Wireless Home Control System

Project members

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Motivation

The goal of this project is to improve the quality of life for people in their homes. Imagine sitting on the couch at home about to watch a movie, but all the lights are on and it's a little warm inside. It is irksome to have to get up and turn off every individual light. With the technology existing today it is perfectly feasible to be able to turn off the lights and turn on a fan with a mobile phone. With the software available today it is even possible for this process to be initiated by voice. The problem that exists is these solutions lack mass implementation. By creating a wireless home control base station that a mobile phone could connect to these visions can be realized. The need to get up and physically interact with an appliance can be made a thing of the past.

Description

We want to develop an easy to use system that allows people at their home to interact with their appliances without having to be in front of them. Our aim is for the solution to be reliable and low cost. The use case scenarios should be intuitive so that even someone who was just visiting could utilize the system. A person using the WHCS should be able to turn on their lights or fans with the press of a button or with a voice command from their mobile phone. They should also be able to turn on their coffee pot from their phone when they first wake up. If someone knocks on the door the person should be able to open the door without having to get up. The system will do passive monitoring as well, so a person will be able to tell the temperature of a certain room of their choice.

The base station will be where the brains of the operation reside. A LCD screen will be attached to the base station to provide information about the state of the system. The base station should also contain buttons to interact with so that a person doesn't have to rely on their phone. The base station will be wirelessly connected to all the control modules located around the house, so all commands will originate from this point.

All the appliances that are targeted by the system will be paired with a control module. There are parts that will be common for all the control modules such as a microcontroller and a rf chip for wireless connection. There are also parts that will need to vary on the control modules based on the appliance that they target. For example the door's control module will need to control a motor while the light's control module will need to control a relay.

Specifications

The base station for the WHCS is the system's integral component. It is important that the base station be small and mobile so you can interact with it in whichever part of the house you choose. Our goal is to have the base station 4"x4" or smaller and the control modules to be 3"x4" or smaller. The base station will have an LCD with at least a 16x4 character stream display. Three buttons will be attached to the base station in order to interact with it without the need for a mobile phone. The station will be able to operate off of 120v AC by plugging into an outlet or by battery power. The mobile device and the control modules should be able to communicate with the base station when within 30ft. Bluetooth communication and other ISM radio frequencies will be used to communicate between the mobile device and the control modules respectively. These frequencies will be approximately 2.4 GHz.

The control modules will interact with different targets around the house. Examples being outlets, lights, and also the front door. Since outlets and lights are powered by 120v AC the control modules targeting those devices can tap the 120v AC lines to power themselves. The control modules will step down the 120v AC to a logical DC voltage in the range of 3.3v-5v. Mechanical relays will be used in order to activate appliances that are powered by the 120v AC lines. These Mechanical relays should be rated to handle 120v AC and the relays we use will be over-rated for the task we will use them for. The relays should be able to be switched with 5v activation voltage.

Our intent is to have two printed circuit board designs created. One for the base station and one for the control modules that can be used for any of the different control module tasks.The PCBs will be double layered. They must be big enough to house a microcontroller with UART (Universal Asynchronous Receiver Transmitter) pins, SPI (Serial Peripheral Interface) pins, and additional pins for GPIO (general purpose input output). The board will also need to fit the RF chips used for wireless communication and the power supply. Space will need to be allocated on the control modules for interfacing with their target.

The Android component of the WHCS should be user friendly and intuitive to use. Once starting the application to interact with the system the user should be able to toggle an appliance within 5 seconds from whatever screen they're on. Commands to the system will be able to be received through speech. A phrase similar to "light 1 on" should

activate a light attached to the system. The android application will communicate to the base station only and will do so through Bluetooth.

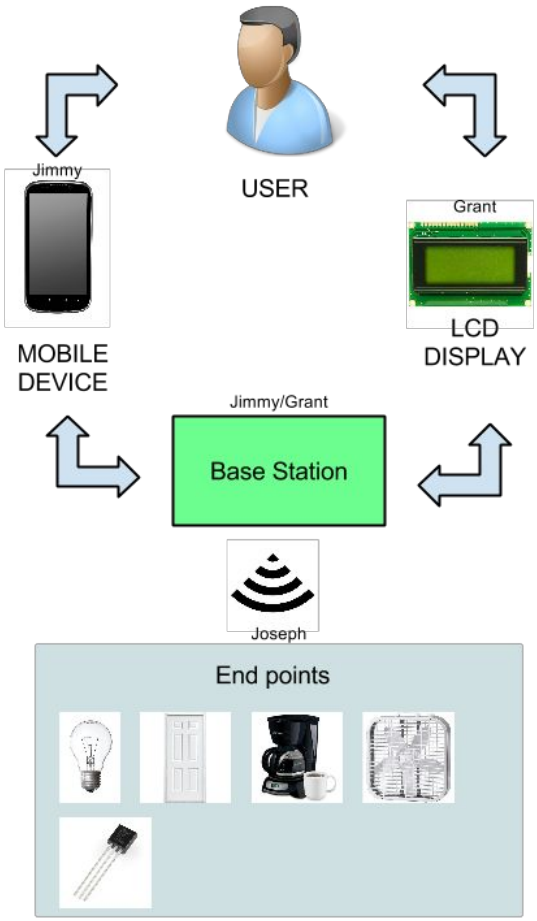
The endpoints that Wireless Home Control System targets are lights, outlets, the front door and sensors (ex. temperature). Lights and outlets will be able to be in the on or off state. The front door will be in either the locked or unlocked state. The sensor will display data based the sensors purpose. A temperature sensor will display the temperature reflecting the location is has been placed.

Budget

Item	Cost	Qt.	Item Total	Note
Base Station Bluetooth Module	$7.95	1	$7.95	
Base Station RF Chip	$0.97	1	$0.97	
Base Station PCB	$90.00	1	$90.00	https://oshpark.com/pricing $5 per square inch. Assumed 4x4 board, and $10 shipping
Base Station LCD	$30.00	1	$30.00	Comes assembled
Control Module RF Chip	$0.97	4	$3.88	Per control module
Control Module PCB	$33.00	4	$132.00	http://www.4pcb.com/33-each-pcbs/
Control module MCU	$4.00	4	$16.00	Per control module
Pocket AVR Programmer	$15.00	1	$15.00	http://sparkfun.com
Solid-State Relay	$17.00	4	$68.00	Alternative to mechanical relay
Bluetooth Capable Phone	$0.00	1	$0.00	Members possess a Bluetooth capable phone
Casing for Modules	$2.00	5	$10.00	
Battery Holder	$2.50	5	$12.50	
DC-DC Step Down (LDO)	$1.00	5	$5.00	1 per board (including control modules)
AC Rectifier	$5.00	1	$5.00	Self-built and assembled (diodes, capacitors)
GFIC Outlet	$17.00	1	$17.00	With safety features
Electronic Strike	$50.00	1	$50.00	For access control
Temperature Sensor	$1.50	1	$1.50	
Light Fixture	$4.50	1	$4.50	Bulb and socket
Tranformer	$15.00	4	$60.00	120v AC to AC voltage of logical DC
Shipping Costs	$8	12	$96.00	Boards , parts, prototyping equipment
Project Miscellaneous	N/A	N/A	$50.00	Wire,Resistors,Capacitors, Inductors,LED's prototyping equipment, etc
TOTAL			**$675.30**	

Block Diagrams

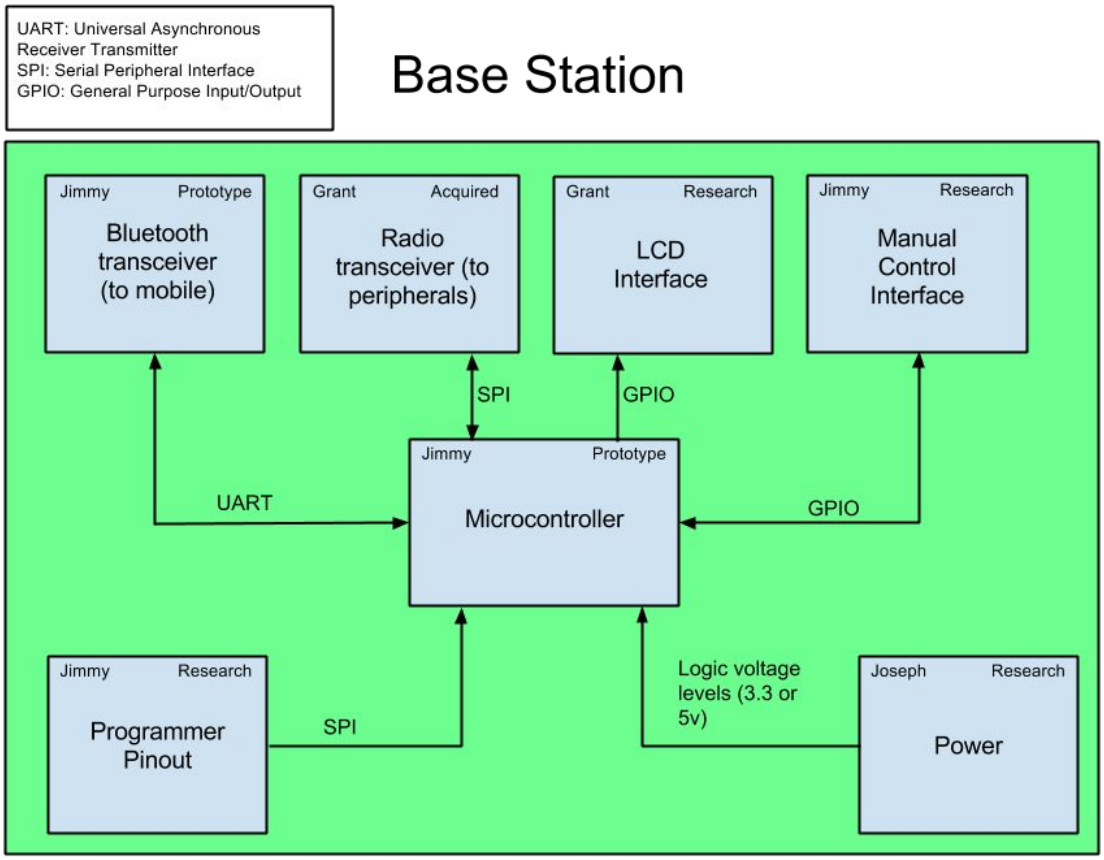
WHCS System Overview



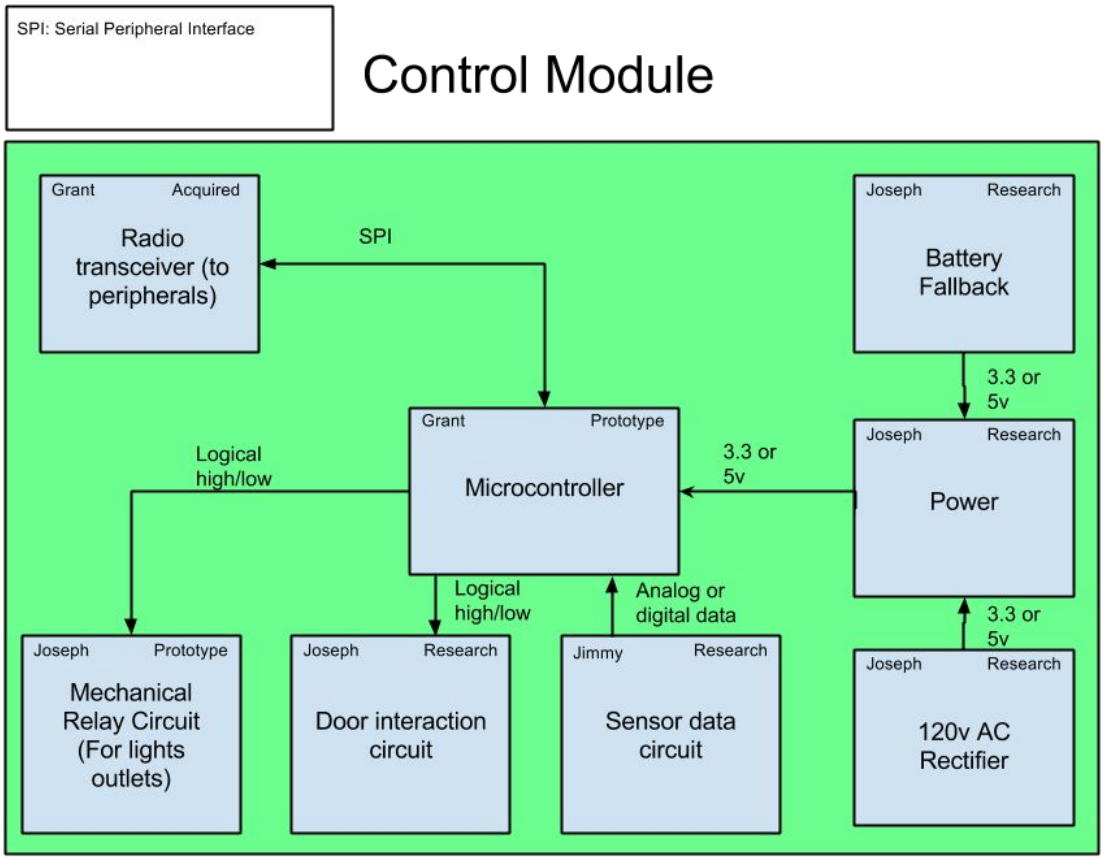
This diagram presents a high level overview of the Wireless Home Control System. The user commands the system through interaction with either a bluetooth enabled mobile device or with the LCD screen. Once a command has been given it is delivered to the base station. The base station then picks the endpoint that the command has targeted and sends a command to that control module. When the control module receives the command the state of the system has changed and the change will be reflected on the device the user is interacting with.

For passive components such as the sensor the user will simply observe either the mobile device or LCD in order to obtain the information the sensor is providing to the system.

Active components will be able to be toggled. These components include lights, outlets and the front door. The system will maintain the state that these components are in so the user interface can relay this information to the user.

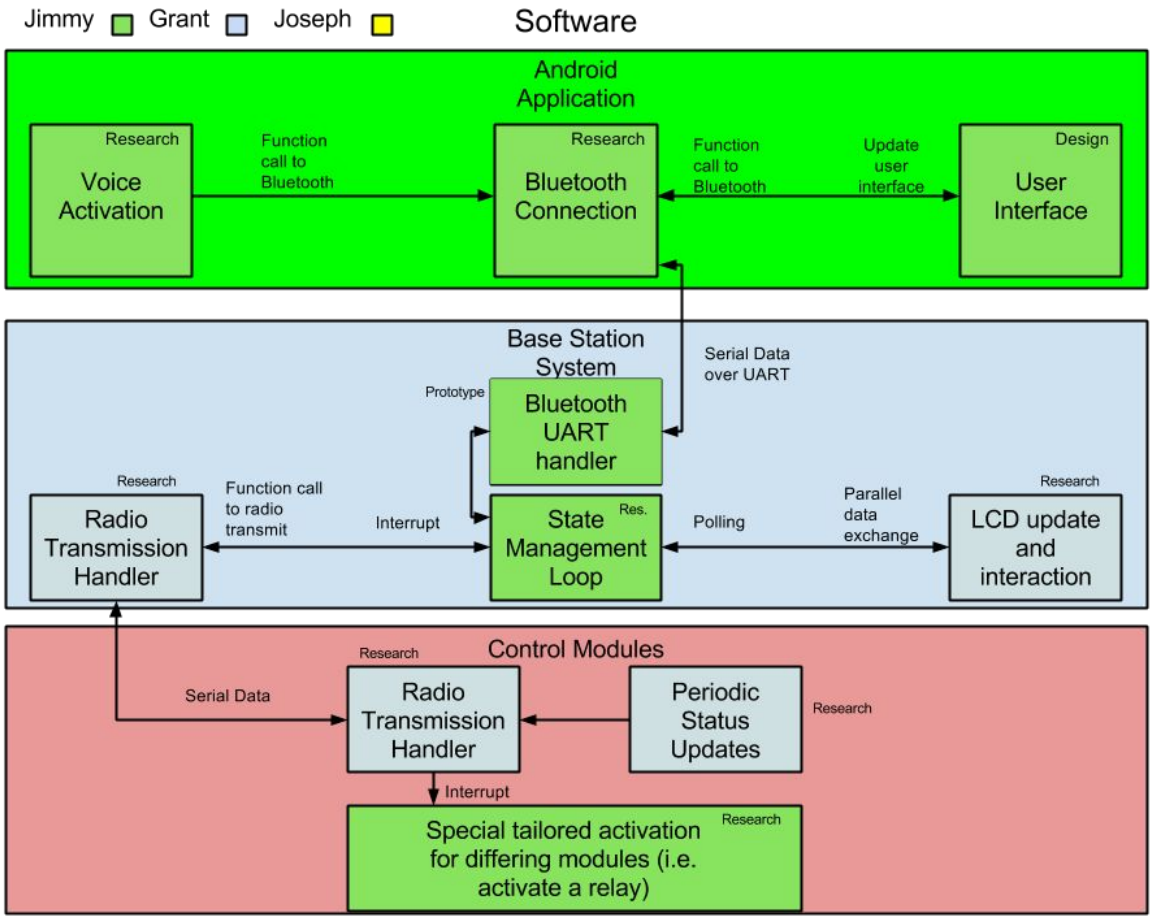


The Base Station manages and collects data from the many Control Units in the home using a common radio transceiver. This network is dynamic, allowing for new devices to be added and associated to the Base Station in real time. In addition, it provides an LCD touch screen for status updates and home control. To provide wireless control, it uses a Bluetooth module to connect to a capable Android device, allowing for remote queries and voice control. A manual control interface (buttons, potentiometers) would communicate basic data to the microcontroller in order to control lower level functions, such as LCD brightness and hard reset.



A control module will be placed at each endpoint that WHCS controls. For endpoints with access to outlet power AC power will be used to power our board. The board will also be equipped with battery power as a fallback for the AC power and will be used as the primary source of power for endpoints without access to outlet power. The board will receive and send information from the base station using a radio transceiver. The microcontroller will be connected to the circuits that will be used to control and read information from the endpoints.

A microcontroller will act as the brains of the control module. When the RF communication chip receives data it will transfer it to the microcontroller in order to initiate changes within the systems state. The control module board will need circuitry in order to be able to interact with lights, outlets, the front door, and sensors. The microcontroller will provide logical signals to toggle these circuits. Whenever the microcontroller wants to relay information it has the ability to communicate to the base station with the same RF chip it receives from.



The software in the Wireless Home Control system will consist of three parts. There is the high level Android aspect, the low level c++ microcontroller base station code, and also the similarly low level control module code. Within these three blocks there are smaller components that interact with each other and there are also components that connect the three main blocks.

Android code will be written in Java with object oriented design practices. Libraries exist for converting speech into text. Our mobile client can leverage these libraries in order to provide a great user experience. A user interface will be provided as a fallback for those who do not wish you use voice activation.

Networking code will be a big aspect of the software considering that there are many wireless components that need to be connected. Data will be exchanged serially and interrupts will be used in the microcontrollers in order to respond to attempts to communicate.

Milestones

	Name	Start	Finish
1	**Senior Design 1**	**02/03/2015**	**04/25/2015**
2	Research Bluetooth Communications	02/03/2015	02/13/2015
3	Research 120V AC Rectification	02/03/2015	02/13/2015
4	Research Communication between 2 RF Chips	02/03/2015	02/13/2015
5	Prototype Bluetooth Communications	02/13/2015	02/23/2015
6	Prototype 120V AC Rectification	02/13/2015	02/23/2015
7	Prototype Communication Between 2 RF Chips	02/13/2015	02/23/2015
8	Research Outlet Control Module	02/23/2015	03/05/2015
9	Research Android App Development	02/23/2015	03/05/2015
10	Research Door Control Module	02/23/2015	03/05/2015
11	Prototype Outlet Control Module	03/05/2015	03/15/2015
12	Prototype Android App	03/05/2015	03/15/2015
13	Prototype Door Control Module	03/05/2015	03/15/2015
14	Research Light Control Module	03/15/2015	03/25/2015
15	Research LCD Interface with Base Station	03/15/2015	03/25/2015
16	Research Battery Powered Fallback	03/15/2015	03/25/2015
17	Research Temperature Sensor Control Module	03/15/2015	03/25/2015
18	Prototype Light Control Module	03/25/2015	04/04/2015
19	Prototype LCD Interface with Base Station	03/25/2015	04/04/2015
20	Prototype Battery Powered fallback	03/25/2015	04/04/2015
21	Prototype Temperature Sensor Control Module	03/25/2015	04/04/2015
22	Research Board Design Software	04/04/2015	04/15/2015
23	Final Documentation Senior Design 1 Complete	04/15/2015	04/25/2015
24	**Senior Design 2**	**05/18/2015**	**08/07/2015**
25	Design Boards	05/18/2015	05/27/2015
26	Bill of Materials Complete	05/18/2015	05/27/2015
27	Send in Order for PCB's	05/27/2015	06/05/2015
28	Prototype Base Station	06/05/2015	06/14/2015
29	Prototype User Acsess	06/14/2015	06/23/2015
30	Prototype Endpoints (lights/outlets/temperature/door)	06/23/2015	07/02/2015
31	Prototype Total Integration	07/02/2015	07/11/2015
32	Design Display	07/11/2015	07/20/2015
33	Build Display	07/20/2015	07/29/2015
34	Add Ordered Boards to the Display	07/29/2015	08/07/2015