Smart Greenhouse: Implementation & Project Details

Group 6

Instructor:

Dr. Derek Reilly

Team:

Matthew Coelho

Lulu Huang

Terry Lin

Mohamad Tawakol

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Introduction

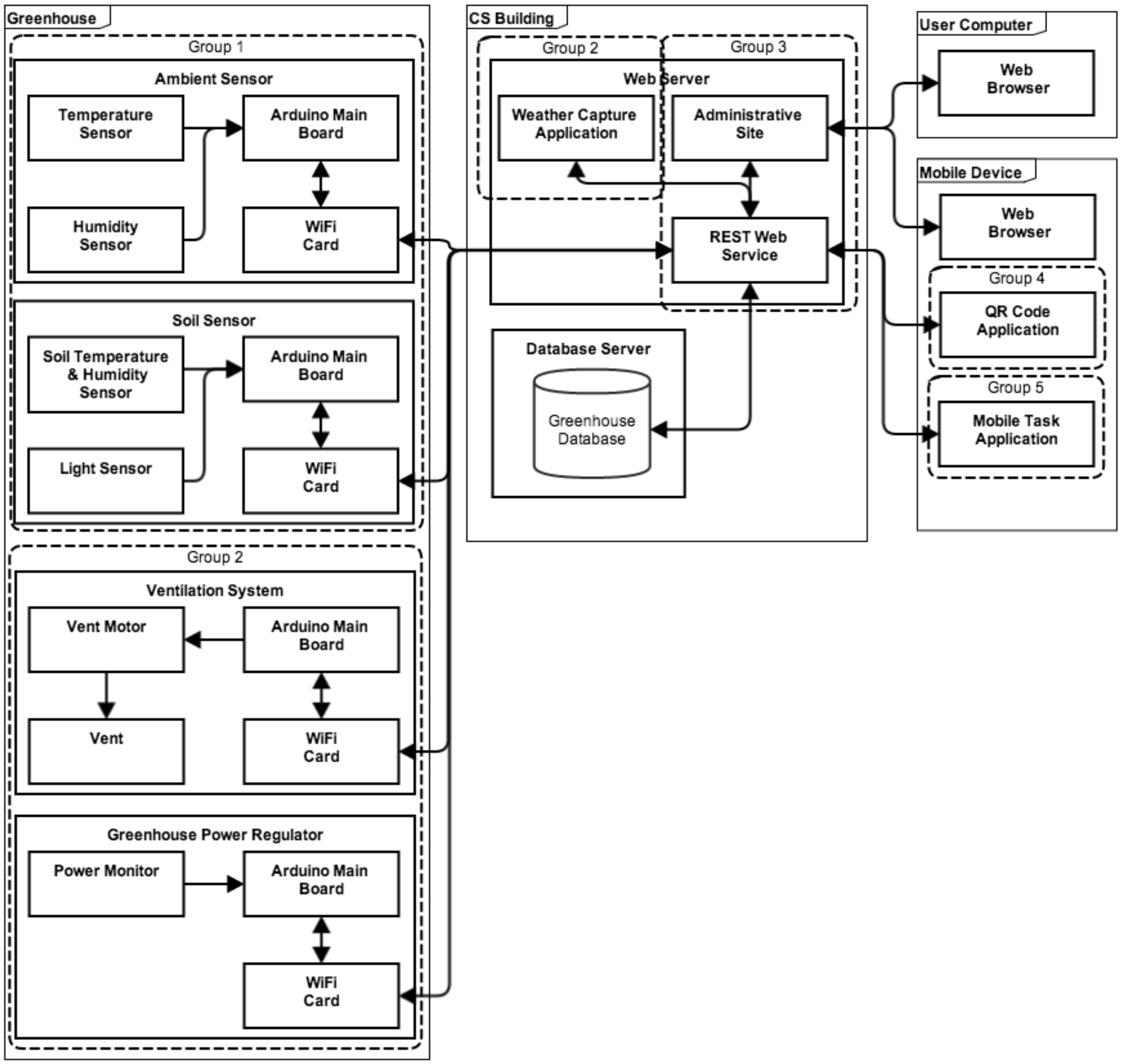
The first part of this document contains the architecture diagram, data flow diagram, user data flow diagram, power data flow diagram and the detail hardware list. This section outlines all the internal web communication along with the hardware specifications.

The second part of document are the information regard to the server and network detail along with database schema and each group's responsibilities. This section outlines all the internal web specification and communication details.

The last part of this document is the proposed physical layout of greenhouse project.

Diagrams

Architecture Diagram



The architecture diagram shows the general structure of the entire system. The below diagram has three main sections: the greenhouse section represents the devices that are housed in the greenhouse, the CS building section represents the devices in the Computer Science Building, and the User Computer section represents the user's interactions with the system.

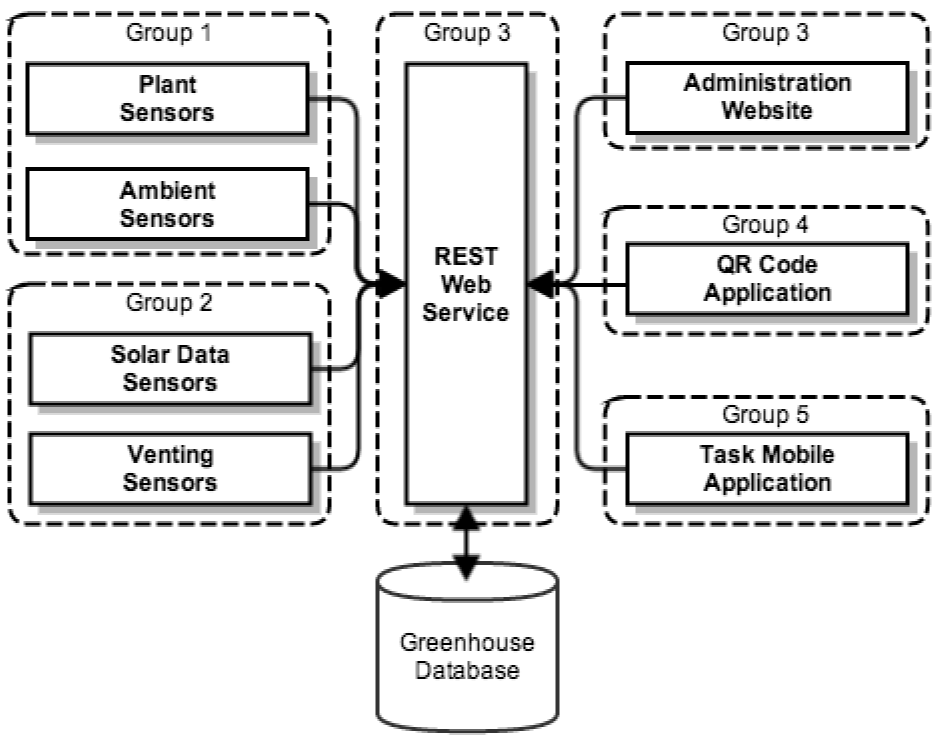
The greenhouse has two types of sensors and a ventilation system. The ambient sensor measures the ambient environment (temperature and humidity in the air). The soil sensor measures a plant's environment (soil temperature, soil moisture, and light). The ventilation system is used to vent out hot and humid air and controls the greenhouse's internal temperature and humidity. This system polls the rest service to determine whether or not the vents need to be opened or closed based on the sensor data stored in the database. These devices communicate to the rest of the system through a REST web service connected by WiFi cards.

The REST service is responsible for passing data throughout the system. It sends and receives data from the sensors, the website, and the database.

The administrative website is used to retrieve data from the database (through the REST service) and display it in an organized and intuitive fashion. It also provides a platform for users to alter devices, add devices to the system, or remove devices from the system.

Users will interact with the system through the administrative website using the web browser on their computer, through a greenhouse information app on their mobile phone, or through a QR reader app on their phone. The mobile app displays basic information on the greenhouse and provides the user with a list of tasks that need to be performed. The QR app will allow users to read QR codes around the greenhouse which contain information on the plants.

Communication Diagram

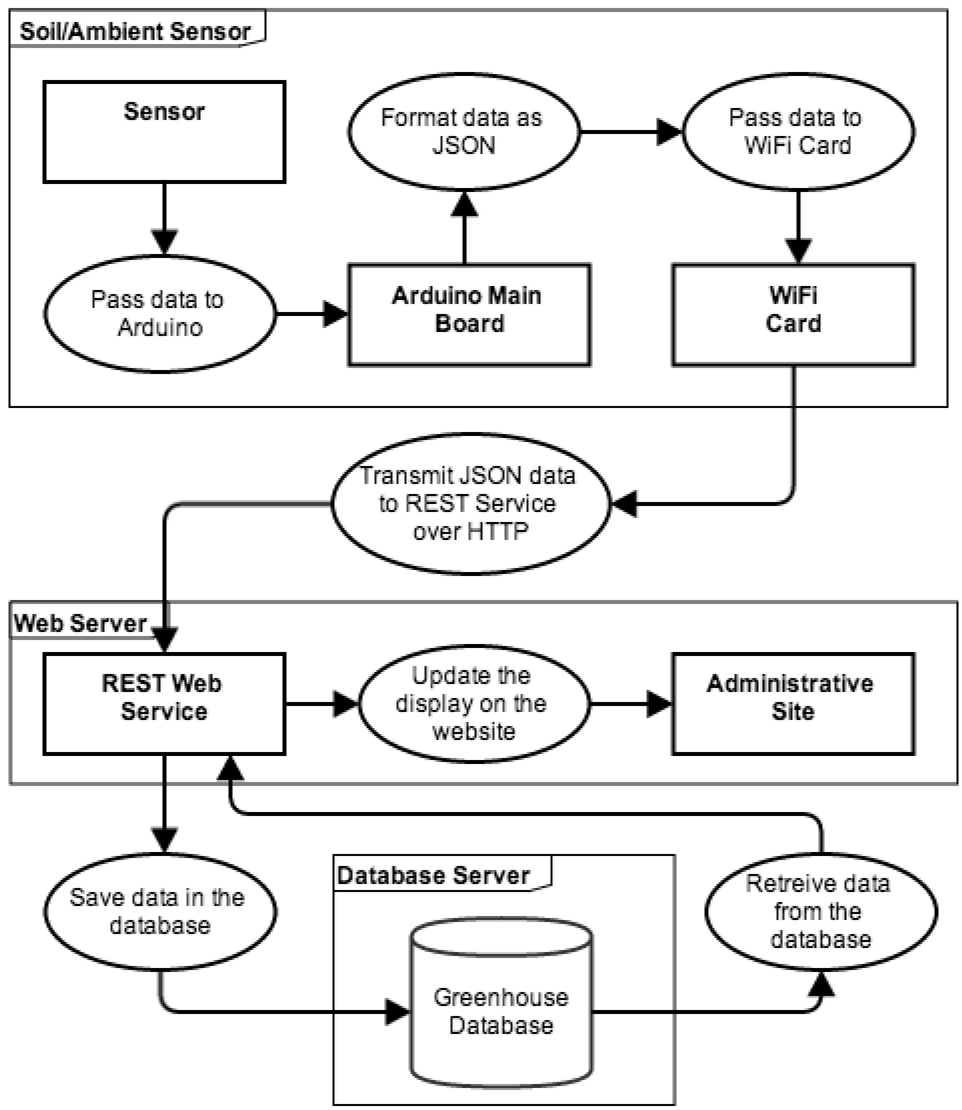


The communication diagram shows how the devices and applications in the system communicate with each other. All of the systems will be interacting with a REST web service. This web service is responsible for handling data and passing data between devices and applications. The web service is the only thing that should be connected directly to the database. All devices and applications will call methods in the service and send and receive data in the form of JSON formatted messages over HTTP.

Data Flow Diagrams

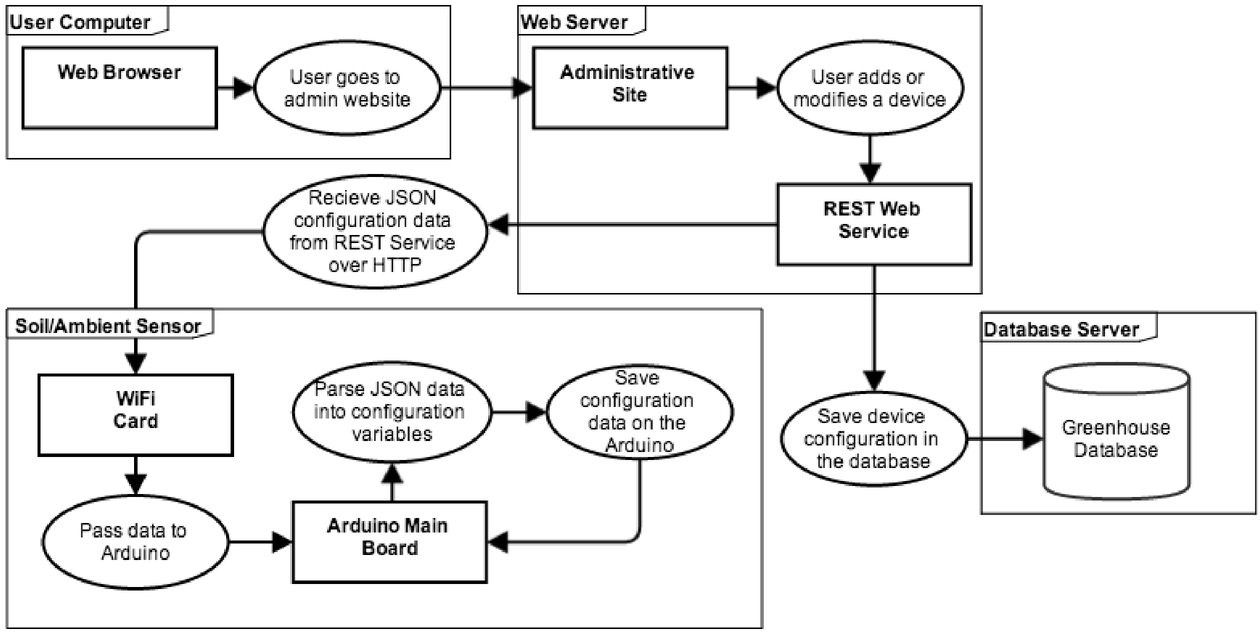
Data flow diagrams show how data is passed around the system. Below you will find three different types of data flow diagrams for sensor data, configuration data, and user data.

Sensor Data Flow Diagram



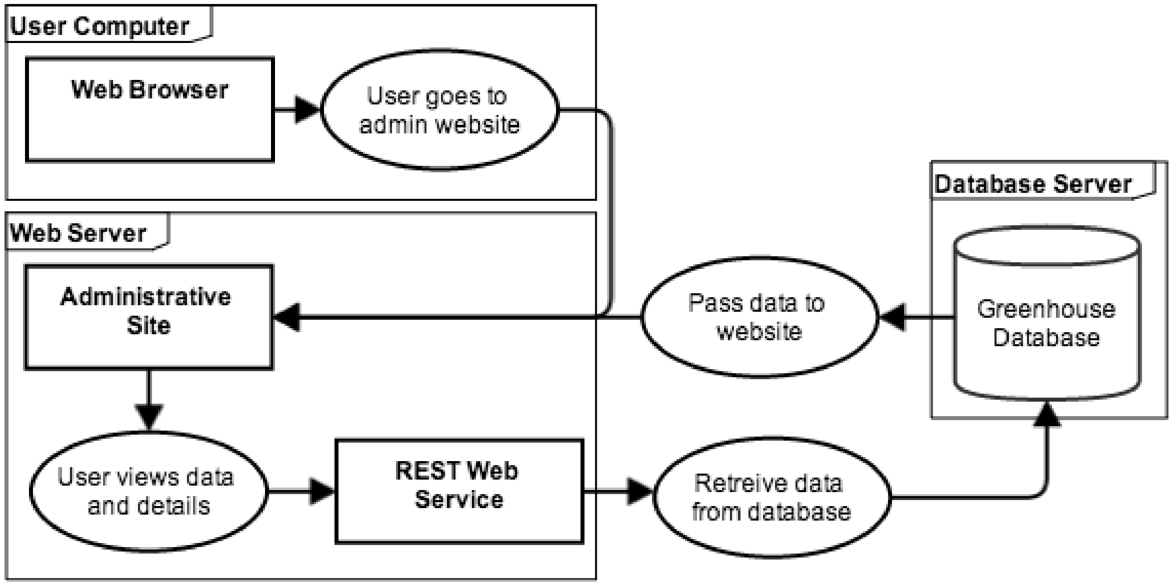
The sensor data flow diagram shows how sensor data traverses through the system. When the sensor retrieves external data, itpasses it to the main arduino board where it gets formatted into a JSON string. It then gets passed to the WiFi card and sent to the REST service over HTTP. The service parses the JSON data and saves it to the database. The service can then read this data from the database and update the site accordingly.

Sensor Configuration Data Flow Diagram



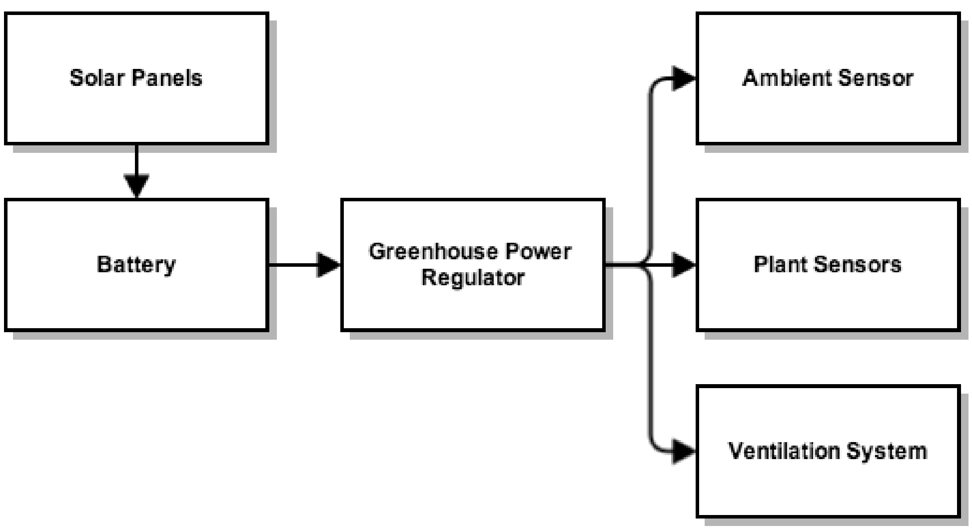
The sensor configuration data flow diagram shows how sensor configuration data traverses through the system. When the user adds a device, removes a device, or changes a device's settings through the admin web portal, the website passes this configuration data to the REST service. The web service saves this data into the database and passes a JSON configuration string to the arduino. The arduino then parses the JSON string and saves the new configuration variables.

User Data Flow Diagram



The user data flow diagram shows how user can view the data how it traverses through the system. When the user accesses the website through their web browser, the REST service retrieves the data from the database and sends it to the website to be displayed.

Power Flow Diagram



The power flow diagram shows how power is distributed throughout the system. The solar panels collect the power which gets stored in the battery. The battery then passes the power onto the power regulator. The regulator measures how much power is being generated by the solar panels and how much power is stored inside the battery. Based on this information, it determines which devices receive power based on the power levels.

Finalized Hardware Details

Hardware List

Plant Sensor

Part	Qty.	Price	Power (mA/H)	Seller
Arduino Uno R3	1	$24.95	50	https://www.adafruit.com/products/50
12V DC 1000 mA Power Adapter	1	$8.95	N/A	http://www.adafruit.com/product/798
CC3000 WiFi Shield w/ Onboard Antenna	1	$39.95	275	https://www.adafruit.com/products/1491
Shield Stacking Headers for Arduino	2	$3.90	N/A	https://www.adafruit.com/products/85
Proto Shield for Arduino Uno	1	$12.50	N/A	https://www.adafruit.com/products/51
Diffused 5mm RGB LED	3	$6.00	60	https://www.adafruit.com/products/159
Soil Moisture & Temperature Sensor	1	$49.95	1	https://www.adafruit.com/products/1298
Photo Cell (CdS Photoresistor)	1	$0.95	4.5	https://www.adafruit.com/products/161
Various Resistors	~ 5	~$5	N/A	
Custom Built Enclosure	1	~$20	N/A	
Total		**$172.15**	**390.5**	

Ambient Sensor

Part	Qty.	Price	Power (mA/H)	Seller
Arduino Uno R3	1	$24.95	50	https://www.adafruit.com/products/50
12V DC 1000 mA Power Adapter	1	$8.95	N/A	http://www.adafruit.com/product/798
CC3000 WiFi Shield w/ Onboard Antenna	1	$39.95	275	https://www.adafruit.com/products/1491
Shield Stacking Headers for Arduino	2	$3.90	N/A	https://www.adafruit.com/products/85
Proto Shield for Arduino Uno	1	$12.50	N/A	https://www.adafruit.com/products/51
Diffused 5mm RGB LED	2	$4.00	40	https://www.adafruit.com/products/159
Wired DHT22 Temperature and Humidity Sensor	1	$15	2.5	https://www.adafruit.com/products/393
Various Resistors	~ 5	~$5	N/A	
Custom Built Enclosure	1	~$20	N/A	
Total		**$134.25**	**367.5**	

Power Regulator

Part	Qty.	Price	Power (mA/H)	Seller
Arduino Uno R3	1	$24.95	50	https://www.adafruit.com/products/50
12V DC 1000 mA Power Adapter	1	$8.95	N/A	http://www.adafruit.com/product/798
CC3000 WiFi Shield w/ Onboard Antenna	1	$39.95	275	https://www.adafruit.com/products/1491
Proto Shield for Arduino Uno	1	$12.50	N/A	https://www.adafruit.com/products/51
8-Channel 5V Relay	2	$11.52	N/A	http://www.robotshop.com/ca/en/8-channel-5v-relay.html
30 Amp Current Sensor AC&DC	1	$31	N/A	http://www.robotshop.com/ca/en/phidgets-30A-current-sensor.html
Various Resistors	~ 5	~$5	N/A	
Custom Built Enclosure	1	~$20	N/A	
Total		**$153.87**	**325**	

Total Cost

Based on the above hardware list, the total cost for a single plant sensor would be $172.15 and the total cost for a single ambient sensor would be $134.25.

If the client were to monitor 10 plants, he would require 10 plant sensors whose total cost would equal $1721.50 The team estimates that only a single ambient sensor would be needed therefore the total cost for the entire sensor array would be $1855.75

Power Requirements

Based on the above hardware list, the power consumption for a single plant sensor would be 390.5 mA/h and the power consumption for a single ambient sensor would be 367.5 mA/h.

If the client were to monitor 10 plants, he would require 10 plant sensors whose total power consumption would equal 3905 mA/h (~4 Amps). The team estimates that only a single ambient sensor would be needed therefore the total power consumption for the entire sensor array would be 4272.5 mA/h (~4.3 Amps).

Server Information

The server this project will reside on is the CS projects server. As provided by Jonathon Amyotte, here is the information required to connect to it:

Website URL: https://projects.cs.dal.ca/greenhouse (Redirection to HTTPS from HTTP is automatic and always in place).

SSH Hostname: projects.cs.dal.ca
SSH Username: greenhouse
SSH Password: UqWA%wiZ7Z4vcpLV

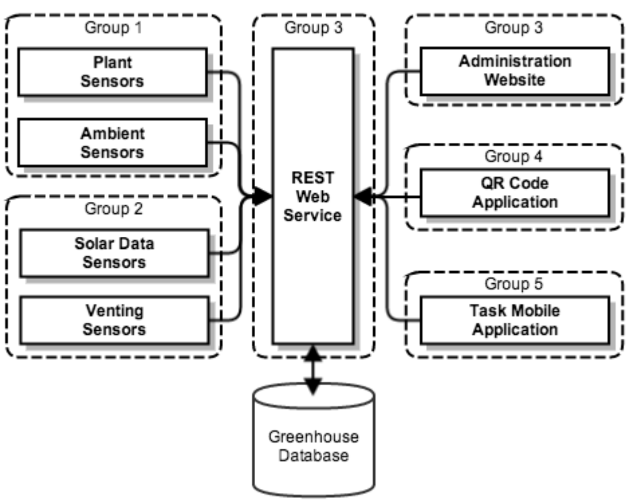
MySQL Username: greenhouse
MySQL Password: oG9gk=yk7DMDUxFJ
MySQL Hostname: localhost
MySQL Database: greenhouse

- The website file space is accessible via the "website" symlink when you login via SSH/SFTP.
- You can change the password at the command line with the "passwd" command.
- There is no restriction on where you can connect from over SSH/SFTP (no regular FTP) or HTTP/HTTPS. Most other ports are blocked.

As is, the server currently only supports the current versions of PHP and MySQL. (No other Databases are supported)

Interface Specifications

In order for this to qualify as a smart greenhouse, all of the groups must create applications that are able to work together and share information. This will be accomplished by employing a RESTful API that will allow everyone to post and get data from one central database. The structure of the REST API was outlined in the communications diagram:



Groups one and two will feed information into the rest service, to be read by the rest of the groups creating the web interfaces for the project. Group three will be creating the REST API and will make it available to all the other groups.

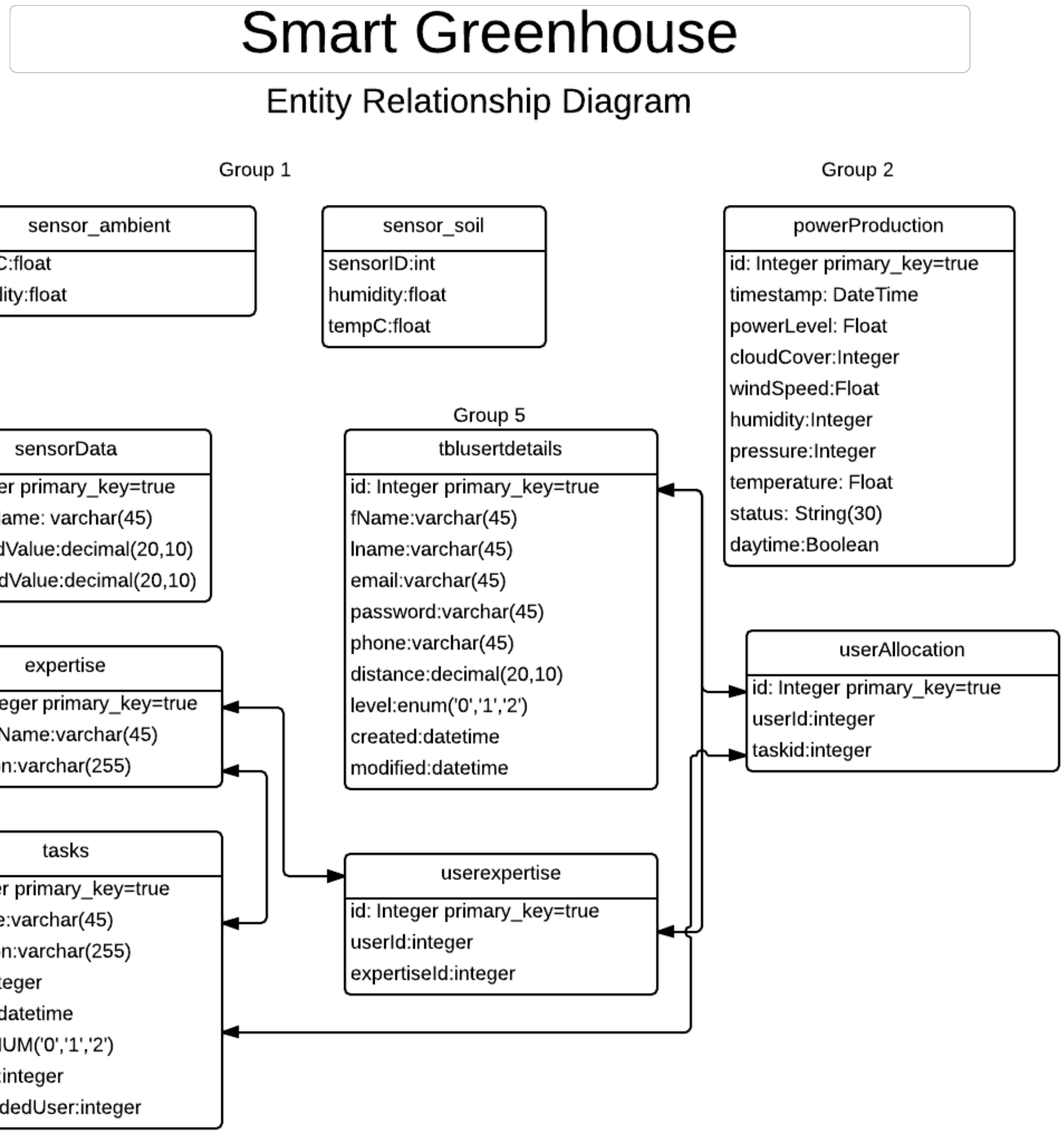
Network Information

There are two main devices that must be able to connect to each other:

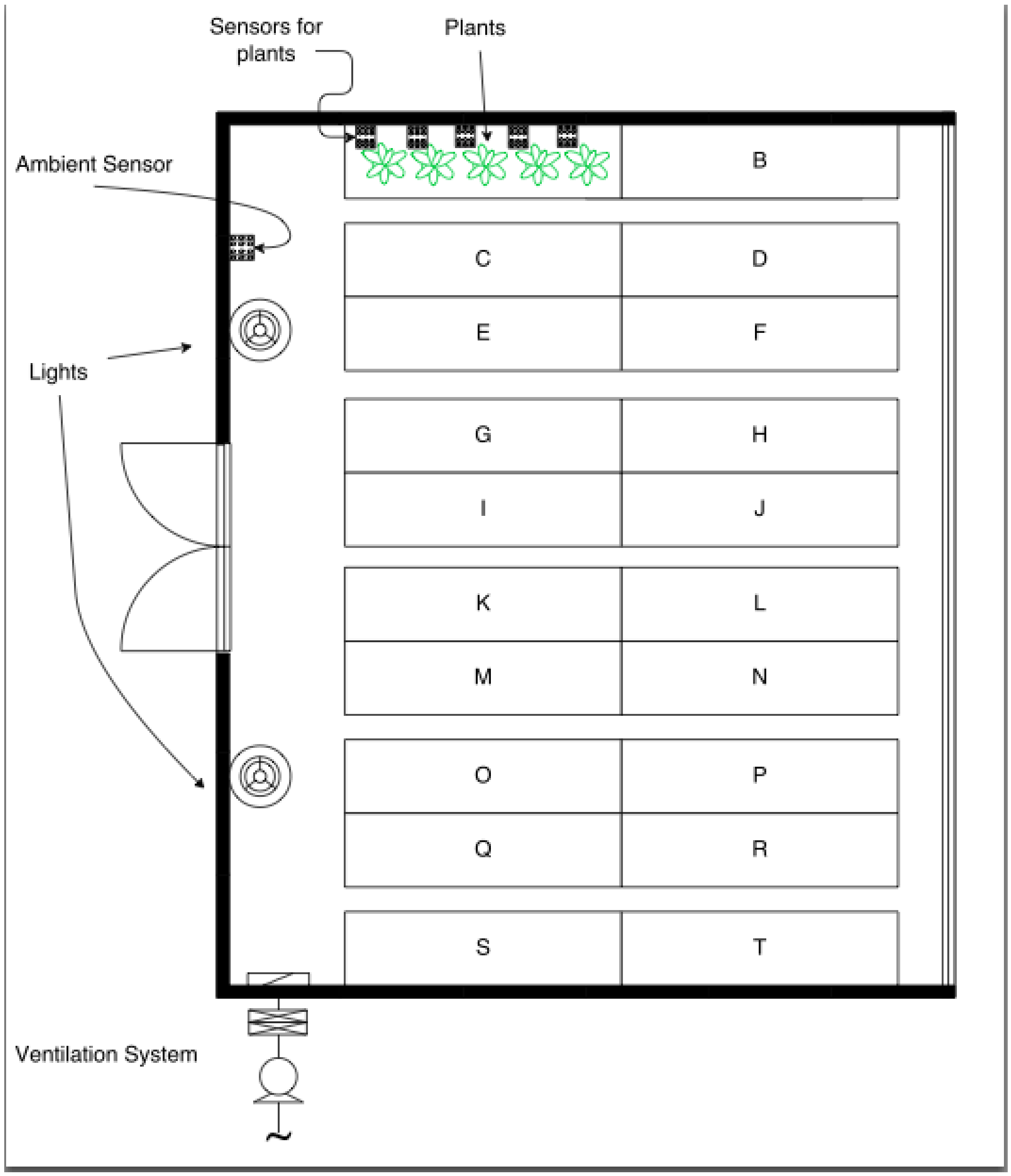
- The Arduinos
    - The arduinos will communicate to each other using the wifi modules
    - They will then connect to the CS WIFI and send their data to the server to be processed and saved
- The Server
    - The server will house PHP scripts that will receive and parse the data into JSON for use by groups creating the interface and scheduling

There is currently a major problem with connecting to the CS wifi as the faculty uses an enterprise router and the WIFI modules are not equipped to connect to that type of router. This can be circumvented by purchasing a new router and setting it up to work just for the greenhouse.

Database Schema



Physical Layout



This is the Physical layout of our greenhouse which refers to the layout of greenhouse of the University of North Carolina (2014). The ventilation system consists of a fan and is positioned in the wall. There are 20 sections in the greenhouse for plants, which tries to make full use of the space in of the greenhouse. Two kinds of sensor are installed, one for plants and the other for the whole environment. This is from group one and two’s work. The right side of the house is the window, which tries to let sun shone into the room. We still need to add the measurement and the light system into the design graph. This will be done once our customs reply. For now, we have two lamps as lighting system. The room is scaled to 12*10 and the door is not open to Henry Street. The layout will be updated in the next milestone.

Reference

UNC Biology Greenhouse. (2014). Department of Biology of the University of North Carolina. Retrieve from http://greenhouse.bio.unc.edu/GreenhousePlan.jpg