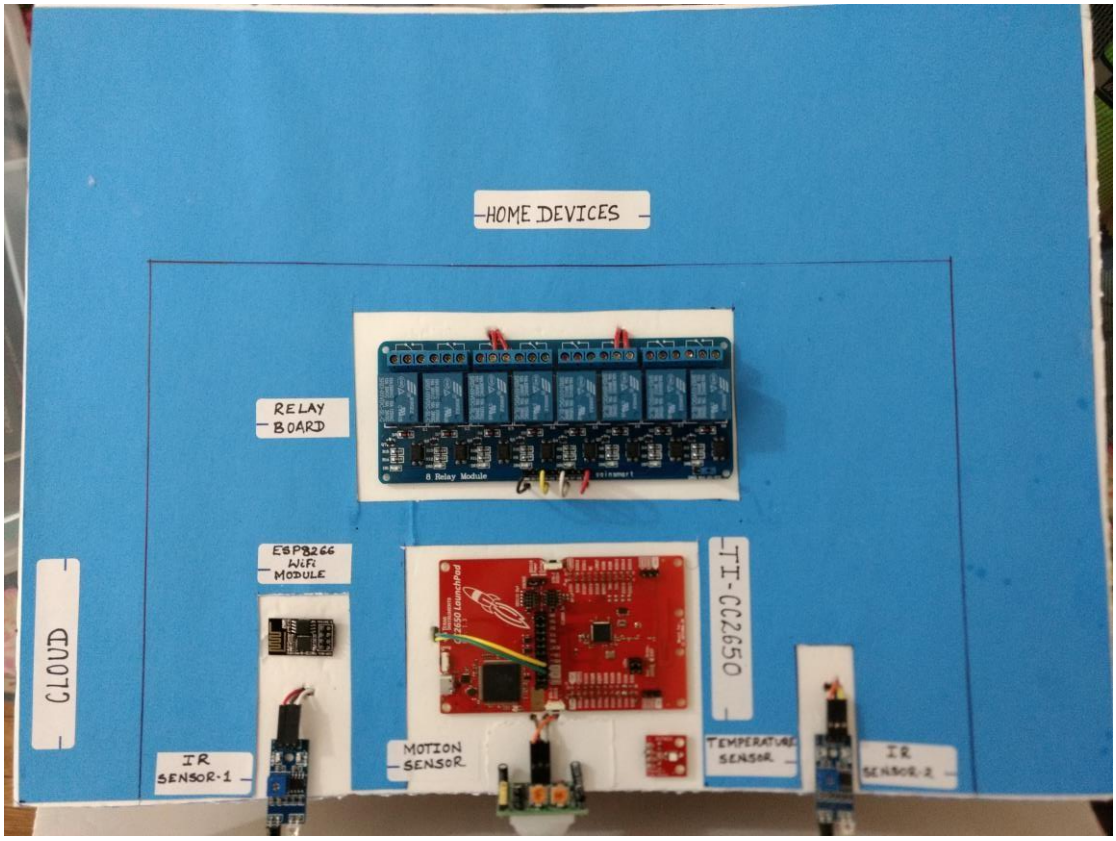

Figure 3: Home Unit

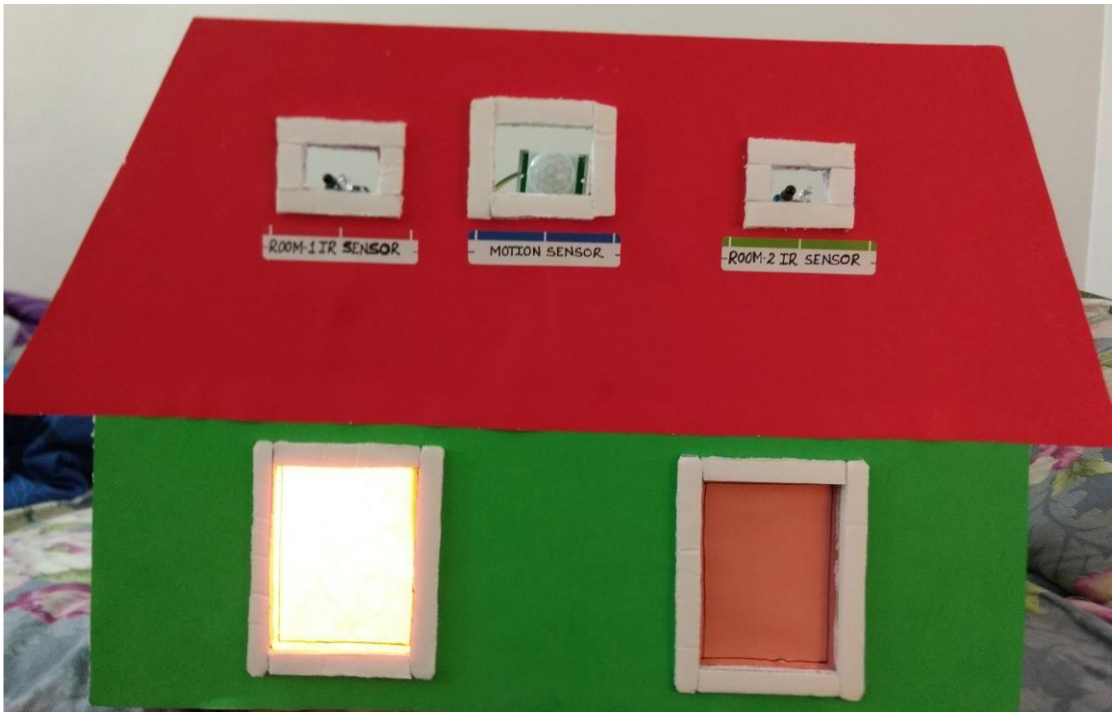

Figure 4: Bulb turned ON through cloud/HWI

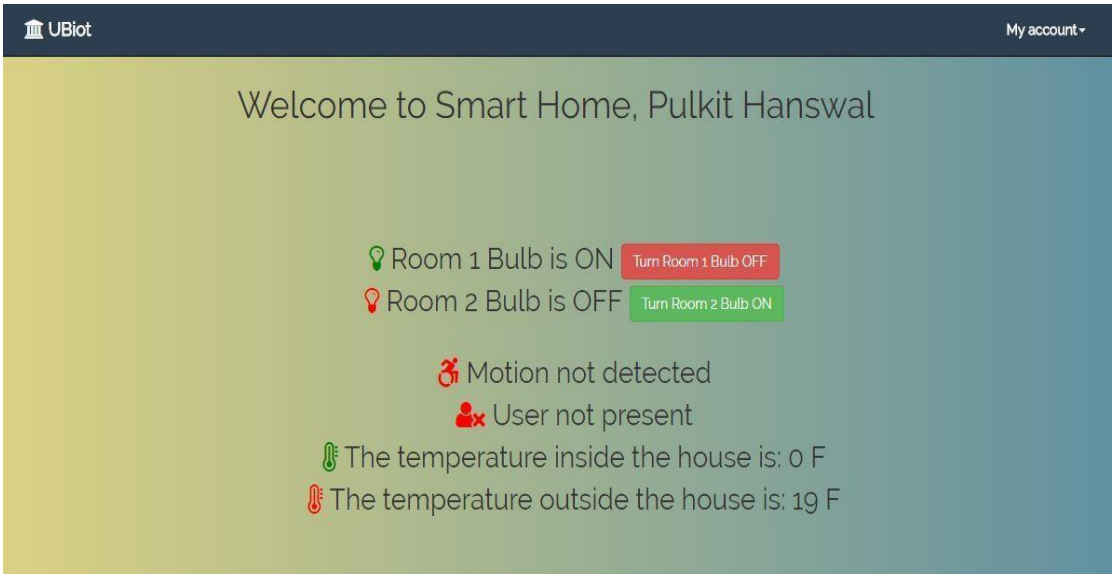

Figure 5: Cloud Unit - User interface

9.2: Future Scope

a) We could use a better WiFi Module which can act as a server and client at the same time, thereby removing the need to poll the server and hence removing the 10 seconds lag from stimuli to response.
b) An Interactive GUI can be developed at home to control the equipment.
c) We could also monitor the power consumption of each appliance in the house.