Home Automation System

Project Members

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Project Sponsors

- None at this time

Project Description

Home automation has been seen as a futuristic idea, mostly inspired by movies and cartoons over the years. Only recently has it become a possibility to actually create such automation through the rise of the Internet of Things (IoT). The IoT is the idea that all devices can be networked to work together seamlessly, each having its own purpose and tasks.

For this project, IoT technology is being embraced to make a simplified home automation system. Independently designed hardware devices will be hooked up to the Internet over in-home WiFi networks. Over WiFi, these devices will connect to a cloud-hosted infrastructure allowing households to register accounts on a platform by which devices can be managed and configured through web and mobile apps in addition to a provided in-home tablet.

With the cloud-hosted infrastructure, these devices can be turned on and off individually or as assigned virtual groups (like to perform a specific task like turning an entire room's lights off). Due to limited time and resources, the primary use case of these devices will be to control lights and fans in a home. This project could extended to control air conditioning, door locks, appliances, and other devices.

Project Goals

The main goal of this project is to create a cheap and efficient home automation system through multiple wireless devices designed for specific tasks (such as turning a switch on and off).

These devices will be used to allow homeowners to control lights and fans from any room in their house, in addition to remotely via a web application or mobile device.

In addition to added control, these devices will also monitor, record, and graph power usage. This will allow homeowners to better account for their energy use.

To further limit the amount of energy used, motion detection and audio recording devices can be used to automatically turn off the power to devices in empty rooms.

Project Specifications

There are some constraints for this project. It must be assumed that the user will have a wireless network and Internet in their home. Additionally, the user must be capable of installing wall switches, which involves basic household wiring.

As for competing products, commercial in-home technologies exist like Vera, Wink, Control4, and many more. These competing products offer a similar setup, although some are not cloud based services like the one proposed for this project.

There are 4 elements of our project with their own specifications:

1. Wall Outlet Plug
    a. must be less than 1.5”x2.5”x2.5”
    b. must accept 120V AC power
    c. must pass through enough electricity to power attached device
    d. must be able to connect to bluetooth
    e. must be programmed to connect to wifi from bluetooth
    f. must be programmed to toggle a relay on or off over wifi
    g. must be programmed to push power usage over wifi to cloud

2. Wall Switch
    a. must be less than 1”x2”x4”
    b. must accept 120V AC power
    c. must pass through enough electricity to power attached device
    d. must be able to connect to bluetooth
    e. must be programmed to connect to wifi from bluetooth
    f. must be programmed to toggle a relay on or off over wifi
    g. must be programmed to toggle a relay from physical button press
    h. must be programmed to push motion detection/sound detection over wifi to cloud
    i. must be programmed to push power usage over wifi to cloud
    j. must contain an energy monitoring IC that records energy usage over time

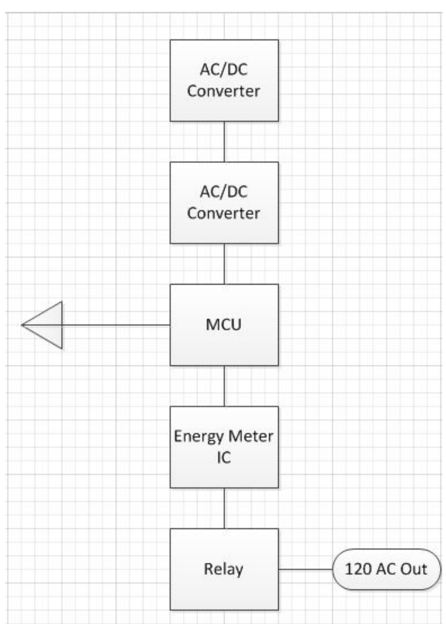
3. Powerlock
    a. must incorporate electric strike
    b. integrate with Bluetooth over Wifi to send signal to powerlock
    c. be able to open door using normal methods
    d. be able to unlock/lock door with press of a button on app

4. Application
    a. must be cross-platform (browser, windows, osx, linux, android, ios)
    b. must be responsive to window size (desktop, tablet, and mobile device friendly)
    c. must run in the cloud (virtual machines)
    d. must allow users to sign up and sign in securely
    e. must allow users to link devices with accounts
    f. must allow users to control their devices
    g. must allow users to group devices to be controllable together
    h. must allow users to program a schedule for their devices/groups
    i. must track and display power usage of devices

Block Diagrams

Wall Outlet Hardware Block (Research)

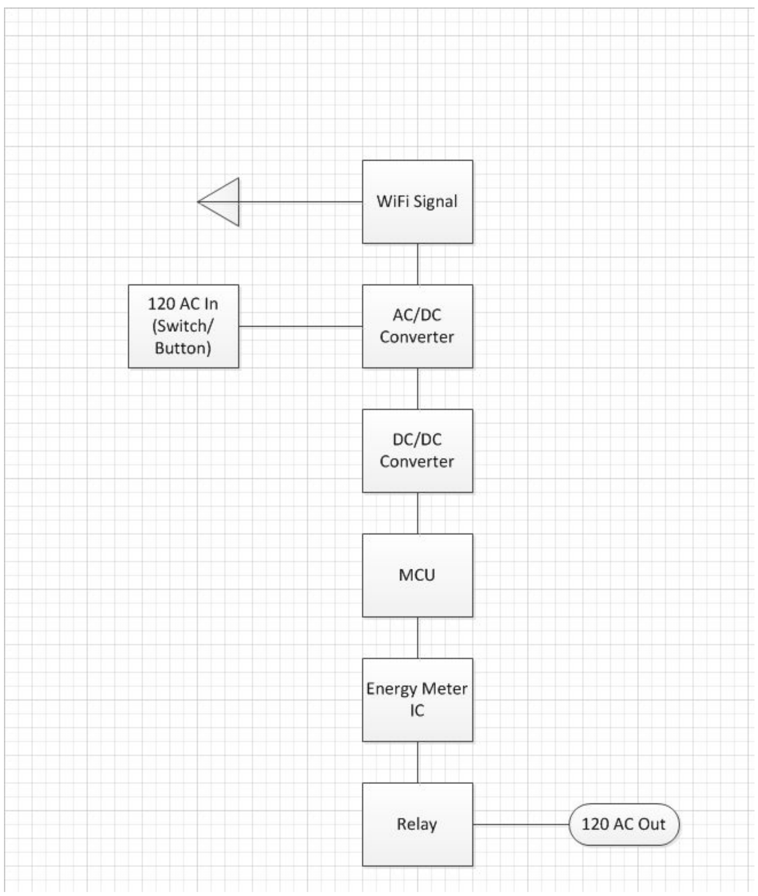
(Administrative Lead: Roneal Valmonte)



The above is a basic input/output of the Wall Outlet component of the home automation system. An input of 120 V goes through an AC/DC converter (and the resulting DC current is degraded to the exact voltage needed to activate the microcontroller (the exact model is still being picked out). The microcontroller, at rest, would not output an AC voltage unless a wireless signal from the app on the smartphone or the tablet turns on the microcontroller. If so then a 120V AC is output, thus turning on the wall outlet and the energy meter IC records this continously until the state is changed.

Smart Wall Switch Hardware Block (Research)

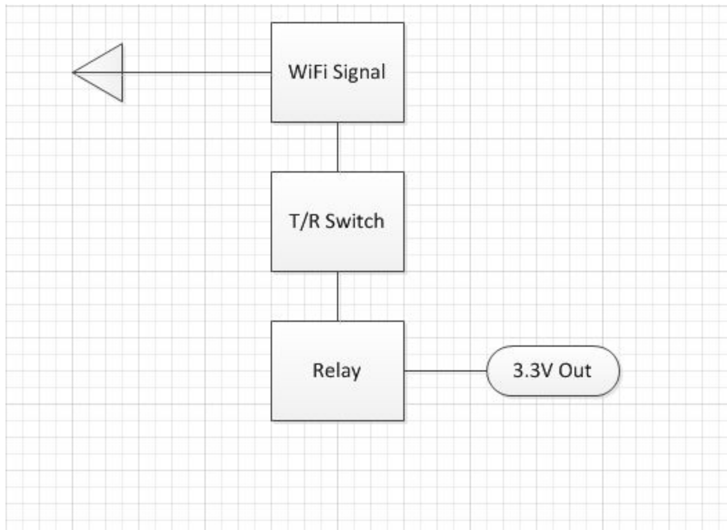
(Administrative Lead: Roneal Valmonte)



The above is a basic input/output of the wall switch of the home automation system. After the user presses the wall switch or toggles the switch in the application, the signal goes through an AC/DC converter and through a DC/DC converter to reduce voltage. The MCU accepts the signal and goes through an energy meter IC that records the voltage being put it over an infinite period of time or until the wall switch is turned off. The output inverts the wall switch's current state.

Powerlock Hardware Block (Research)

(Administrative Lead: Roneal Valmonte)

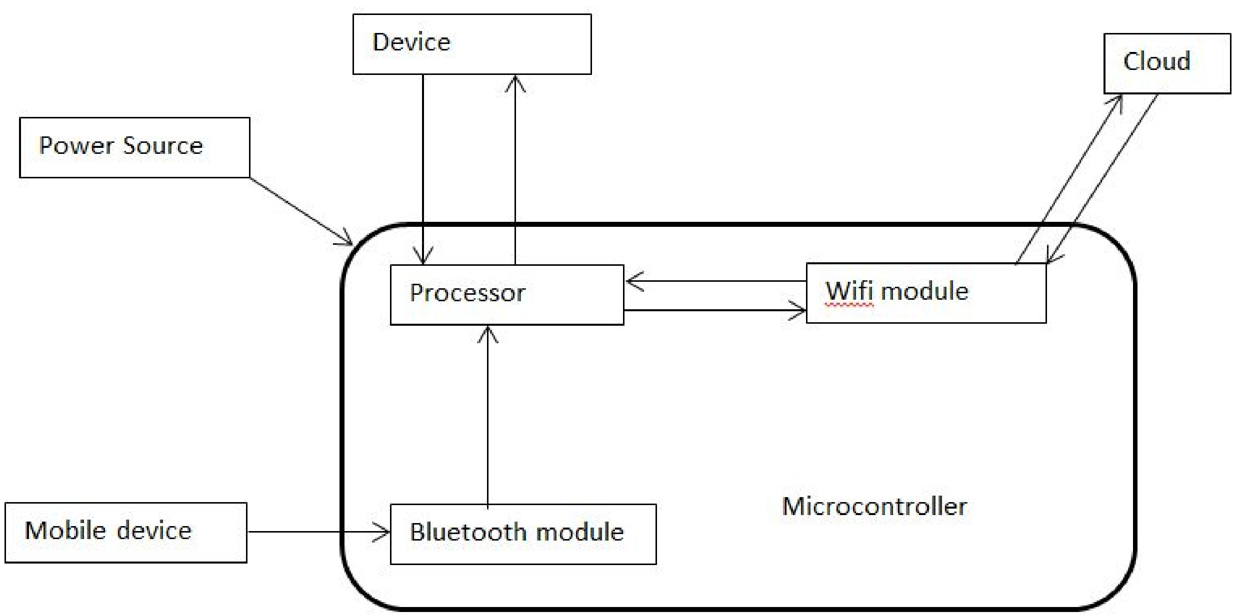


The above is a basic input/output of a tablet command of the powerlock system used for the doors. The door can accept a wireless signal using the app that goes through a Wi-Fi signal. The signal then opens/closes a latch that will allow a 3.3 DC voltage to go through, opening or closing the electric striker. This can all be circumvented if the door is opened normally.

Microcontroller Block (Research)

(Administrative Lead: Jeffrey Benoit)

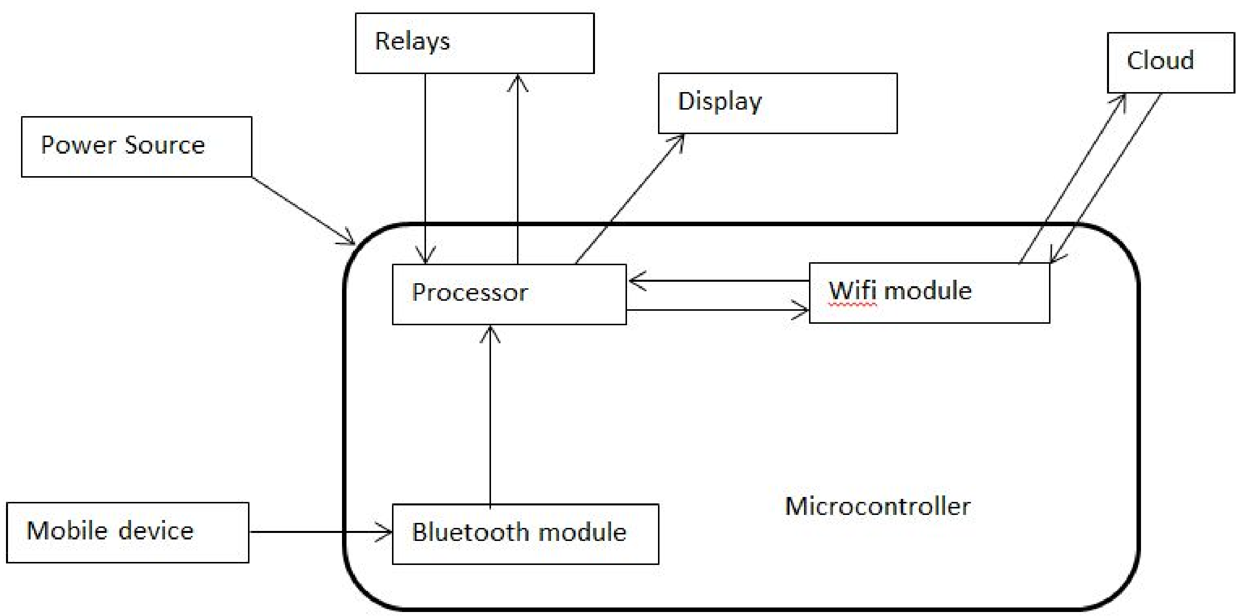
Microcontroller Overview



The above is the basic layout that will be used for all microcontrollers used in each of the devices. The microcontroller will receive data from the device as to its current state, and send that data to the wifi module to be sent to the cloud server, and in turn also receives data from the cloud, via the wifi module, as to which state the processor will tell the device to be in. The microcontroller will also receive input from mobile devices via the bluetooth module, however this will only be input and will only be used to configure the wifi module for connecting to the desired wifi network and allow connection to a private or protected wifi network. The processor will convert the received data to the correct format for output, and send the output to the correct destination, while still being able to receive new data. Efficiency and accuracy of the process will be the most valued metrics, there should be very little if any delay between a command being entered from the app/cloud and the microcontroller, less than 1 second of delay is the desired goal.

The only deviation from this base design other than the signals and data sent and received between the processor and device would be in the design of the thermostat, which adds an output display that is also controlled by the microcontroller, a block diagram for this device's microcontroller is shown below.

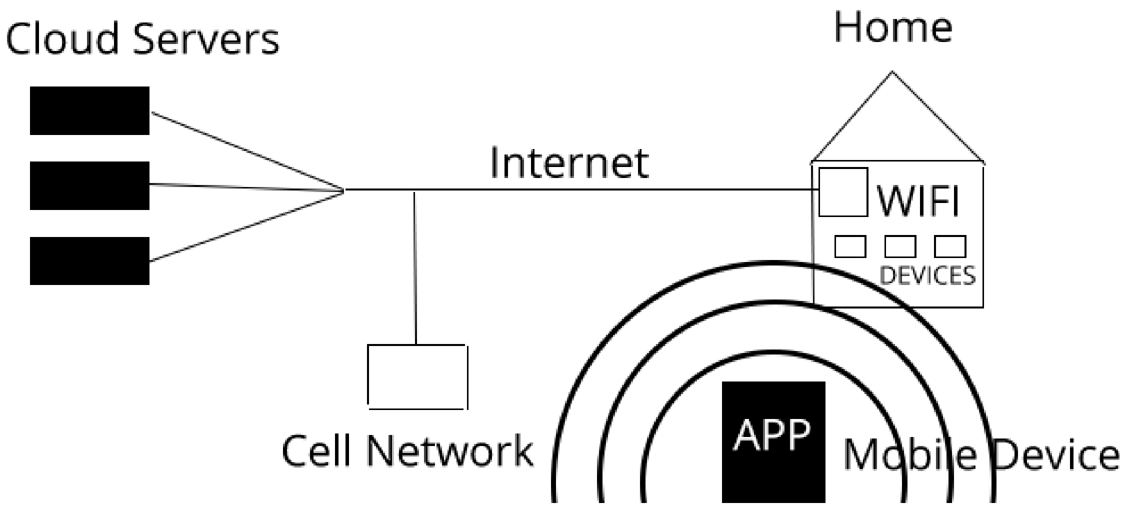
Thermostat Microcontroller Block Diagram



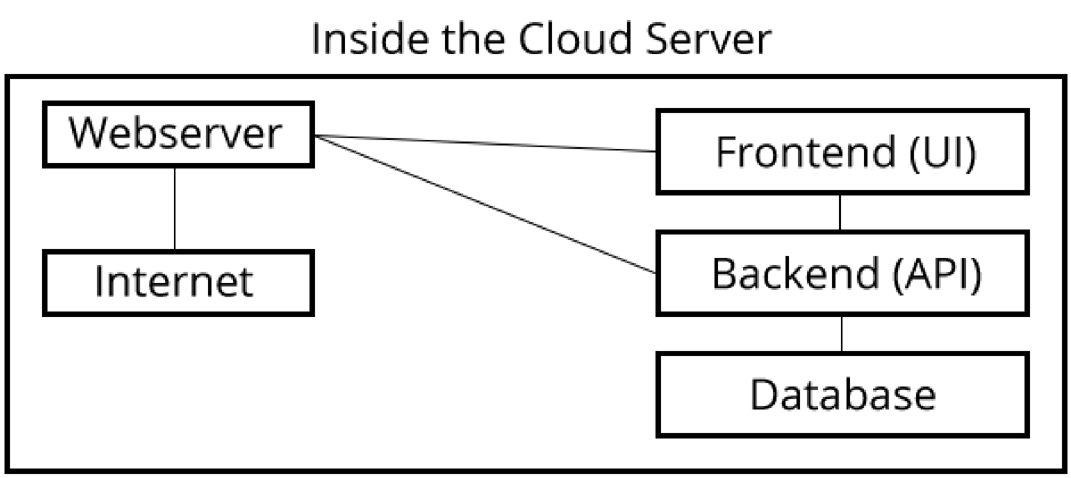
Application Block (Research)

(Administrative Lead: Zachary Zapasnik)

App Overview



The above is a basic overview of how the application will function. The app will communicate with over wifi and the cellular network with our cloud servers, which will allow users many different functions, from turning different appliances on or off, unlocking a door, monitoring the power usage of the connected device, throttling power output (i.e. dimming a light), and more. The devices inside the consumer home will be connected over wifi to the cloud servers too, but they will be using SSL encrypted persistent sockets to allow the cloud servers to push commands to them as well as receive data in realtime.



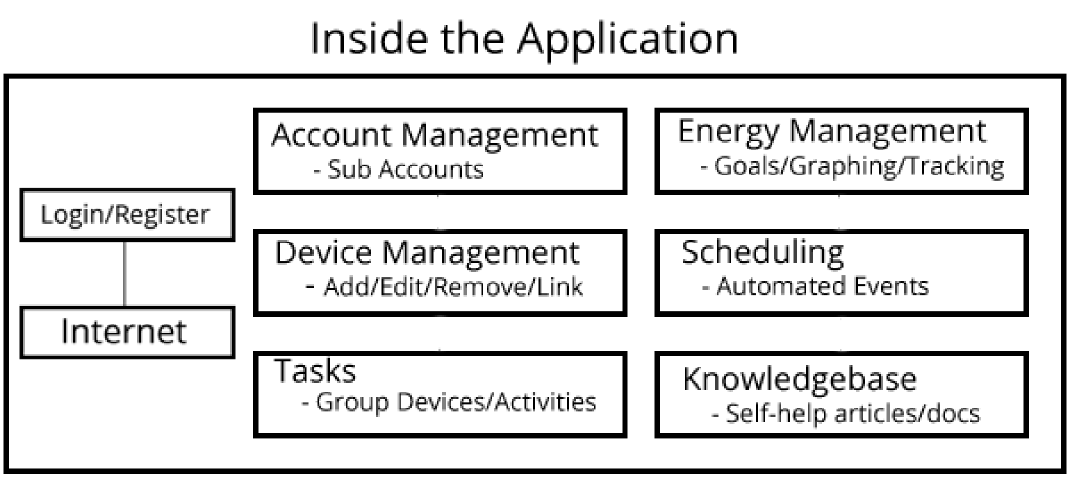
The cloud server will be designed to horizontally scaled (meaning multiple servers can be used and accessed simultaneously). To do this, sessions will be persisted the database and no stateful information will be kept in memory. The cloud server consists of 4 general pieces: the webserver, the frontend, the backend, and the database.

The webserver serves resources for the frontend and tunnels traffic to the backend. We will be using one of the most popular webserver softwares, NGINX, for our servers. It is a barebones, quick, and fast webserver.

The frontend is the website and control panel. It will load on customer browsers and give the customer control over their home from anywhere. The frontend will be coded with HTML5/CSS3/JavaScript/AngularJS technologies, which is standard for new websites at present. Packaged Chrome apps for mobile devices will be offered as well to provide native control from mobile devices (in addition to their necessity in the initial setup of home automated devices). These packaged apps will run from a fork of the frontend (to keep the theme and function of the existing site), but will contain mobile device specific code to interface directly with bluetooth and wifi device APIs.

The backend will provide an application program interface (API) coded in a JSON REST format, which will allow the frontend and mobile apps to dynamically render views based on data from the database in addition to sending and retrieving commands and data from the controlled home devices. The backend will be developed using NodeJS, an asynchronous JavaScript runtime. NodeJS works well with applications needing concurrent non-blocking IO operations.

Finally, the database selected for use is MongoDB. Relatively new, MongoDB is a scalable database software sporting document data models where queries are formed using JSON instead of SQL. Because data is stored as documents rather than rows in a table, it scales better across multiple servers in real-time than an SQL table would.



As described above the application will be coded using HTML5/CSS3/JavaScript/AngularJS technology. Through the app, the customer will login or register for the app. Once logged in, the user will be able manage their home automation system. Users can manage their account (change password/email) and add sub accounts (useful for households where children/spouses need accounts). There is an area to manage devices, which handles the adding, removing, editing, and general configuration of devices. When a user things of home automation, they don't think of controlling just one devices at a time. The Tasks area will allow users to group together devices for control together. For example, all of the lamps in a room can be grouped together to turn on and off together. Devices will be able to belong to multiple groups to allow for diverse configurations. Since the cost of electricity is ever increasing and our dependence on electricity is growing, there needs to be a reliable way to track, monitor, and limit power usage. The energy management portion of the control panel will organize devices' power usage data in an easy to understand way and allow configuration of goals to help keep power bills under control. Most individuals have a daily or weekly schedule, so through the scheduling area a static schedule can be set. This schedule can be disabled if plans change abruptly, so the schedule should not cause issues. Since home automation is rather new and not all customers may be capable of understanding all options in the control panel initially, there will also be a self-help knowledgebase available for searching documentation on features and settings.

Project Budget

Project Estimates	
3x Relay Harness	$8
1x Button	$4
1x Matrix Circuit Board	$4
2x Adafruit Mini Microcontroller	$20
2x BT/WiFi Combo Microcontroller	$50
3x Virtual Machines	$15/month
1x Electric Strike	$50
2x MCP3309 Energy Measurement IC	$5
Research, Development,and Implementation	$100

These prices are based on speculation according to popular shopping sites such as Amazon and Raspberry Pi. Over the course of the design process more components will be added according to new goals and new additions to the home automation system.

Project Milestone

Task	Start Date	End Date	Duration
Determine Project	08/24/2015	09/07/2015	14 days
Research Similar Projects	09/07/2015	09/15/2015	7 days
Design basic prototype	09/15/2015	09/29/2015	14 days
Research how to accomplish hardware design	09/29/2015	10/08/2015	9 days
Finalize prototype design	10/08/2015	10/15/2015	7 days
Begin gathering parts and assembling prototype	10/15/2015	11/05/2015	21 days
Begin app design	11/05/2015	11/19/2015	14 days