ECE 435 Final Report
Raspberry Pi Weather Server

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1 Introduction

The Raspberry Pi weather server is a simple web server that displays real time and historical weather data in a graphical format. Its purpose is to provide a web interface for viewing local indoor and outdoor weather trends via the constant collection of real time data. In short it functions as follows. The web server back-end collects data from two sources, a temperature sensor connected directly to the Pi and an online weather reporting service. The collected data is then processed and added to a locally hosted database. The web page then takes this data and dynamically generates an interactive graph, plotting indoor temperature versus outdoor temperature as well as displaying a few pertinent current outdoor weather conditions.

This report will describe the inspiration, development process, and final results of the implemented server and is structured as follows. Section 2 describes related work that is similar to the implemented server. Section 3 describes the setup and development of the server and section 4 reviews the final implementation. Section 5 concludes the report.

2 Related Work

As far as Raspberry Pi projects go the simple weather server is a fairly common one. A quick Google search for "Raspberry Pi weather server" will return over 400,000 results, many of which provide code and detail the entire design and implementation. A few of the more notable mentions are raspberryweather.com and a surprisingly thorough instructables. However if you take a look at most of these projects they actually differ fairly significantly from the server implemented here. Generally the projects that can be found online result in turning the Raspberry Pi into an actual, literal weather station. That is to say an array of sensors are added to the Pi, some sort of weatherproof/resistant casing is created, and then the whole thing is nailed to a tree or strung up on the side of someones house. The server running on the Pi then reports back the local outdoor weather data that is collected by its onboard sensors.

While these projects are certainly cool and useful they were not the inspiration in our project and as such our weather server functions a little differently. Instead of creating a local weather station that records the weather outside of our house we wanted to showcase the difference between the indoor temperature and the ambient outdoor temperature. As such the Pi is kept indoors and its only peripheral sensor is a small 1-wire temperature probe. The outside temperature data that is displayed on the web server is all pulled from an online weather service and then parsed and formatted to our liking.

The reason we went about the project this way was to try and discover the cause of our houses thoroughly inconsistent heating. Seemingly regardless of what the thermostat is set to our indoor temperature is usually either uncomfortably hot or way too cold. Our theory was that our thermostat was broken and our houses temperature was more or less responding to swings in temperature outside instead of automatically compensating and remaining at a relatively constant temperature. If we could graph the indoor temperature versus the outdoor temperature over a period of time we would be able to see any trends and potentially diagnose the problem.

3 Experimental Setup

This section details the implementation of the Raspberry Pi weather server and is divided into three sections. Hardware design, software design, and security implications.

3.1 Hardware Design

The hardware used was relatively limited and consists only of a Raspberry Pi model 3B and a DSB18B20 temperature sensor. The sensor communicates with the Raspberry Pi over 1-wire and has the following pinout.

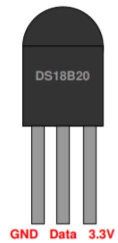

Figure 1: DSB18B20 Pinout

The sensors 3.3V pin is connected to 3.3V on the Pi, GND on the sensor is connected to GND on the Pi and data on the sensor is connected to GPIO4 on the Pi, which is the designated 1-wire GPIO pin. Additionally GPIO4 is connected to 3.3V with a 10K pullup resistor. A full wiring diagram is presented below.

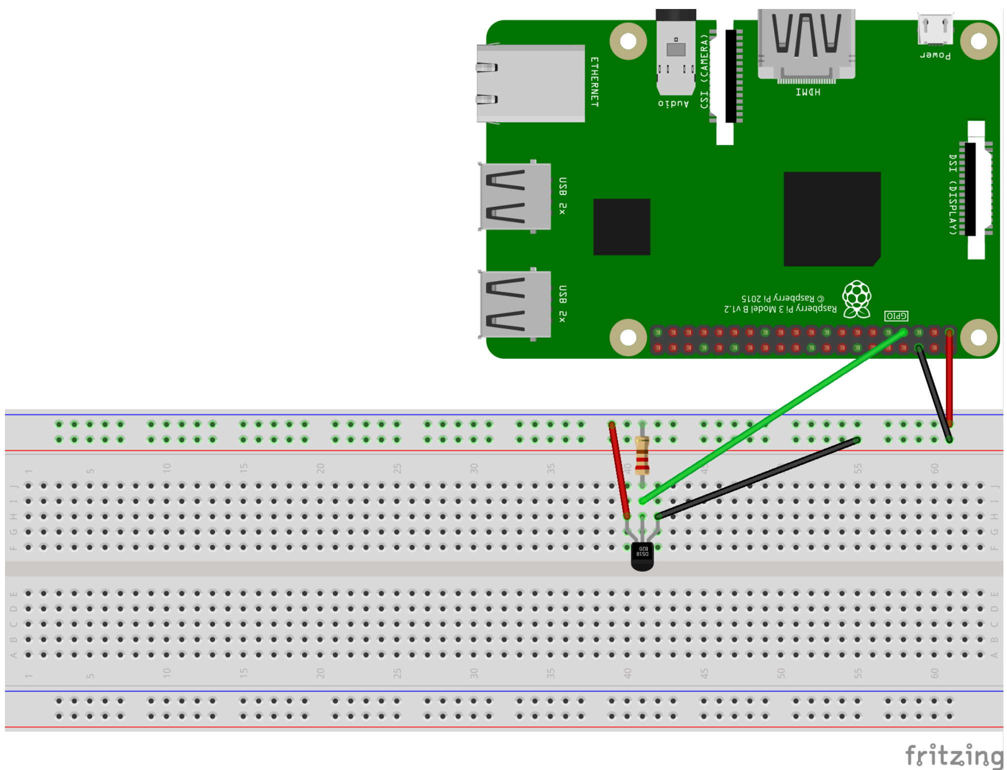

Figure 2: Raspberry Pi to Temperature Sensor Wiring Diagram

Note that the resistor shown in the diagram is not color accurate for 10K Ω but rather serves to display the proper pin placement.

3.2 Software Design

At a high level the Raspberry Pi weather server is a layer 7 application with software that mostly consists of the common LAMP (Linux, Apache, MySQL, Python) software stack with a little bit of C. A flowchart of the project software setup is presented below.

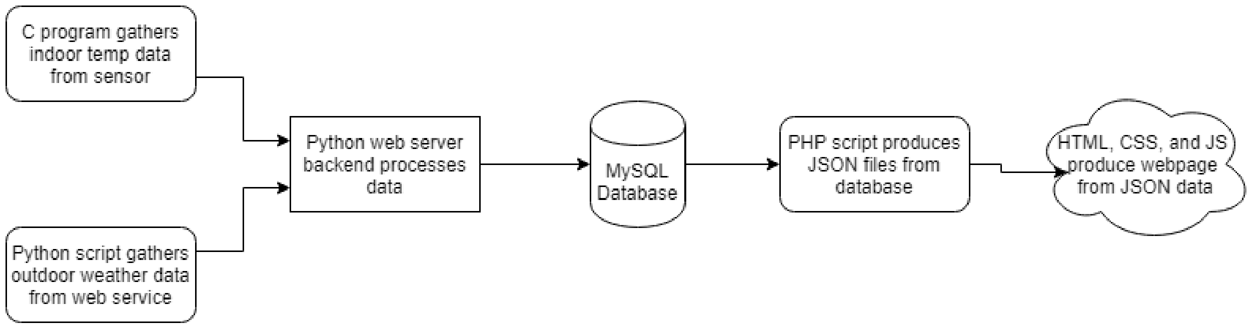

Figure 3: Software Stack Flowchart

In the first stage data is gathered by both a C and Python script. The C script communicates with the DSB18B20 temperature sensor over the 1-wire protocol and returns a floating point value in degrees Fahrenheit corresponding to the current indoor temperature. In addition to this a Python script is run that grabs select weather data from an online weather service over HTTP. This data includes temperature in degrees Fahrenheit, pressure in millimeters of mercury, relative humidity, and the current weather conditions.

The next stage is the Python backend which acts as the core of the web server and serves as the bridging mechanism between local data and a hosted web page. It decides when to run the C and Python scripts from the first stage, formats the returned data for entry into the database, adds a time stamp to the formatted data, and then handles entering it into the MySQL database.

Up until now the setup for the project has been relatively straightforward and has required very little "infrastructure" to get going. Stage one consists of a simple C program gathering data from a temperature sensor and a simple Python script pulling weather data from an online service. Even the Python backend of stage two is really just a Python script that calls a few different functions. However stage 3, the MySQL database was not quite as straightforward. First MySQL had to be installed via the following terminal command:

```
sudo apt-get install mysql-server
```

The install process walks through a brief setup process and afterwards MySQL can be accessed with:

```
mysql -u root -p password
```

Once logged in to MySQL a new database needed to be created with the command:

```
CREATE DATABASE weatherdata;
```

To use the database that we created above:

```
USE weatherdata;
```

After the database was created we needed to set up two separate tables, one that would store all the recorded indoor and outdoor temperature values so that they could be graphed against each other. As well as one that would only store the current outdoor weather conditions to be displayed on the sites "weather cards". The first table was created as follows:

```
CREATE TABLE weather (id INT NOT NULL AUTO_INCREMENT PRIMARY KEY,
                      datetime BIGINT(16),
                      outsidetemp FLOAT(5,2),
                      insidetemp FLOAT(5,2));
```

This created a table with 4 columns. The first an auto incremented integer "id" column that serves as a unique id for each row due to the PRIMARY KEY argument. The second a large integer for storing the date/time via seconds elapsed since the Linux epoch, and the third and fourth columns 5 digit floating point numbers with 2 digits after the decimal point for storing indoor and outdoor temp. The created table can then be viewed using:

```
DESCRIBE weatherdata;
```

A screen shot of our resulting table is provided below.

```
mysql> describe weather;
+-------------+-------------+------+-----+---------+----------------+
| Field       | Type        | Null | Key | Default | Extra          |
+-------------+-------------+------+-----+---------+----------------+
| id          | int(11)     | NO   | PRI | NULL    | auto_increment |
| datetime    | bigint(16)  | YES  |     | NULL    |                |
| outsidetemp | float(5,2)  | YES  |     | NULL    |                |
| insidetemp  | float(5,2)  | YES  |     | NULL    |                |
+-------------+-------------+------+-----+---------+----------------+
4 rows in set (0.00 sec)
```

Figure 4: weatherdata Table Architecture

The second table that stores various information on the current weather was named weathercards and created using much the same procedure as above. Once again a screen shot of the resultant table is shown below.

```
mysql> describe weathercards;
+-------------+-------------+------+-----+---------+----------------+
| Field       | Type        | Null | Key | Default | Extra          |
+-------------+-------------+------+-----+---------+----------------+
| humidity    | int(3)      | YES  |     | NULL    |                |
| pressure    | int(4)      | YES  |     | NULL    |                |
| tempnow     | float(5,1)  | YES  |     | NULL    |                |
| description | varchar(20) | YES  |     | NULL    |                |
| id          | int(11)     | NO   | PRI | NULL    | auto_increment |
+-------------+-------------+------+-----+---------+----------------+
5 rows in set (0.00 sec)
```

Figure 5: weathercards Table Architecture

Once these tables were created the Python backend could successfully insert its collected weather data into the tables by using the MySQLdb library. Screen shots of each table with some data in them are provided below.

```
mysql> select * from weather;
+-----+------------+-------------+------------+
| id  | datetime   | outsidetemp | insidetemp |
+-----+------------+-------------+------------+
|  11 | 1512466003 |       27.63 |      72.61 |
|  12 | 1512466306 |       27.63 |      72.39 |
|  13 | 1512466608 |       28.40 |      72.39 |
|  14 | 1512466910 |       28.40 |      72.16 |
|  15 | 1512467212 |       28.40 |      72.05 |
|  16 | 1512467515 |       28.40 |      71.94 |
|  17 | 1512467817 |       28.40 |      71.94 |
|  18 | 1512468119 |       28.40 |      72.05 |
|  19 | 1512468421 |       28.40 |      72.50 |
|  20 | 1512468724 |       28.40 |      72.72 |
|  21 | 1512469026 |       28.40 |      72.61 |
|  22 | 1512469329 |       28.40 |      72.50 |
|  23 | 1512469631 |       28.40 |      72.16 |
|  24 | 1512469933 |       27.66 |      72.05 |
|  25 | 1512470235 |       27.66 |      71.94 |
|  26 | 1512470538 |       27.68 |      71.82 |
|  27 | 1512470840 |       27.68 |      71.49 |
```

Figure 6: weather Table

```
mysql> select * from weathercards;
+----------+----------+---------+---------------+----+
| humidity | pressure | tempnow | description   | id |
+----------+----------+---------+---------------+----+
|       80 |     1011 |    32.2 | broken clouds |  1 |
+----------+----------+---------+---------------+----+
1 row in set (0.00 sec)
```

Figure 7: weathercards Table

Now that the MySQL database is set up to our liking we can move on to stage 4, the PHP scripts. Since all the PHP, HTML, CSS, and Javascript files of stage 4 and 5 need to be located on the server we need to install Apache to use as our web server first. Apache web server installation is a fairly common and straightforward process and documented installation instructions including PHP installation for the Raspberry Pi are provided here. As such Apache and PHP installation will not be covered in this report.

Once Apache with PHP was successfully installed two PHP files were created, weatherData.php and weathercardData.php. These files logged into the weatherdata database and then accessed their respective tables. The table data was then parsed to JSON format and output as plain text. The final output of the PHP files is shown below.

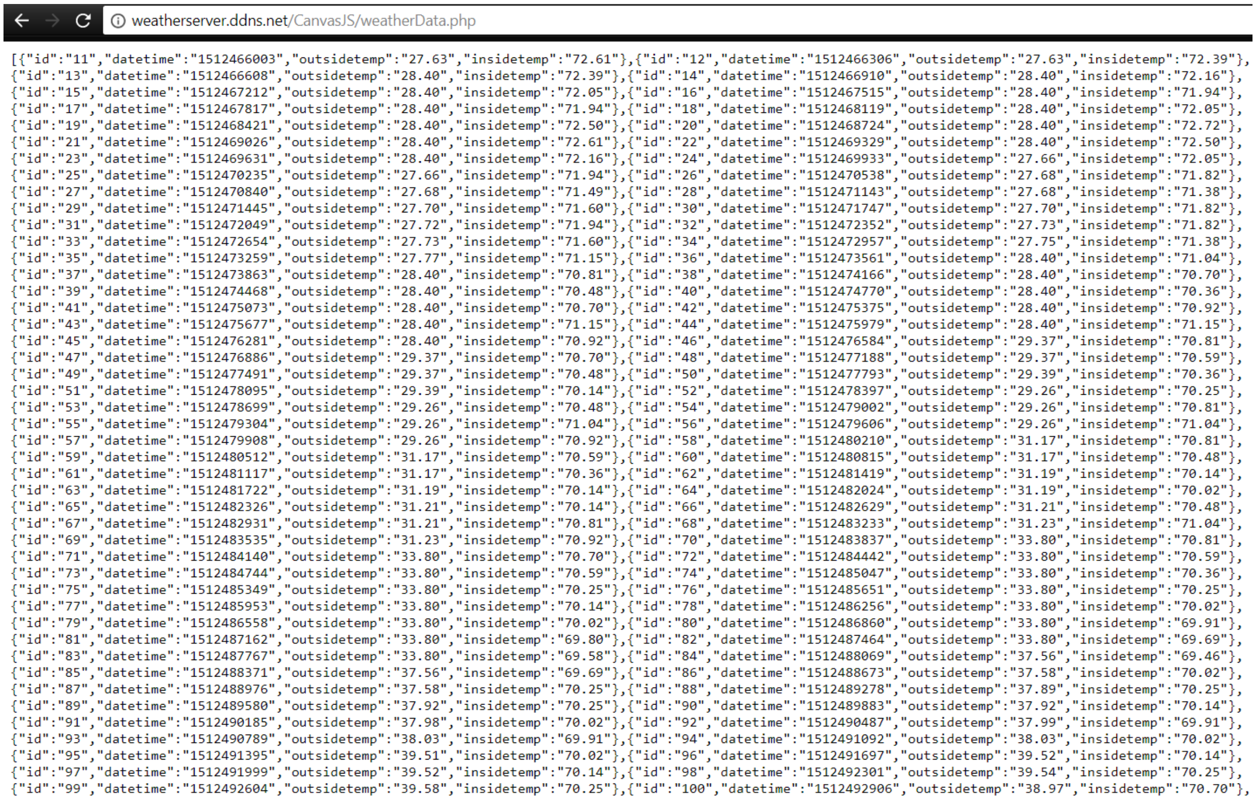

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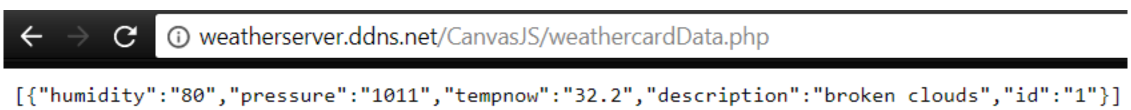
Figure 8: Output of weatherData.php



[{"humidity":"80","pressure":"1011","tempnow":"32.2","description":"broken clouds","id":"1"}]

Figure 9: Output of weathercardData.php

Finally stage 5, the web server front end, took the data from the PHP files and using a mix of Javascript (specifically the CanvasJS library), HTML, and CSS created a dynamic web page to display data. More specifically an interactive graph using the Javascript library CanvasJS was set up to graph indoor temperature versus outdoor temperature over time. Underneath the graph four "weather cards" were created to show the most current weather conditions in the form of outdoor temp, humidity, pressure, and current conditions. The final output as a fully functional web page is shown below.

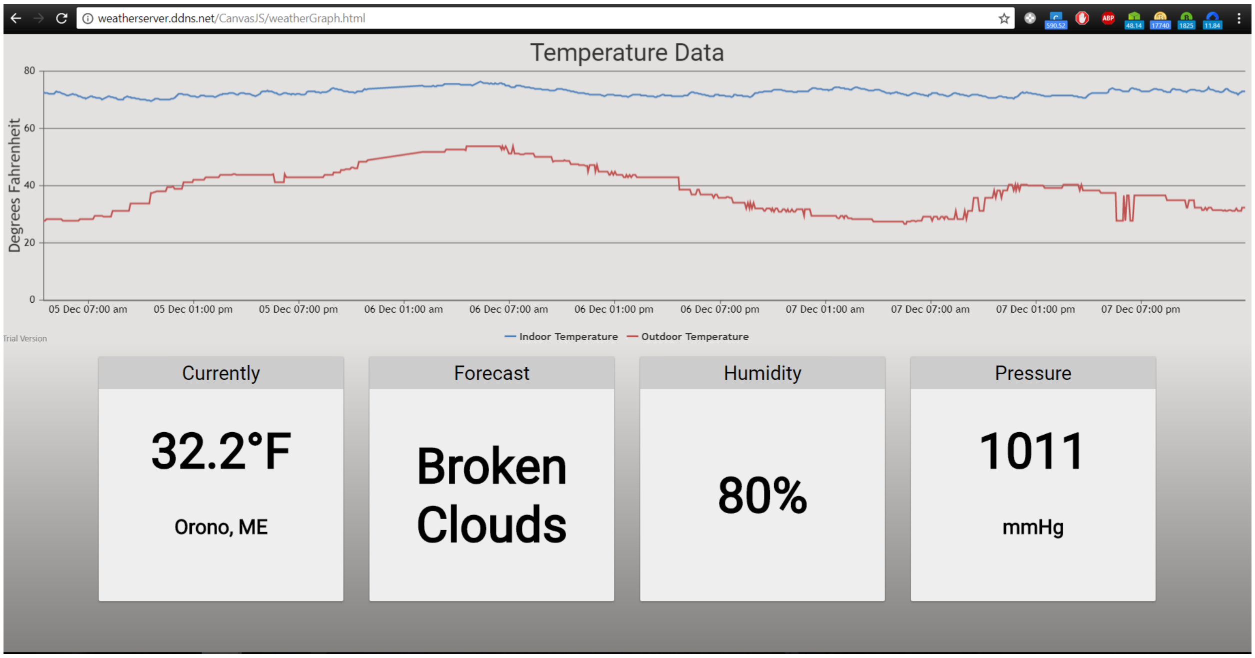


Figure 10: Final output of the Raspberry Pi Weather Server

3.3 Security Implications

Unfortunately great care was not taken to design the web server to be as secure as possible and as such there are many security flaws. First an foremost the client server connection is made over HTTP instead of HTTPS and is therefore inherently insecure. Beyond that both the Apache web server and MySQL database are running on a user with root permissions, meaning if either of these services were able to somehow be compromised they could potentially compromise the entire machine. In addition to this the MySQL database is operating under its root account and the username and password are hard coded into each of the PHP files accessing it. This provides an easy entry point for an attacker to gain root access to MySQL and then potentially use an exploit to gain access to the rest of the machine. Finally in order to access the server over the internet port 80 on our router was opened and forwarded to the Pi's server. In general it is not a good idea to have port 80 open as it is commonly a port that many potential malicious actors often try and use to gain access to a PC.

4 Results

The final output of the Raspberry Pi web server was something that we were pretty happy with. All of the features we set out to implement more or less made it into the final product without too much trouble. The interactive graph plotting indoor versus outdoor temperature worked better than we expected and the weather cards provided a nice way of seeing the weather at the current time. While most of the final output of the project has already been showcased in section 3.2 the screen captures are provided here once again for convenience.

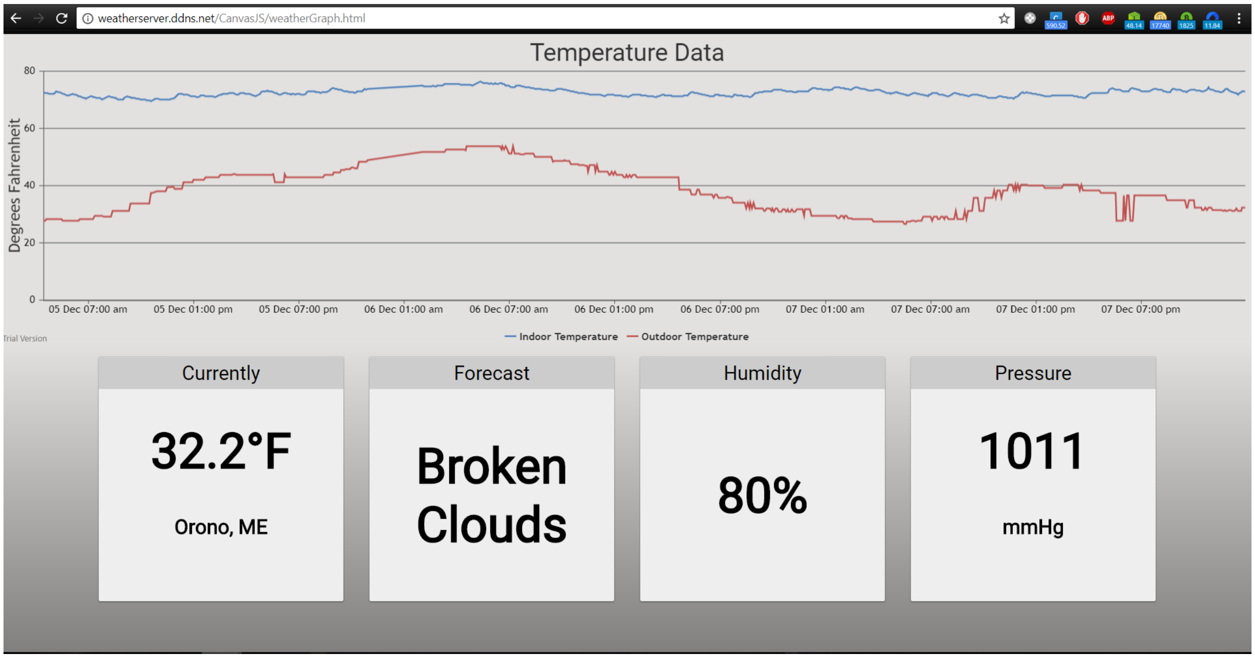


Figure 11: Final output of the Raspberry Pi Weather Server

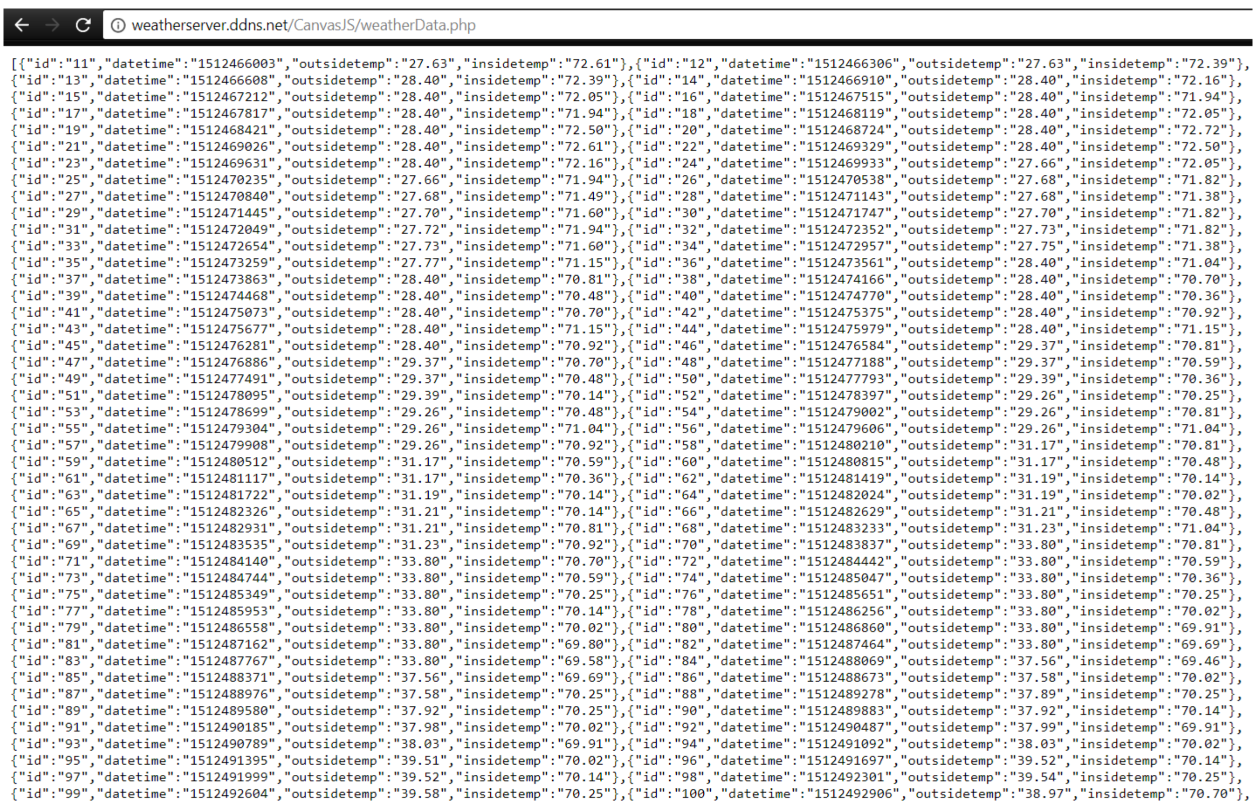



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Figure 12: Output of weatherData.php

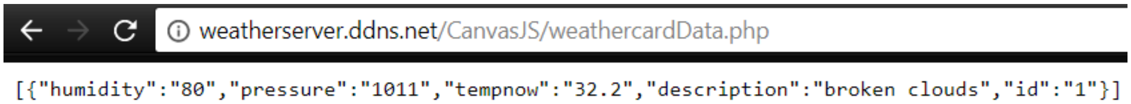

Figure 13: Output of weathercardData.php

5 Conclusion

Overall the project came together fairly well and with relatively few hiccups. The most challenging thing to get working was the CanvasJS chart of indoor versus outdoor temperatures. While the documentation of the library is very thorough it almost exclusively deals with interfacing charts with static data defined as a chart parameter itself. There is basically no information on how to take dynamic data parsed from JSON and present it to the chart API in a manner which it understands. In the end we ended up more or less having to make some educated guesses as to how it wanted the data presented in order to finally get it working. As far as future work is concerned it would be nice to add more data to the web page from devices connected to the Pi as well as improve the CSS/HTML formatting.

6 Appendix

Source code attached in email