Smart Home Devices

Idea Domain: Wireless, Automation, Energy/Power

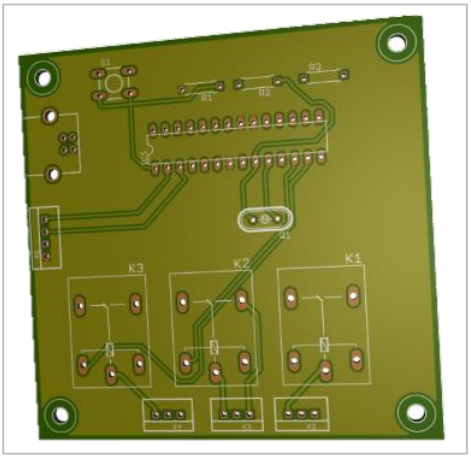
Abstract

Our idea is to automate the boring stuff by empowering the user with robust, affordable and scalable smart home solutions in terms of an end to end product integration of various peripheries which is driven by Internet of Things. We want to give the user the freedom in choosing whatever is relevant to his home, thereby providing him with increased flexibility. The following gives an overview of each vertical of the idea:

1. **Smart Switch Board** - The smart switch board will make the mechanical switches redundant, enabling the user to control all his devices from anywhere in the world. It shall be a plug and play non-invasive product with easy installation.
2. **Sensor Board System** - Smart sensor board which when integrated with the Smart Switch System would make a robust climate control system for the home along with giving notifications for cases of accidental fire and leakage of LPG
3. **Energy Monitoring System** - A marriage of a smart switch board along with the machine learning/artificial intelligence to make a more power/energy efficient home. It would enable the user to manage his electricity bills and enable capping the electricity usage in his/her home.
4. **Universal Remote** - To bring all the IR controlled devices under the control of a single remote which to achieve firmware independence of the device. Universal remote shall be able to control all IR operated devices in the house. For example, Television, Air conditioners, etc.

Existing Prototype

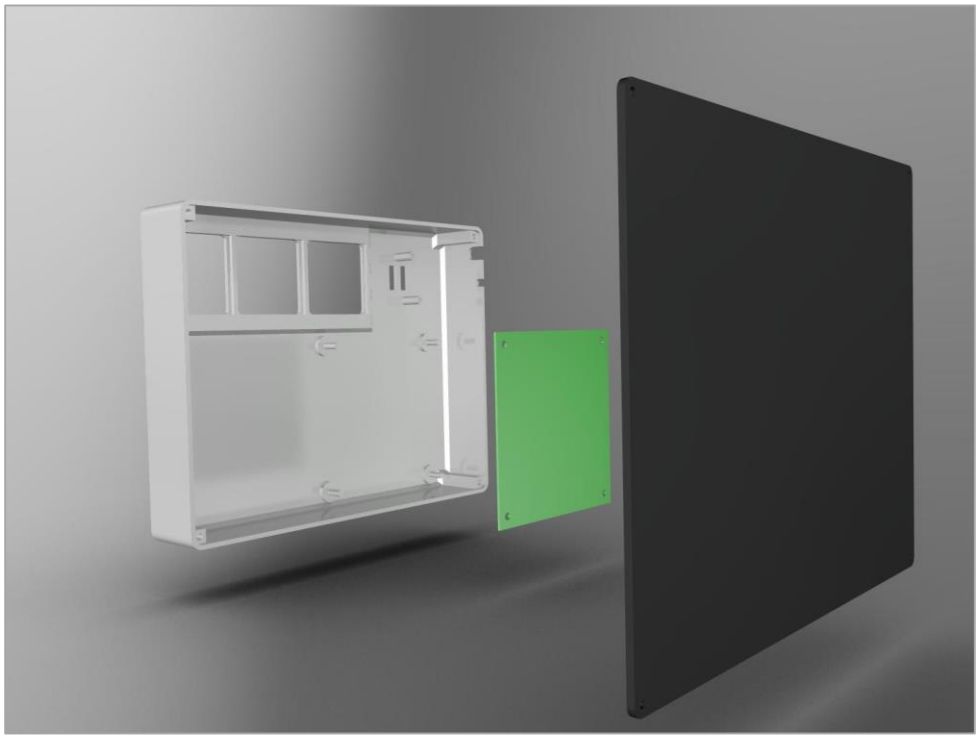
Our current prototype is a primitive one and is limited to basic operations such as switching of plug sockets. It currently features Raspberry pi as the central unit and three sub-devices: switchboard, sensor board and universal remote.



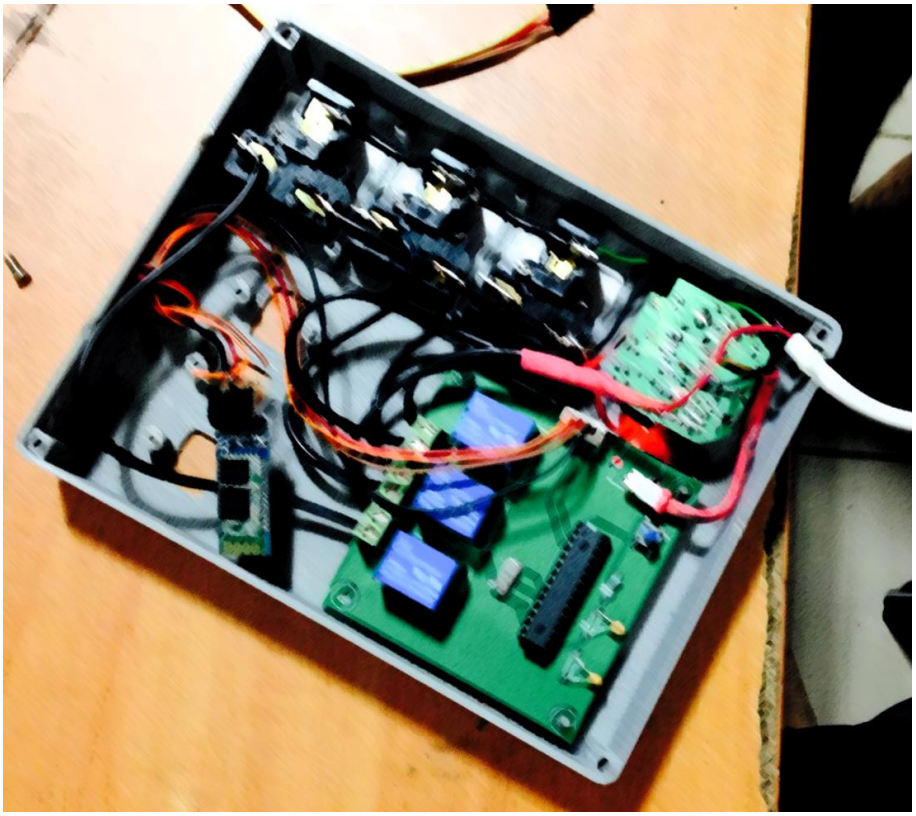
The switchboard offers three plug sockets which are controlled using relays and a microcontroller inside it. It connects to the raspberry pi using Bluetooth. The switching can be controlled through a web application written in a popular web framework called Ruby on Rails. We have also added Simon, an intelligent personal assistant, who can take actions over your voice commands which makes use of Chrome's Speech to Text API and uses a machine learning API to add intelligence to it. Additionally, the web app follows a hierarchy system. Certain user/s will have the power to control who can use certain devices in the same house.

The sensor board is basically a shield on the Arduino Uno which takes inputs from sensors and utilises wired I2C connection as a mode of communication. The universal remote is a direct attachment to the raspberry pi which gives a very low level control to the user.

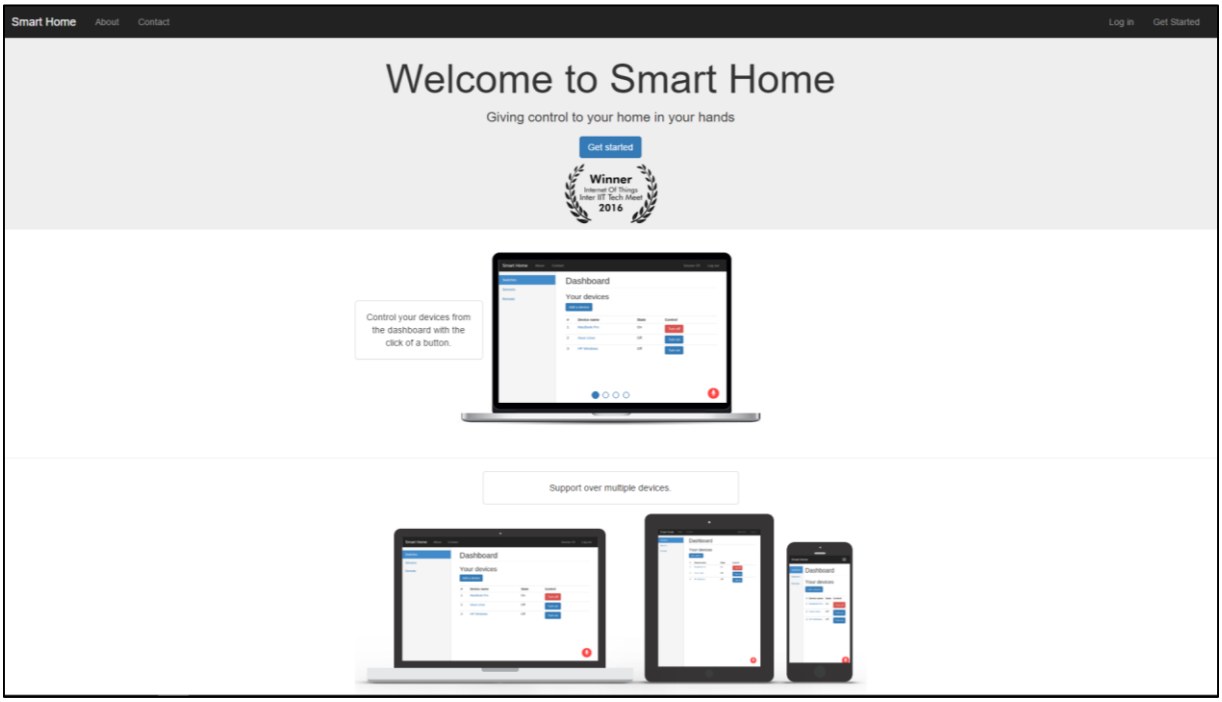
The Render of our Case



This is our final prototype showcased at inter-IIT Tech Meet:



Screenshot of our webpage: https://interiit.herokuapp.com/pages/welcome



YouTube link for brief description: https://www.youtube.com/watch?v=36ZuRDEtNUY

Our proposal

We intend to expand our current prototype to a marketable stage. We plan to make the whole project scalable and keep it open to customization at the same time. We wish to revamp the technology in all our current prototypes focusing mainly on our flagship product, the switchboard so that the available technology can be used to the fullest. We also have several enhancements in our mind which we would like to implement.

We have iterated through the design and architecture of our switchboard several times. The first one featured a direct connection to phone over Bluetooth controlled through a basic android app. Then we took a step forward to connect it to the local Wi-Fi network and successfully implemented the control from devices which were connected to the same network. As of the latest prototype, we achieved the internet connectivity. There are several drawbacks to our current model. We would like to renovate our product drastically.

The sensor board also went through many designs and prototypes. Some of which failed in some or the other way or used an architecture that wasn't compatible with the other parts of the project. The latest one used an Arduino shield for controlling the sensors and sending data to the central microprocessor in this case the raspberry pi. We used wired communication between the board and the raspberry pi. Now the next task will be to make this prototype smaller in size, introduce some embedded system and make communication wireless using Wi-Fi or some other similar technology.

Switch Board	
What we already have	**Further Plans**
Basic Relay switching	Porting to Wi-Fi
Web application	Scalable Web app + Local
BT connectivity to raspberry pi	Upgrade to Raspberry pi Zero
Ready-made plug sockets	AC voltage regulation
Simon	Energy monitor
3D printed case	Automation/ Intelligence
	Redesign + compact PCB + better relays
	Override switches
	Custom/Bulk plug sockets
	Native Android / PC app
	Safe connection

Presently we have a custom made PCB which makes use of the ATMEGA 328p microcontroller embedded into the PCB and it communicates with the Raspberry Pi using UART communication protocol making use of two paired HC-05 BT Module(Class 2), which presently gives us a range of 10 meters(ideal case). We are making use of a rectifier and DC/DC voltage step down circuit to convert the 230V AC supply from the mains to 5 Volts to power our PCB and for toggling the relays. In addition to the hardware, on the software side we have a web application written in Ruby on Rails framework which has a voice enabled intelligent personal assistant called Simon which is similar to something like Siri or Jarvis. We make use of a machine learning API in the backend to add intelligence to the system. Our entire system is presently packaged into a 3D printed case which was designed and printed in the facilities of Centre for Innovation, IITM.

In future we wish to improve on the present design greatly. We wish to make use of WiFi over Bluetooth because using Wi-Fi increases the range of the operation along with giving the ability to have multiple connectivity as opposed to Bluetooth's one to one connection. Apart from having an app hosted on a cloud server, we wish to run the app locally as well so as give the user the ability to make use of the service in case of no internet connectivity. Currently the voice assistant runs on Chrome only, in future we wish to make cross browser and cross platform. In the future design, we wish to use Raspberry Pi Zero as opposed to Raspberry Pi B+ Model as it reduces the cost and size of the entire system.

Apart from these enhancements, one major change in the system is to add an energy monitoring capability to the system. We wish add energy measuring circuitry to each switch board so that usage of a particular device can be optimised. We plan to add our own Machine Learning engine to the system to make it smart and add automation to the system, one such feature is the ability to track the Energy bill for a house and get real time updates for the same. While incorporating these enhancements in the design we wish to make the entire system compact as well and wish to drastically reduce the size of your PCBs. Also we would like to expand our support through mobile apps in addition to the web-app that we have.

Sensor Board	
What we already have	**Further Plans**
CO_2 , LPG, Temperature and Humidity	Porting to Wireless
Arduino Shield	PCB design + Embedded processors
Wired communication	More Sensors: 1. Light 2. Sound
Primitive 3D printed case	Better 3D printed case
	Web Interface + Analytics

At present, the sensor board consists of a DHT11 (humidity and temperature sensor), a MQ-135 CO_2 gas sensor and a MQ-6 LPG gas sensor. The board is an Arduino Uno shield. The data from the sensors is transmitted using I2C wired transmission to Raspberry Pi. This data is logged in the web app and the user is notified in case of danger i.e. if there is LPG leakage or something burning in the house. The sensors are placed on a basic 3D printed case.

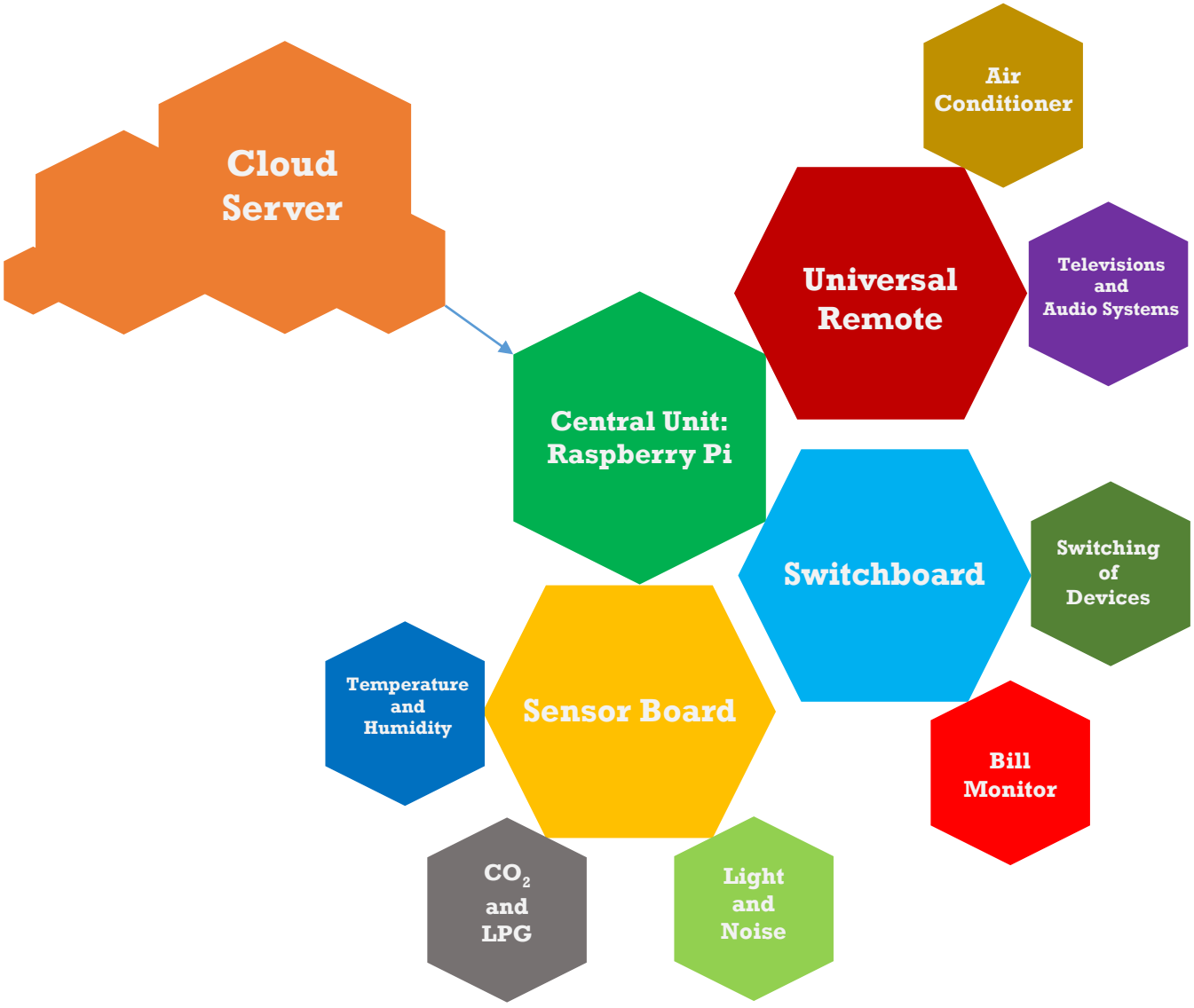
In the future, we wish to add more sensors like photodiodes to control lighting and curtains of a room. We also plan to replace the Arduino shield with a properly designed PCB and embedded processors. To make it hassle free, we wish to establish wireless communication with Raspberry Pi using ESP8266/NRF. Data analytics is another aspect we wish to look into. The sensor data will be analysed to provide a better user experience by controlling different devices according to the user's daily use. We will also improve the design for the case.

Universal Remote	
What we already have	**Further Plans**
Wired interface with raspberry pi	Porting to Wi-Fi
Uses LIRC	Wireless capability
Redirected Web link	User-friendly interface
Basic operations and limited remote support	Web app integration
	Integration with Switchboard
	standalone microcontroller
	PCB design
	3D printed case

Presently the universal remote it a very primitive piece of circuitry which has an IR LED and a TSOP receiver and a NPN transistor. It is directly connected to the raspberry pi using wires. As for the software part it uses LIRC (Linux IR control) for controlling different devices. Currently all its files are based locally on the raspberry pi and one has to redirect to the local server in order to control devices.

In the future we want to make the universal remote wireless by using Wi-Fi modules. Also we want to make the interface friendlier. Also the current circuit lies on a very small GCB but for the final product we want to make a PCB with a standalone microcontroller and also encase it in a 3D printed case.

Architecture



Switch board:

The switchboard receives power from home AC supply and has a Wi-Fi-chip for communication. The user can toggle power on/off for each socket. The app sends request to the Wi-Fi-chip which controls the power supply to the respective plug socket accordingly. The devices are tagged and identified by the switchboard so that the user need not remember in which socket is the device plugged in. When the user is at home i.e. connected to the home network, the local app hosted on the Raspberry Pi is used. Otherwise, the app hosted on the cloud server is accessed. This ensures faster and effective data transmission.

Sensor board:

The sensor board module sends data i.e. temperature, humidity etc. to the web app through the Wi-Fi-chip. The web app shows the current environment condition to the user and also collects the data to show variation with time. This variation can be further used to automate certain devices like lights, curtains etc.

Universal Remote:

This is a firmware independent universal remote. It uses a wired connection between the module and the raspberry pi and works on LIRC (Linux IR control).One can control all the devices that work on IR signals using your smartphone. It currently works locally over a server that is setup on the raspberry pi. The web app redirects you to the local IP address where one can a particular remote and operate the selected device.

Overview of Tasks

Our project includes tasks from all the domains. The classification of tasks is explained as follows:

1. **Electronics:** Our project involves tasks such as PCB designing, Sensor and controller selection and designing the circuits and schematics.

2. **Embedded:** This module has several roles to play in the project starting from wireless communication between different modules and data acquisition from various sensors to controlling switches in the switchboard. It would include making use of various communication protocols to interface various peripheries of the smart home devices.

3. **Software:** This is a very crucial part of our project and it is involved in several segments of the project. We have the main script of the web application running on the cloud server. Apart from that we will also have several scripts running on the raspberry pi which process the data, add intelligence to the system and automate the processes in your home.

4. **Mechanical:** It includes designing and 3D printing of the case for prototyping of all the elements in our project.

Our Team

Our team comprises of students from IIT Madras who want to innovate and explore new technologies.

Akshit Kumar

I am a second year undergraduate student in the department of Electrical Engineering at IIT Madras. My interest lies in programming. Previously my contributions to the team were making PCBs and writing some interfacing programs. During the term, I'll be associated with working on some basic software development.

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Kushal Kakkad

I am a second year undergraduate in Chemical Engineering at IIT Madras. Electronics is a major hobby for me and this is a platform for me to display my finesse in this field. My previous contribution included designing the basic architecture for the circuitry also some amount of software like microcontroller programming. I am also familiar with the basics of 3D modelling. So during the term, I'll be working on PCB designing for the modules and also some 3D modelling.

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Sourav Debnath

I am a second year undergraduate in Mechanical Engineering at IIT Madras. Irrespective of my courses, I am immensely involved in web development and basic programming. My previous contribution included making a responsive web app for controlling the switchboard and providing a basic user interface with voice assistance. I am also adept at 3-D modelling. During the term, I'll be working on Web Development and Machine Learning.

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Sourya Varenya

I am a second year mechanical engineering undergraduate at IIT Madras. My role in the team would be related to the area of embedded electronics. Previously, my contributions to the team were designing the microcontroller schematics, modelling the case and getting it 3D printed. So during the term, I would be associated with the software development, embedded systems / electronics part of the project and 3D modelling and printing of the case.

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