Smart Home Project Synopsis

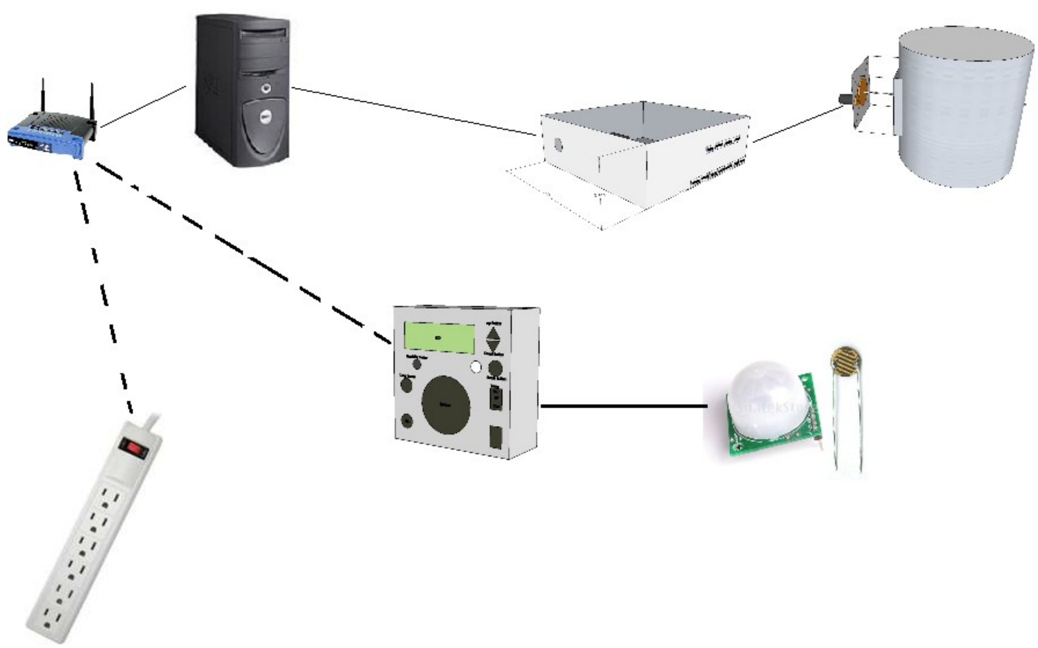
GroupList

Levi Balling - leviballing@gmail.com

Dario Bosnjak -bdario1@comcast.net

Christopher S. Johnson - christopher.s.johnson@utah.edu

Todd Rogers - u0634986@utah.edu



Introduction

A smart home will take advantage of its environment and allow seamless control whether you are present or away. With a home that has this advantage, you can know that you home is performing at its best.

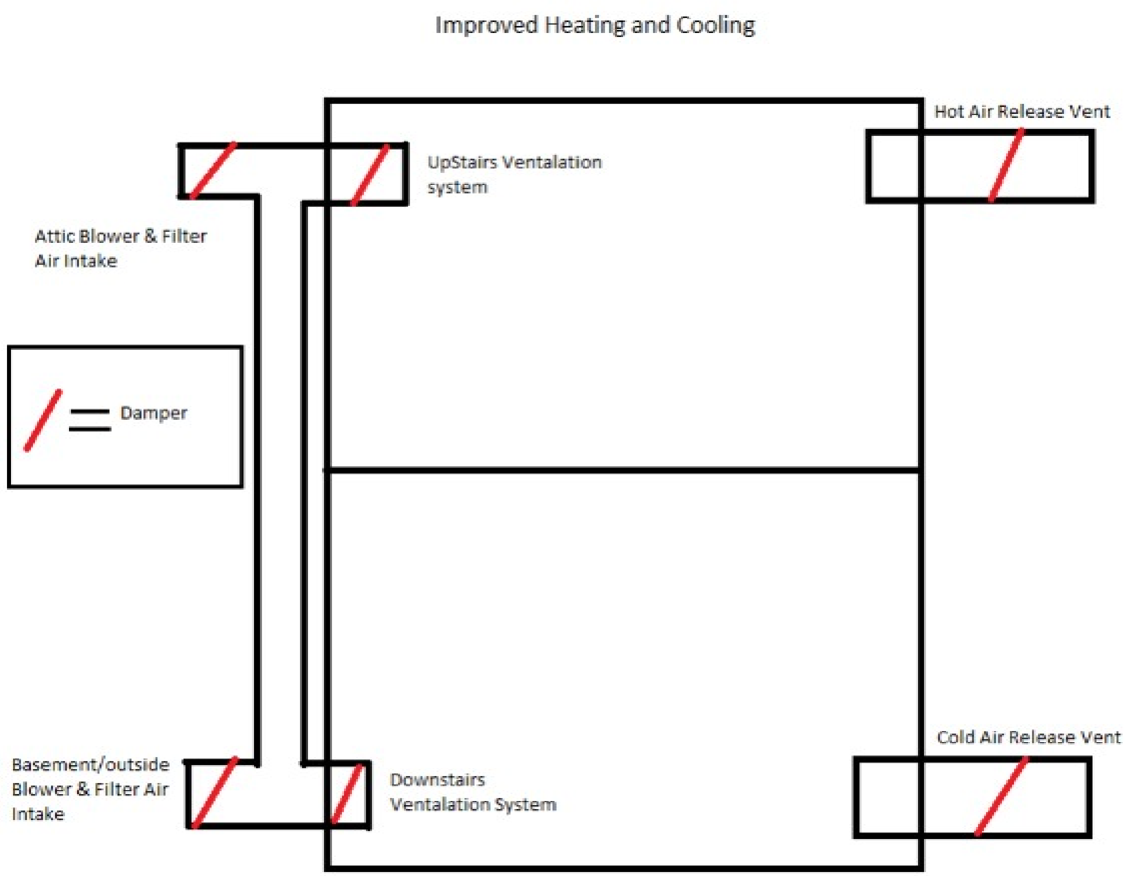
Functionality

Temperature Controller

The goal of temperature control is to make the home more efficient, save money and allow the temperature to be evenly displaced throughout the home. This will be controlled using temperature sensors displaced throughout the house with one in each room, in the attic and outside. Heating and cooling systems in new homes are designed to function without taking advantage of any outside conditions. This makes most homes inefficient when weather conditions are better outside than in the home. An example of this occurs during summer nights when it is 63 degrees outside (noaa.gov), and 75 degrees inside with the A/C on to lower it to 72 degrees. This turns on the A/C unit, and costs a lot more than necessary.

This system is useful during the winter too. When the temperature is warmer in the attic, the system will pull air from the attic into the basement. It will also open a cool air release damper in the basement to outside and allow the cold air to flow out of the house. If the temperature is warmer outside, and not in the attic (unlikely in winter but common in spring and fall), it will draw from outside, and displace it into the basement, and release the cold air. When it is colder in the attic than it is outside then it will maintain regular temperature control.

During the summer if the temperature is cooler outside, then it will pull air from the basement or outside into the upstairs ventilation system. It will also open a hot air release vent, allowing better air flow. If it is warmer outside, and cooler in the attic (unlikely) it will distribute like before.



Occupancy Detection

Tracking the occupied or vacant status of each room allows the house to turn lights and appliances on and off automatically as well as manage the temperature in individual rooms without human intervention.

Determining this room occupancy status has been attempted in the past using a motion sensor and a countdown timer. Whenever there was motion detected, the room would be deemed occupied, and the countdown timer would be reset to begin counting down toward zero. When the timer reached zero without being reset by further motion, the room would be deemed unoccupied.

The problem with this is strategy is that if the duration of the countdown timer is short, then if motion is not detected on a frequently basis, the room may be inaccurately assumed vacant when it is still occupied; if, on the other hand, the duration of the countdown timer is long, then the room will be deemed occupied long after all persons have vacated it.

The solution to this problem is to add a third component to supplement the motion sensor and countdown timer-- a light beam interruption detector. The light beam interruption detector is positioned between the two posts of each doorway or between the sides of each archway dividing spaces into separate rooms. The occupied state of each room can only change immediately following the interruption of the light beam as people pass from one room or area to another (assuming people do not enter and leave through the windows). Furthermore, motion will quickly follow an interruption of the light beam if the room becomes occupied.

Due to these facts, once the light beam is interrupted, the system can determine quickly—in as little as 5-10 seconds—whether a room bordering that light beam has become occupied or vacant. If the room is found to be occupied during that time period due to motion having been detected, then no further motion is required to maintain that status until the light beam is interrupted again. If the room is mistakenly assumed to be empty after that time interval, because of a lack of motion during that interval, all it takes is one wave of an occupant to the motion sensor and the house will change the status of the room to occupied.

WIFI

Implementing an Arduino microcontroller will allow us to gather the data from different sensors throughout the house and broadcast the data to a server that will be set up using Wifi Interface. A WiFi shield for Arduino will be connected to the server using the TCP/IP protocol with an assigned IP address that the server will use to process to the information on that IP. We are using the WiFi Shield WiShield V2.0, which will have direct plug and play with the arduino board and will allow us to use the existing pins on the board. The shield comes without an external antenna which will be added for better range and more directed signal.

We are planing on running an Apache server where we could store the data that comes in from the micro controllers. This data will be formatted and displayed on a secure website which is accessible from any internet connection. We running a basic server on the arduino board, with few functions which is less user-friendly. Using the WiFi we will be able to send and receive data. Once we get the information from a temperature sensor in one of the rooms, and we decide to turn on the fans in the room to change the temperature, we would send a command to that micro controller that will be in charge of running the fans, to start to pump the desired air inside that room. Below is a diagram to illustrate wifi operations in the house.

Room Controller box

Each room will have a single controller box, that will contain a MCU that will connect a variety of devices that provide different features of the smart home. The box will connect to the room monitoring sensors and room fan vents. It will also be connected to an outlet 12V 1.5 amp or some greater power supply.

Server

The central server is the hub of all activity and performs two important functions. First, it takes input events created by sensors and other talking devices, and it executes scripting commands in response to these input events to generate output events in the form of commands that it sends to devices like switched outlets. Second, it creates a web-based interface for interacting with the home's various systems as well as for editing the scripting commands that the home executes in response to various stimuli.

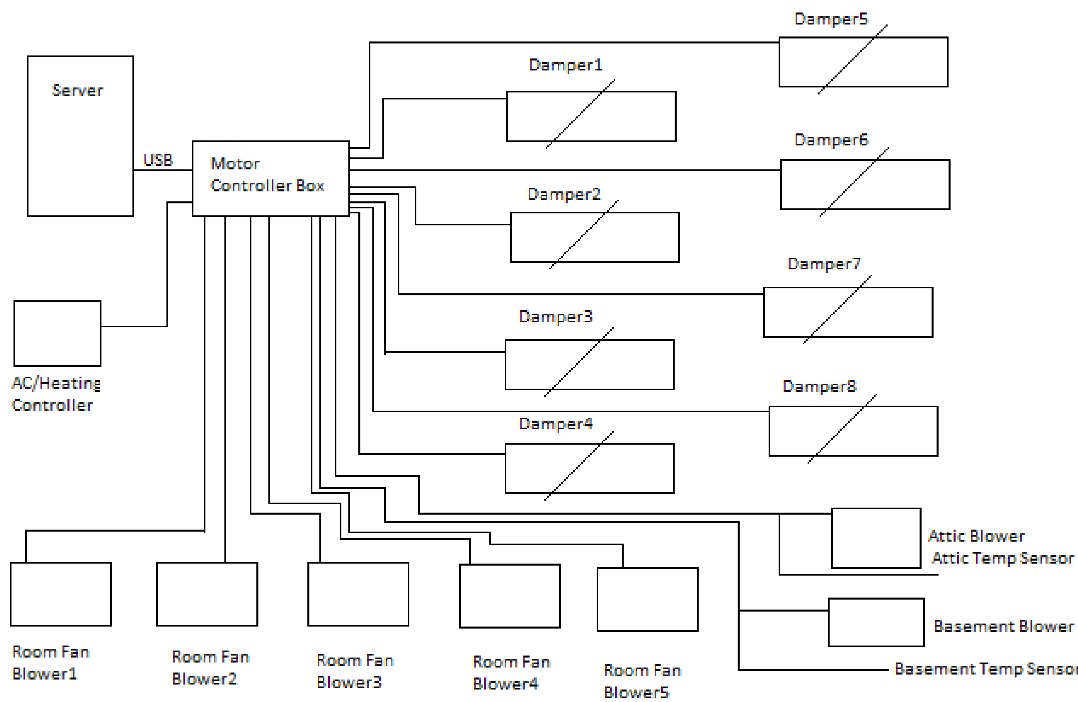
We have chosen Python as the language in which we will implement the core server software that tracks the state of input devices and sends command events to output devices. User plug-ins will be written in Python to hook into the core server software and communicate in response to input or other events such as things occurring on a schedule. The reason for choosing Python is that it is an easy-to-learn, interpreted, general purpose language which can add new code, like plug-ins, on the fly without recompiling, relinking, and restarting the whole program.

Outlet Controller

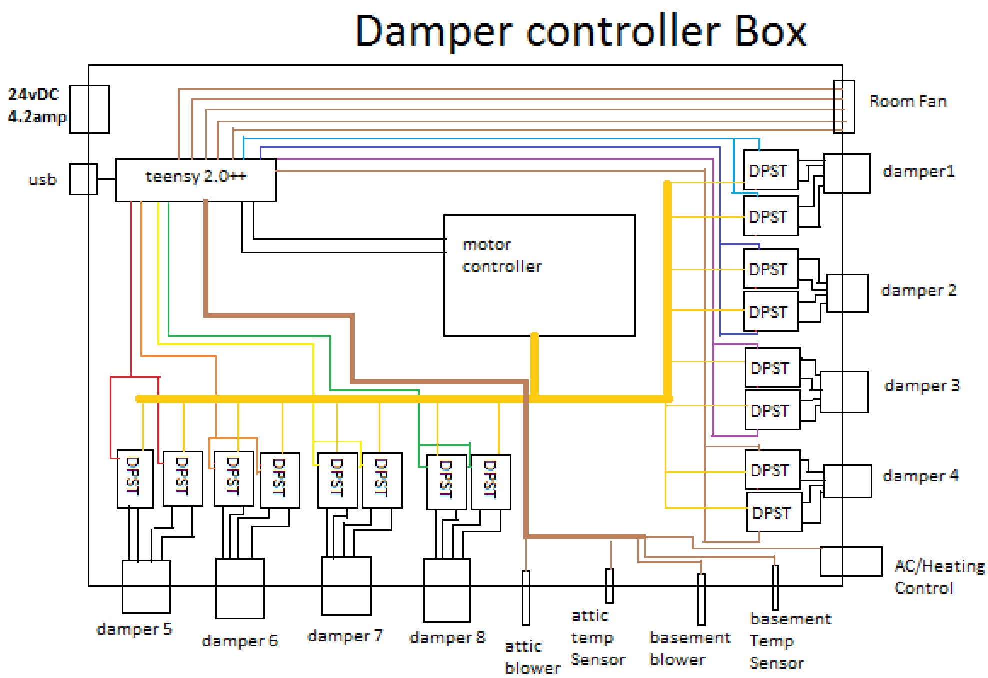
The outlet controller will be in the form of a power strip. It will be mobile and reconfigurable. This power strip will plug into any standard wall socket, and be unwired except for power. The sockets will be switched on and off via the controller box, or the server computer using the internet. Power strips will enable persons to control power to any device which would normally run from a 120v 60 Hz outlet. The power strip will monitor power for devices which are plugged in. This data will be available at the controller boxes and server computer.

Implementation

Temperature Control

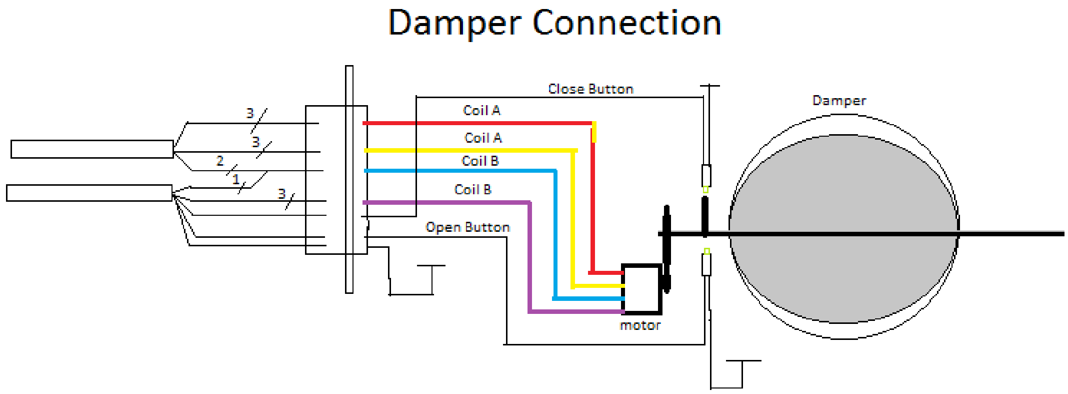


The temperature control system will use a variety of components. Temperature sensors will be placed in every room, outside, and the attic; we are using LM335AZ temperature sensor. They will be calibrated together to allow for relatively accurate temperature readings. We are going to be using dampers to control the air flow. These dampers will be built using stepper motors, gears, and tin. This allows our project to meet Utah building code. We will have 2 different types of blowers, a furnace blower, and small fans for the individual room blowers. These will be controlled using the same relay as our outlet controller. The individual room blowers will be Delta AFB1212SHE-4F1A, They are variable speed fans that are controlled by a frequency's duty cycle. This will allow us to pull more air out of certain specific vents. The vents will be controlled by the motor controller box.



The motor controller box will interface with 5 fans, 2 blowers, 8 dampers, existing AC and heating, 2 temperature sensors, and a server. It will be hard wired together which will provide ample power to each device. The motor controller box will require 24 V and 2 amps to drive the motors and other circuits. It will be powered by a 24VDC 4.2 amp power supply. This will be able to drive all of the fans, relays and other components. It will communicate over a teensy 2.0++ usb, this micro controller will control all of the signals to all of the devices.

The motor controller is a bipolar directional, stepper motor driver. It will be able to step the motors in either direction. It can supply up to 1 amp on each coil of the 4 wire stepper motors. These motors will be attached to a 6" damper. The damper will have a motor mount with a gear that is attached to the center post of the damper. The ratio of the gears will allow the damper to have a torque rating. This will prevent it from moving when the air is blowing through.



The main furnace blows at 1355 CFM with the air pressure in ducts this will lower to a smaller smaller value ~1100 CFM. The room blowers will help the air through the ducts if they need assistance. Each room blower has a rated 148 CFM without resistance. These blowers will be useful in certain rooms which are located far from the furnace. Therefore, 5 room blowers are sufficient for this issue. The dampers can be used used to control how much airflow goes into specific rooms. This allows homeowners to select into which rooms to direct the heat, and the server will be able to determine whether there is a commonly unoccupied room that doesn't need heating or cooling, based on the room monitoring system.

In a home with 11 heat registers there is ~100 CFM going into each room. With a 1000 CFM blower in the attic and the basement there will be enough air flow to curculate the whole house.

For our demo we will be using smaller fans that will show the effectiveness of our system. Our demo large fan will be a Delta AFB1212SHE-4F1A. This will pull air from outside, and from the attic. We will access smaller fan by removing them from old computers. Both of these types fans will be powered with 12V, the relay that will power these fans run on 5VDC.

Occupancy detection

The light beam interruption detector can be created easily with a CdS photo-sensitive resistor and a laser pointer or other concentrated light source, both of which are in our team's possession, along with appropriate analog circuitry to produce a digital output. The motion sensor will the DYP-ME003DD-H low voltage PIR motion detector module. It may need some circuitry also to create a digital signal of the correct voltage range.

Interface specifications for motion detector

Supply current	DC 0.8V--9V
Current drain	<150uA (Voltage different,current different）

Voltage Output	High/Low level signal:3.3V TTL output
Detection distance	3--7M
Detection range	<140°
Delay time	(default 10S +-3%) Can make other time
Blockade time	2.5 S(default) Can make other time
Trigger	L:Non-repeatable trigger H:Repeat Trigger (default)
Turn off during daylight	Can be added as customer requirment
Compact size	28mm*28mm

CdS photo-sensitive resistor specifications to be determined experimentally.

WIFI

Wifi Shield with Arduino will consume about 5V-7V. The voltage regulator will be able to provide enough power for it to run. The Wi-Fi will be 802.11b at 1Mbps and 2Mbps throughput speeds. It will give us the ability to establish secure and insecure networks such as WEP (64-bit and 128 bit) and WPA/WPA(TKIP and AES) PSK security. This chip has low power usage.

- Sleep mode: 250µA
- Transmit: 230mA
- Receive: 85mA

The chip uses SPI for host communication. (max speed 25MHz) It has a feature for an on-board PCB antenna. The CS pin is switchable for serial flash between digital pin 10 and digital pin 7. We will be communicating on 802.11b with the Netgear router at about 1 Mbps

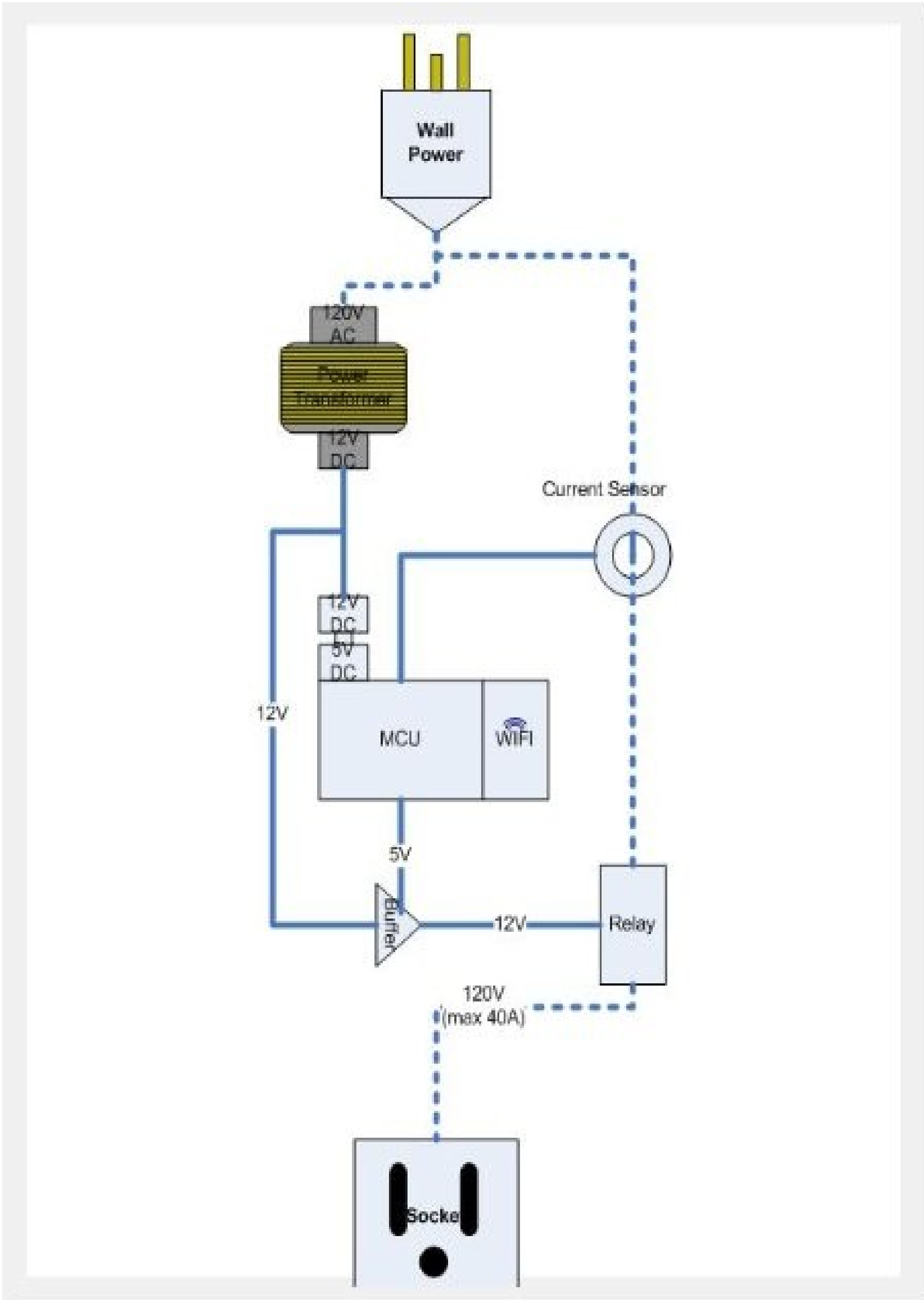
Pin Usage

- SPI
  - Slave select (SS) : Arduino pin 10 (port B, pin 2)
  - Clock (SCK) : Arduino pin 13 (port B, pin 5)
  - Master in, slave out (MISO) : Arduino pin 12 (port B, pin 4)
  - Master out, slave in (MOSI) : Arduino pin 11 (port B, pin 3)
- Interrupt (Uses only one of the following, depending on jumper setting)
  - INT0 : Arduino pin 2 (port D, pin 2)
  - DIG8 : Arduino pin 8 (port B, pin 0)
- LED : Arduino pin 9 (port B, pin 1)
  - To regain use of this pin, remove the LED jumper cap
- 5V power
- GND

The implementation strategy will consist of first getting the board to talk with the WiFi router and send data and receive commands. The webpage will be running on apachi server with .jsp commands ready to send necessary instructions to the board. The data from the sensors will have to be captured by the pins on the arduino and sent over WiFi for the server to display the information to the user. Server side will be responsible to organize the information using html, css and Java Script (jsp) languages.

Outlet Controller

The module will provide power to the MCU and WIFI chip, power sensors, leds, and the outlet. A 120VAC to 12VDC power supply will be used to provide power to the relay. The 12VDC will also power the onboard electronics via a 3-5V voltage regulator. Monitoring these power sockets will be done using a hall effect current sensor. These sensors will possibly need to be combined with a low amperage sensor for the full range of use. These sensors will interface with the onboard ADCs on an Arduino board. An automotive relay will be used to switch power from the wall. It can source 40 amps through contact while the coil runs on 12VDC. These 12V coils will be switched on and off via a transistor controlled by the 5V logic on the Arduino.



Wall Power
120V AC
Power Transformer
12V DC
Current Sensor
12V DC
5V DC
12V
MCU
WIFI
5V
Buffer
12V
Relay
120V (max 40A)
Socke

Room Controller Box

The controller box in each room will be connected to the room monitoring system. It will also supply power to it and communicate across a cable. The cable could be installed in the walls of the home due to low cable power.

The controller will also interface with the smaller room blower using a single PWM signal line to control the speed of the fan. The fan speed is controlled by the duty cycle. It will provide power to the fans with 12VDC with a LM7812 voltage regulator. This will supply the fans with 1.00 amp of current. The voltage regulator may not be necessary if we have a 12VDC power supply.

The controller will also have a LM335AZ temperature sensor that provides an output of 10mV/K. We can use this to control the temperature of the room. This will send a command to the server, and the server will control the dampers, along with the individual fans in each room.

Interfacing together

The different rooms will be connected to a server over a router. The server will allow for an easier programming interface. We will also be able to setup the server to be connected to from anywhere. It will have a simple security setup that will prevent outsiders from taking control of the home. The server will also allow real time information on the status of the home. The information will indicate whether the room is being occupied, what the temperature is in that room, and in the home. The server will calculate the average temperature by combining all the different temperatures in the home. It will have control of the furnace and A/C allowing occupants to turn it off while away from home, and turn it on before they arrive home to a warm/cool house.

Along with the ability to control different rooms, homeowners will be able to configure which outlets go to which room. homeowners will also be able to turn on any desired device while away from home. This will also allow occupants to turn on appliances like a coffee maker from their bed in the morning, or on their way home from work.

Time and Risk

Temperature Controller

Time	Risk	Task
week 1-2	| 7 |	Develope Motor Controller
week 3-6	| 7 |	Motor Controller Box
week 7-8	| 2 |	Motor Controller Code
week 9	| 1 |	Fan Controller Code
week 9	| 1 |	Temperature Sensor Code
week 9-10	| 2 |	Cables
week 11-12	| 4 |	Demo Setup
week 13-15	| 7 |	Debug

Occupancy detection

The risks in this part of the project are relatively low and include trouble lining up the light source and receiver of the light beam interruption detector, the CdS light sensor not working, issues getting the motion detector to work, and others. On a scale of 0-10 (higher numbers mean greater risk), these risks register at a 3.

WIFI

Time	Risk	Task
week 1	| 2 |	Communicate with the sensors
week 2-4	| 6 |	WIFI shields interfacing assign specific IP addresses
week 5-6	| 3 |	Wi-Fi shields communicate with Server
week 7-9	| 5 |	Server communication - store gathered data from sensors
week 9-11	| 5 |	Send commands back to the Arduino MCU
week 12-13	| 7 |	Testing
week 14-15	| 1 |	Demo Setup

It could be pricey to have an arduino board that would be assigned to an individual sensor since they might be separated far apart, which would be pricey. In order to go around this we were planning on getting individual microcontrollers and putting them on a proto board and programming it ourselves to have it gather data from as many sensors as it could that are close together and send them to a "master" arduino board with a wifi shield that would communicate with the server. We were having issues with trying to program the individual microcontrollers with the right firmware but we are still testing that option to save money and not have to buy the whole board with the shields.

Outlet Controller

Time	Risk	Task
week 1	| 2 |	Component wiring/testing
week 2-4	| 6 |	Arduino wiring, ADC tuning, Current sensors
week 5-6	| 3 |	Power controls/programming
week 7-9	| 5 |	WIFI shield interfacing
week 9-11	| 5 |	Server communication
week 12-13	| 7 |	Power strip casing, making things fit
week 14-15	| 1 |	Demo Setup

Server

Time	Risk	Task
week 5	| 2 |	Setup web server(apache)
week 7	| 5 |	Setup security
week 8	| 4 |	Communicate to COM port (pyserial)
week 9-12	| 9 |	Communicate to IP addressed wifi devices
week 12-14	| 7 |	Debug
week 15	| 5 |	Demo Setup

Bill of Materials

Temperature Controller

Motor Controller

Qty	Vendor	Part number
1	National Semiconductor	555 timer
1	OctoPart	MC74HC194N(4 bit bi-directional Shift Reg)
1	National Semiconductor	SN754410NE(Quad Half-H Bridge)
1	National Semiconductor	LM7805(5V voltage regulator)
6	National Semiconductor	2N3904 or 2N4400
1	Radio Shack	LED
1	N/A	1N4148 Diode
1	N/A	1N4001 Diode
5	N/A	3.3Kohm
2	N/A	470ohm
7	N/A	10Kohm
1	N/A	1uF
2	N/A	4.7uF
1	N/A	470uF

Damper

Qty	Vendor	Part number
8	All Electronics	Mineba NMB-MAT # PM42L-048-UAJ9 Stepper Motor
1	Homedepot	Thick sheet of plastic -Custom laser cut gears
8	Homedepot	Vent Dampers
8	Homedepot	5/16x1” Coupler
1	Homedepot	5/16x4' Screw pole
8	All Electronics	9 Dsub connectors
8	All Electronics	9 Dsub Backshells
16	All Electronics	SPST button Switches
2	Homedepot	6'x Heating vent pipe

Motor Controller Box

Qty	Vendor	Part number
18	All Electronics	DB9 Female board mount
16	Digikey	5VDC Relay
16	Senior hardware lab	2N3904
1	PJRC	Teensy 2.0++
2	Digikey	100 mil sockets
16	Ece parts room	Resistors

Room Fan Controller

Qty	Vendor	Part number
5	Jameco	AFB1212SHE brushless fan
5	All Electronics	DB9 female

Basement/Attic Blower Controller

Qty	Vendor	Part number
2	Google	Furnace Blowers
2	All Electronics	A/C 120V Socket
2	A/C	A/C 120V Plug
2	DSPT	120VAC Relay

Room Sensor

Item	Vendor	Contact person	Phone
CdS photo-sensitive resister	already in possession	N/A	N/A
laser	already in possession	N/A	N/A
DYP-ME003DD-H low voltage PIR motion detector module	http://www.suntekstore.com/	could not be reached	+86-13725596257 dial 011 first (number appears bad)

WIFI

Qty	Part number
1 WiFi shield for Arduino	WiFi Shield WiShield V2.0
1 Arduino Duemilanove	Digikey,Arduino and Jameco
1 WIFI Router	Netgear wifi router

Outlet Controller

Qty	Part number
5 Relays	CB1AHF-12VRELAY AUTOMOTIVE SPST 70A 12V, Panasonic
5 Current Sensors	ACS709LLFTR-35BB-TSENSOR CURRENT 75A 5V BI 24QSOP, Allegro Microsystems Inc
5 Transistors	2N3904TFTRANSISTOR NPN 40V 200MA TO-92-Fairchild Semiconductor
1 Power Suppl	VOF-25-12PWR SUPPLY 24W OPEN 12V 2.0AV-Infinity VOF-25CUI Inc
2 Voltage Regulators	LM78L05ACZXAIC REGULATOR 5V 0.1A 5% TO-92-Fairchild Semiconductor
1 Arduino Demilanove Board	
1 Wifi Shield	
1 Power supply	

Server

Qty	Part number
1	Computer
1	Wireless Router

References

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Average Temperatures – www.noaa.gov