



UCSC Extension Silicon Valley

The Internet of Things: Sensors, Platforms, Communications, and Applications

EMBD.X413.(2)

Winter 2018

Final Project Presentation For A Weather Station

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Instructor: Gilbert P. Garcia

Date: March 20, 2018



Weather Station Features

IoT Architecture: Publisher/Subscriber Model

Takes Temperature and Pressure Samples

Every Temperature and Pressure Sample is:

- Timestamped and Assigned a Unique Sample ID
- Displayed on LCD, Primary Console
- Written into a Database for Storage
- Backed Up into a Log File
- Sent over to PubNub

Allows Turning On or Off of an LED remotely

Hardware/Software

Raspberry Pi 3

HDMI Monitor, USB Keyboard and Mouse

Sensor/Actuator from SunFounder Kit

Miscellaneous Accessories

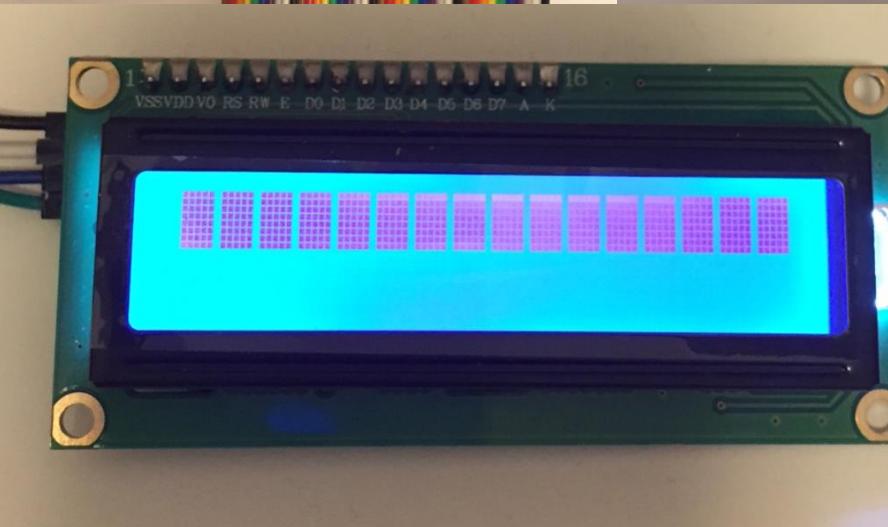
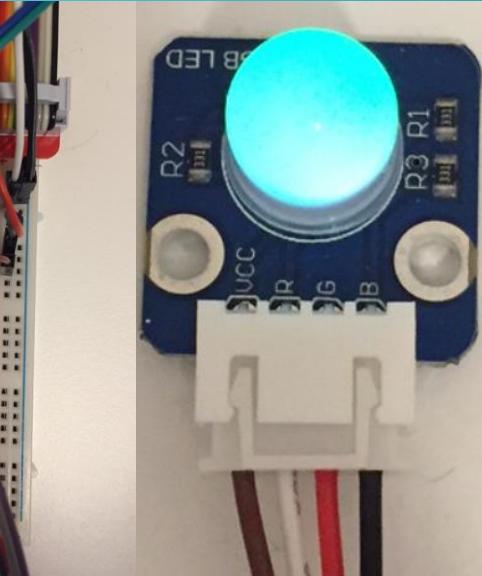
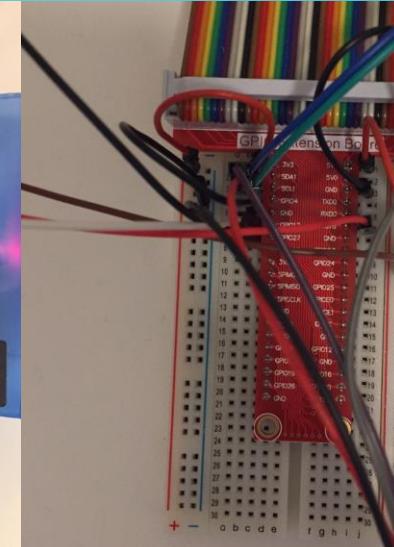
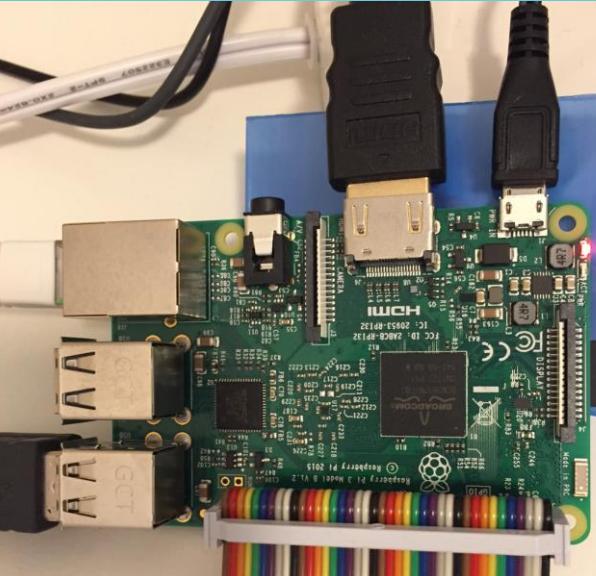
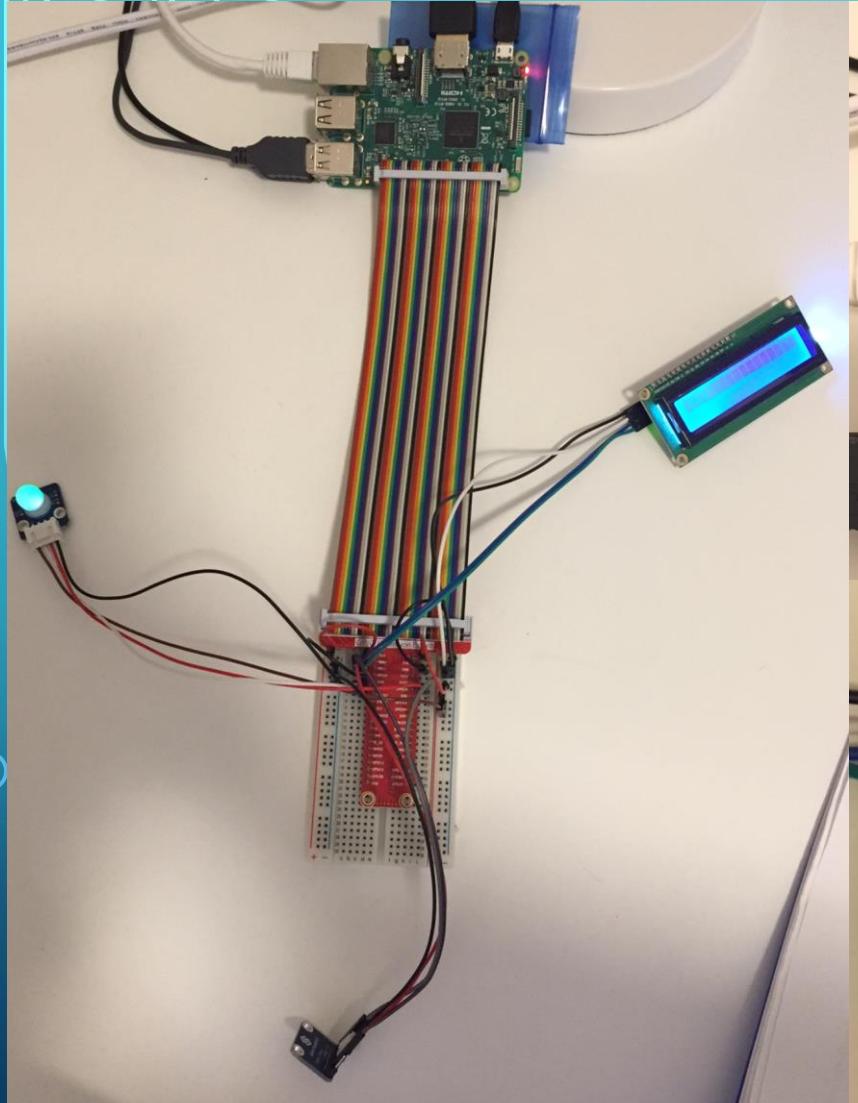
Raspbian – Main OS, Python - Programming

Apache 2, Flask – Web Server

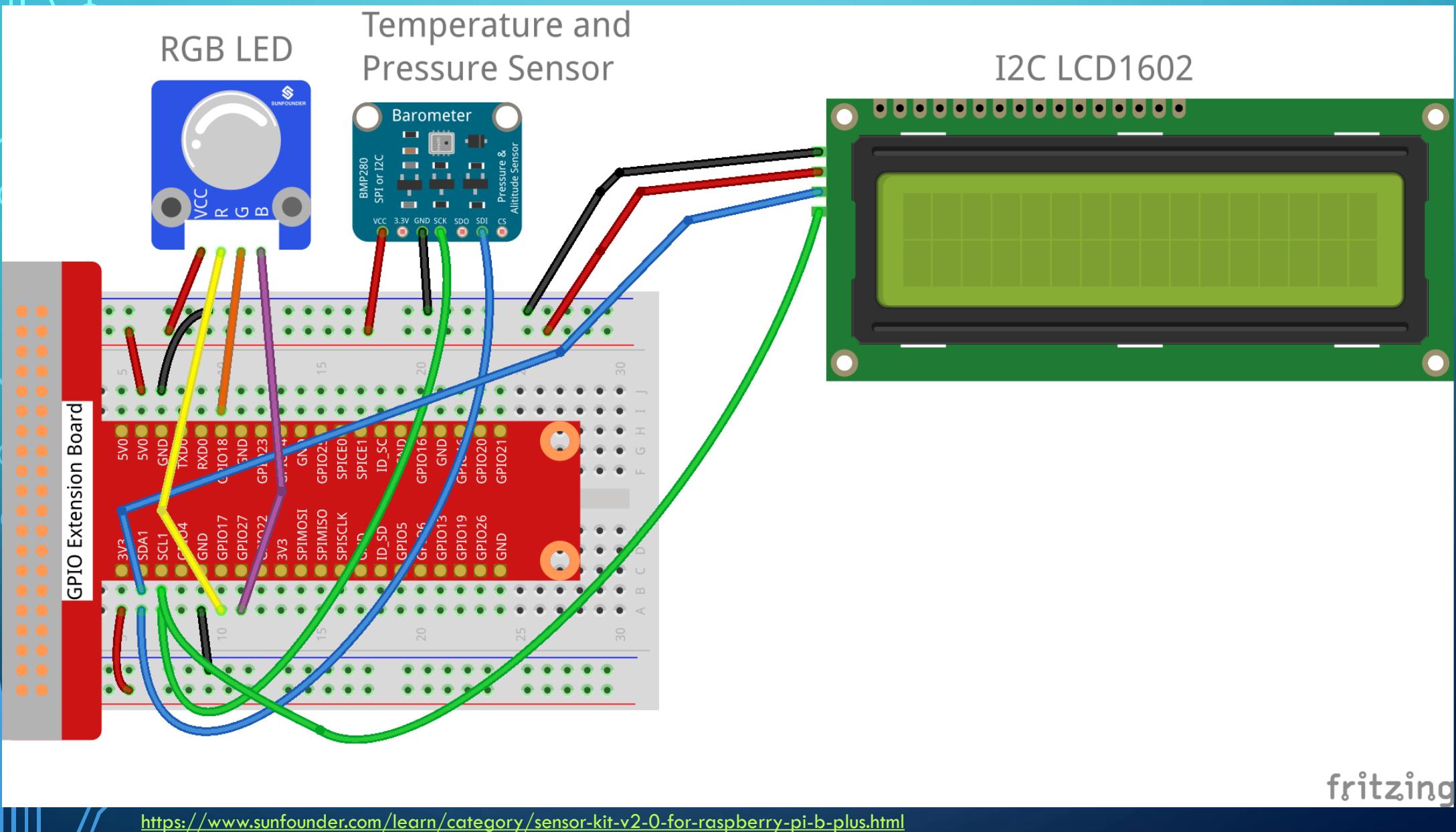
SQLite3 – Database

HTML, CSS, JS – Webpage Dashboard

Weather Station Hardware

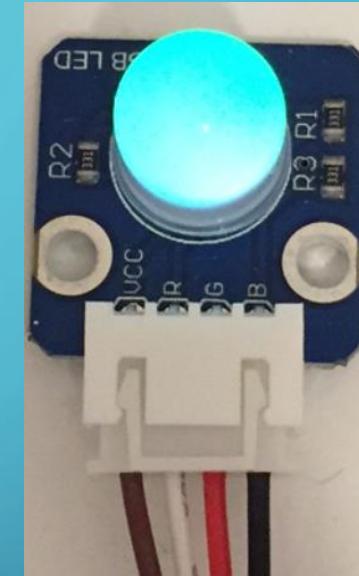
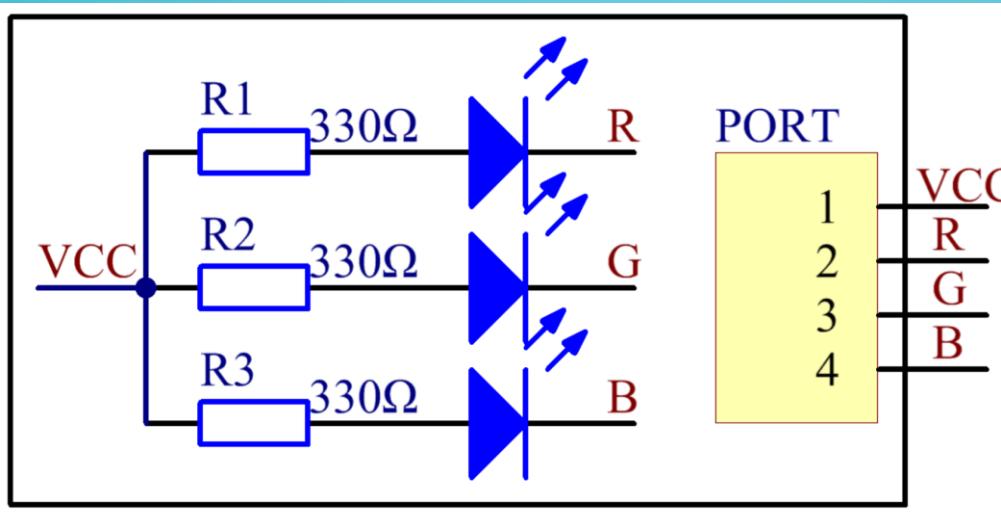


Fritzing Wiring Diagram



Schematics

RGB LED

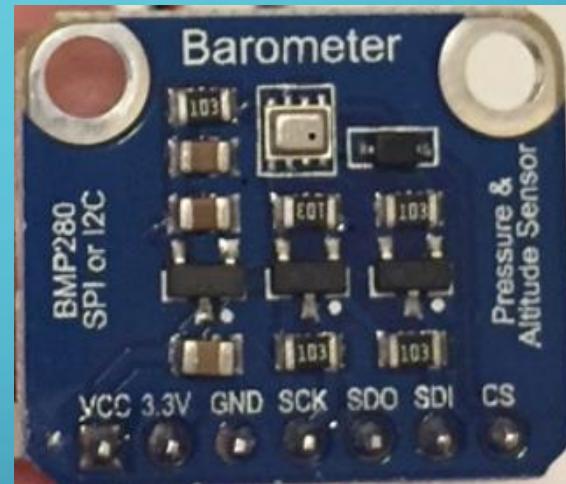
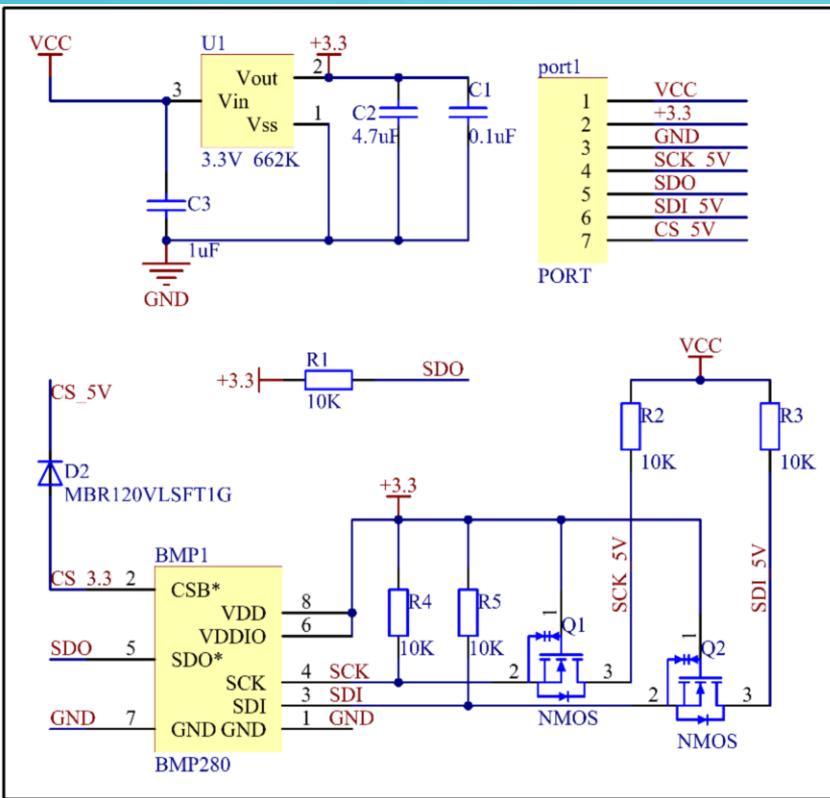


Wiring Guide

Raspberry Pi	T-Cobbler	RGB LED Module
5V	5V0	VCC
GPIO0	GPIO17	R
GPIO1	GPIO18	G
GPIO2	GPIO27	B

Schematics

BMP280 Temperature and Pressure Sensor



Wiring Guide

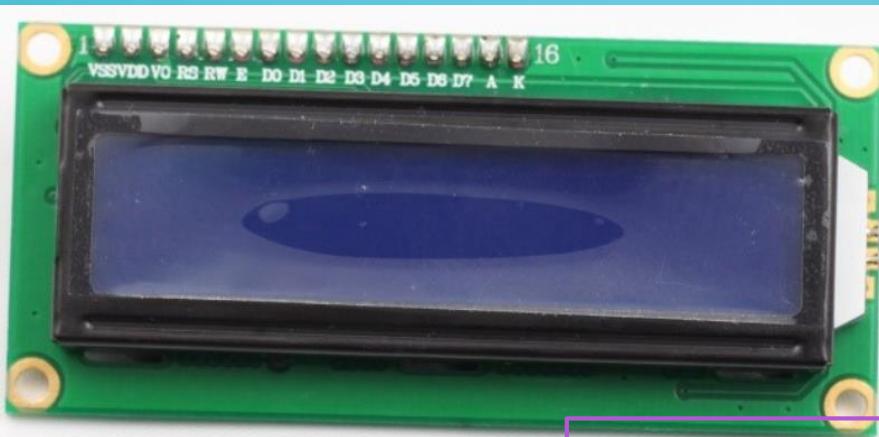
Raspberry Pi	T-Cobbler	Barometer Module
SCL	SCL1	SCL
SDA	SDA1	SDA
5V	5V0	VCC
GND	GND	GND

http://wiki.sunfounder.cc/index.php?title=BMP280_Pressure_Sensor_Module

<https://www.sunfounder.com/learn/sensor-kit-v2-0-for-raspberry-pi-b-plus/lesson-31-barometer-sensor-kit-v2-0-for-b-plus.html>

Schematics

I²C 1602 LCD Display



Front

ST7065C 40Ch Segment/Common
Driver For Dot Matrix LCD



Back

PCF8574 8-bit I/O
Expander For I2C
Bus

ST7066U Dot
Matrix LCD
Controller/Driver

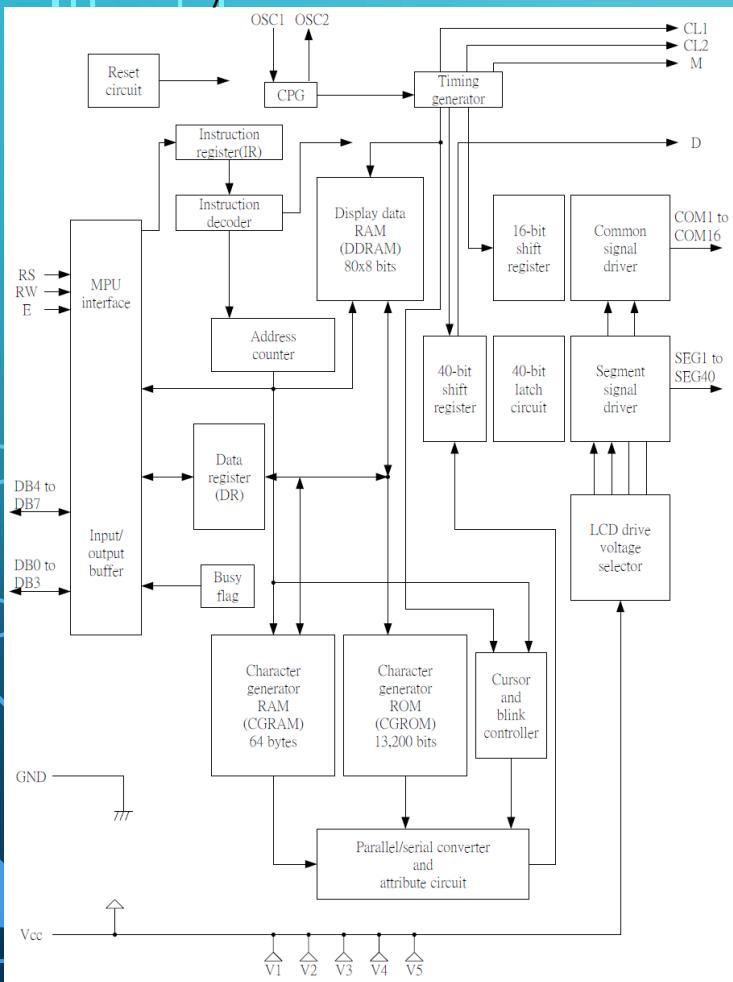
Wiring Guide

Raspberry Pi	T-Cobbler	I2C LCD1602 Module
SCL	SCL1	SCL
SDA	SDA1	SDA
5V	5V0	VCC
GND	GND	GND

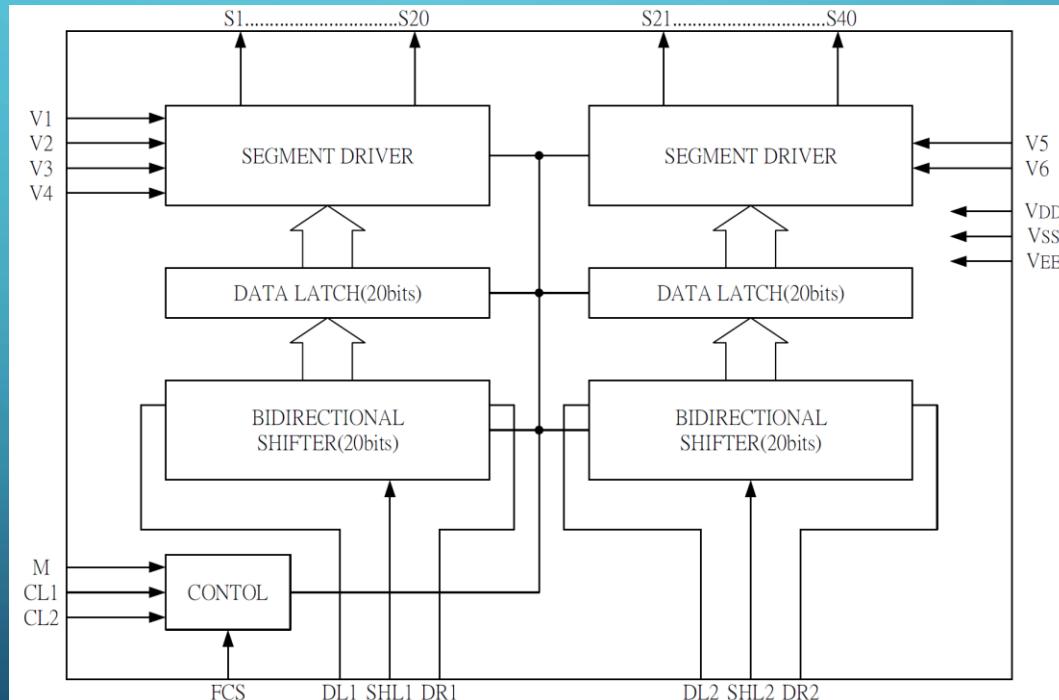
Schematics

I²C 1602 LCD Display

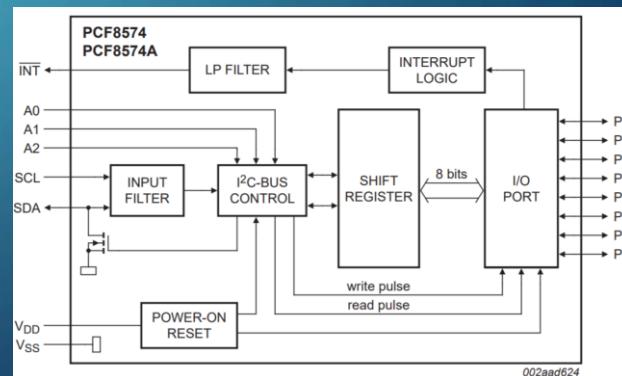
ST7066U Dot Matrix LCD
Controller/Driver



ST7065C 40Ch Segment/Common Driver For Dot Matrix LCD



PCF8574 8-bit I/O Expander For I²C Bus



<http://www.sitronix.com.tw/sitronix/product.nsf/Doc/ST7066U?OpenDocument>

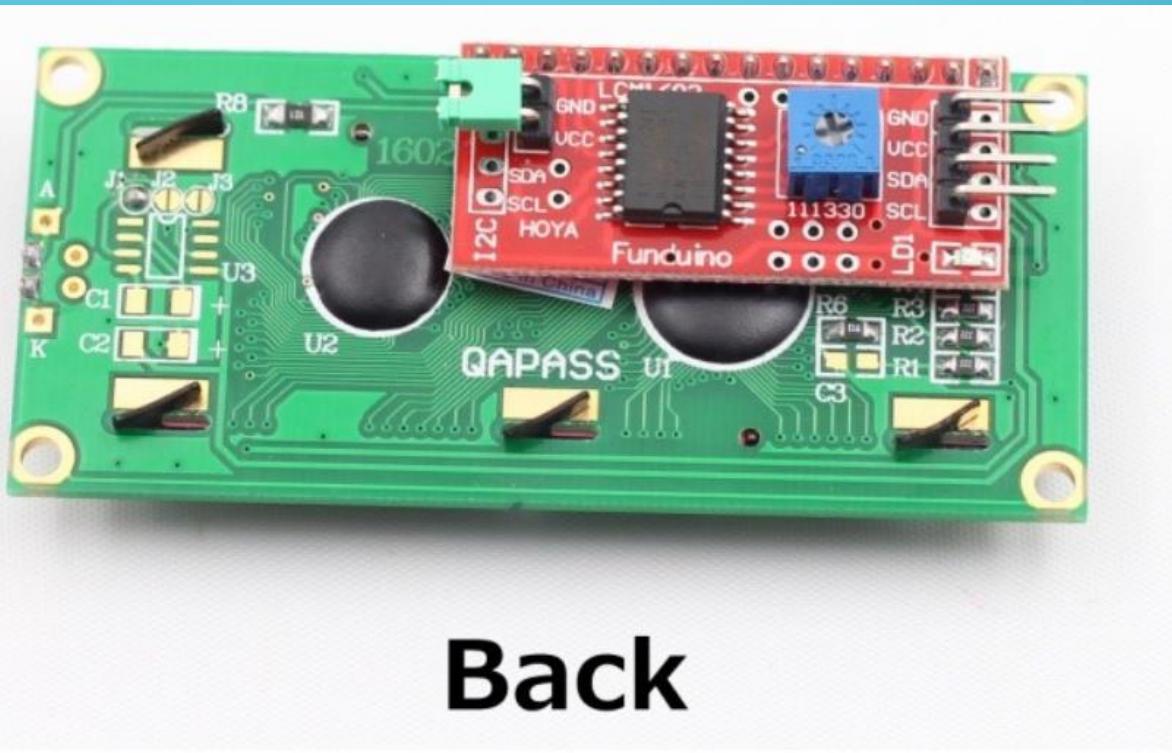
<http://www.sitronix.com.tw/sitronix/product.nsf/Doc/ST7065C?OpenDocument>

https://www.nxp.com/docs/en/data-sheet/PCF8574_PCF8574A.pdf

Schematics

I²C 1602 LCD Display

Only two pairs of wires are needed



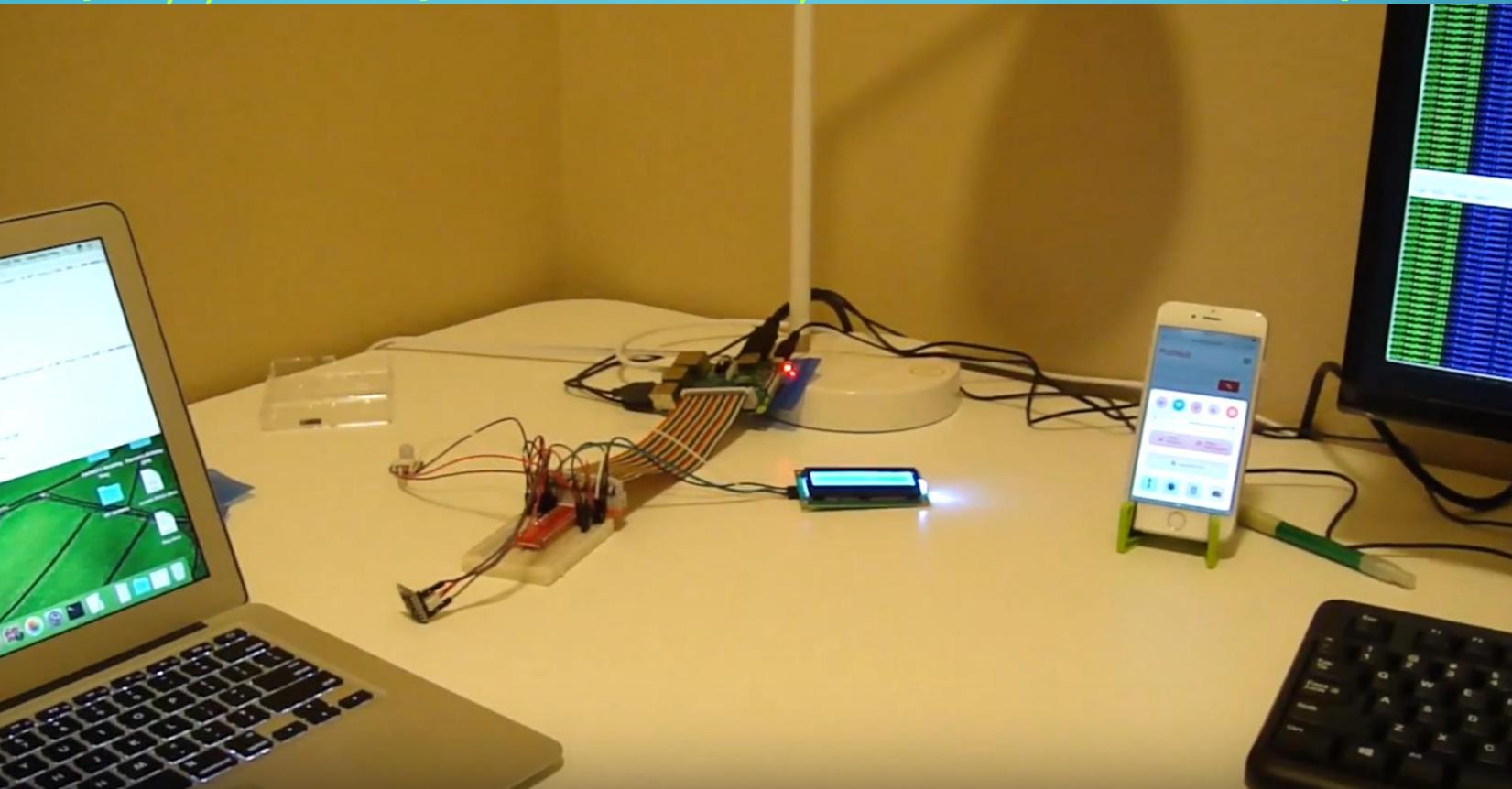
VCC and GND:
Supply Voltage for ICs
and LCD Back Light

SDA and SCL:
Serial Data and Serial
Clock for Driving the LCD
Character Display

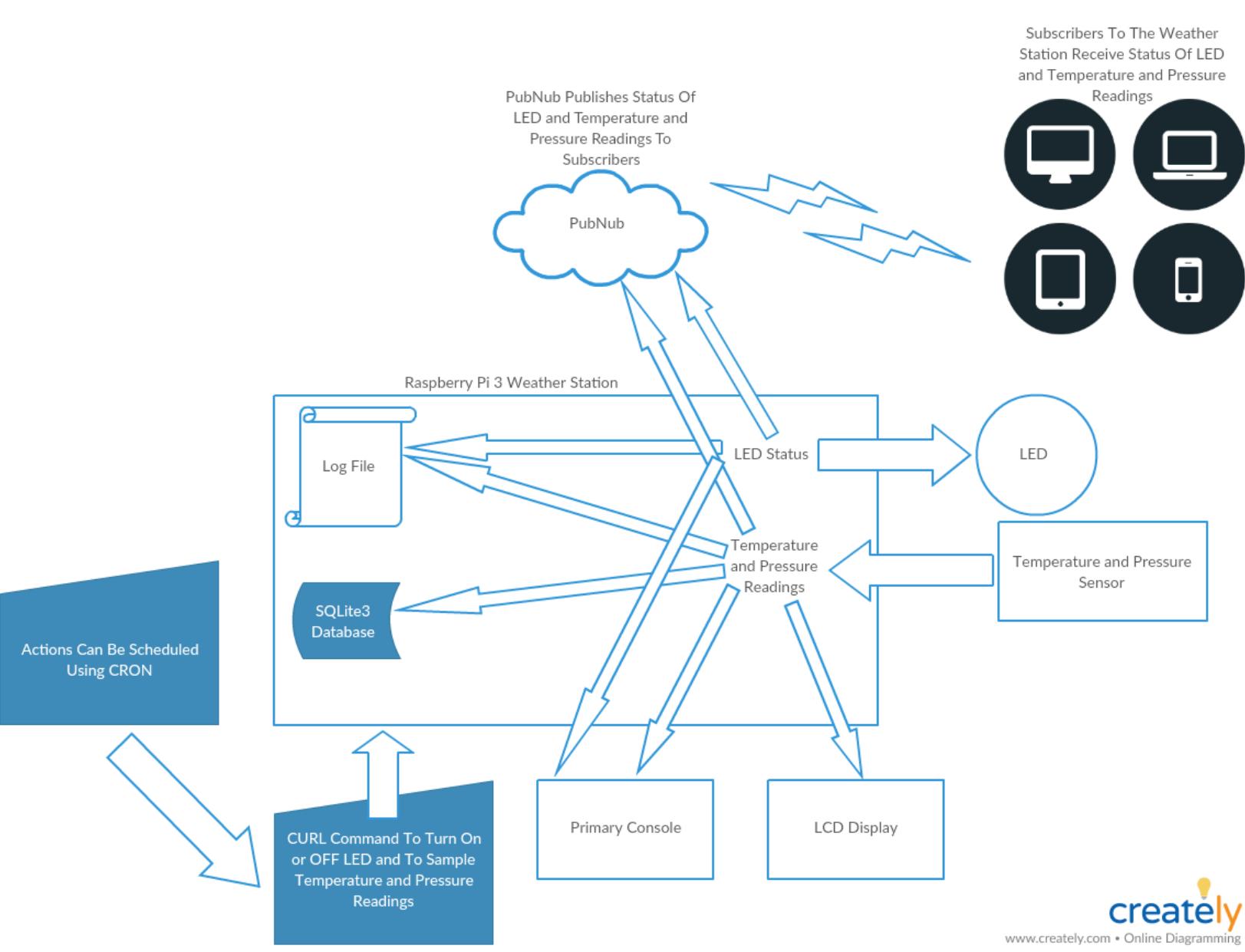
Project Demonstration In YouTube

https://www.youtube.com/watch?v=zUYmMlv_fIE

<https://www.youtube.com/watch?v=H9olcqLv-DI>



Data Flow Diagram



CURL Commands

To Sample Temperature and Pressure:

```
curl -i -h "content-type:application/json" -x get  
http://192.168.1.200:8080/final/api/sensors
```

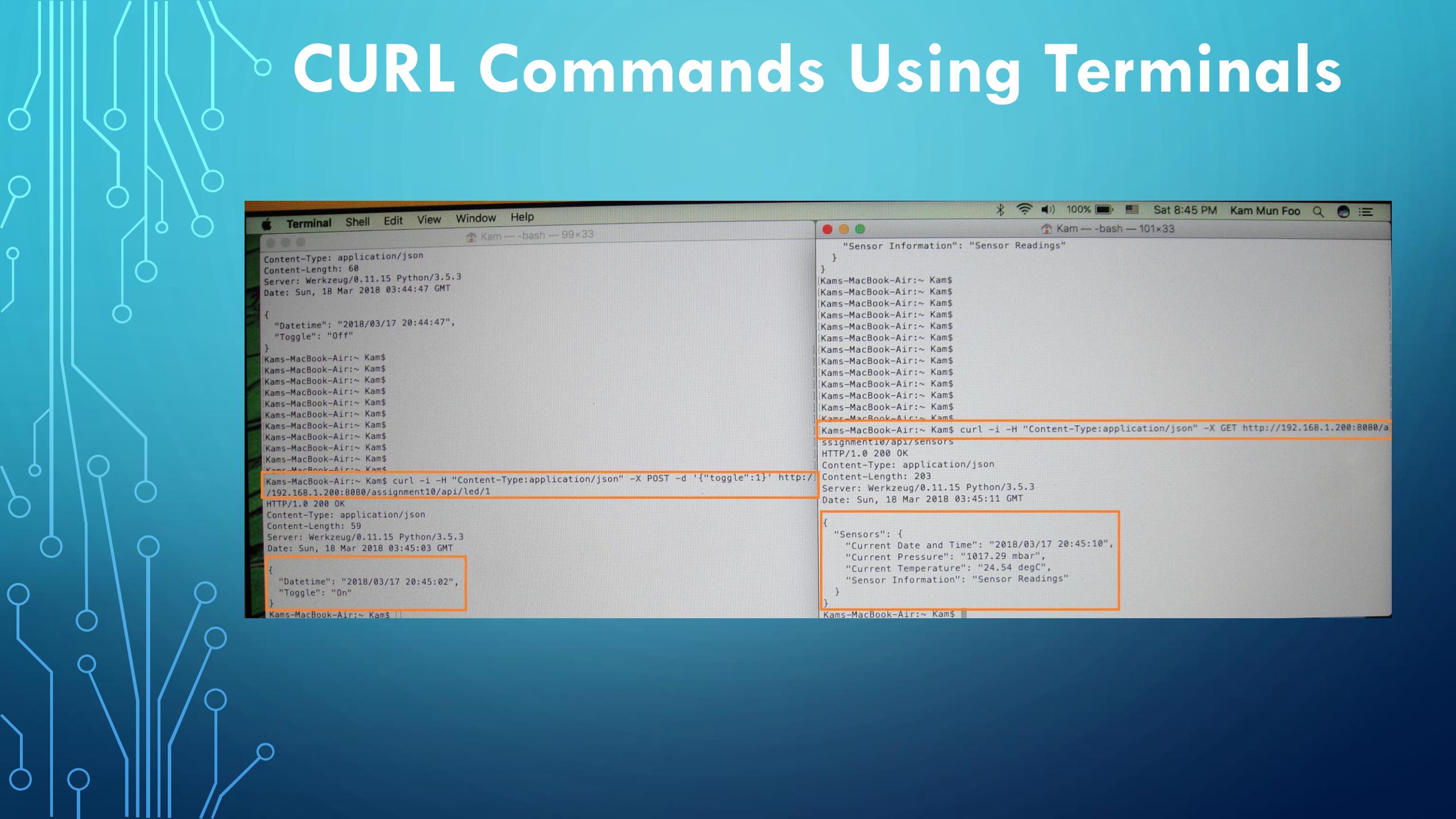
To Turn On LED:

```
curl -i -h "content-type:application/json" -x post -d '{"toggle":1}'  
http://192.168.1.200:8080/final/api/led/1
```

To Turn Off LED:

```
curl -i -h "content-type:application/json" -x post -d '{"toggle":0}'  
http://192.168.1.200:8080/final/api/led/0
```

CURL Commands Using Terminals



```
Terminal Shell Edit View Window Help
Kam — bash — 99x33
Content-Type: application/json
Content-Length: 60
Server: Werkzeug/0.11.15 Python/3.5.3
Date: Sun, 18 Mar 2018 03:44:47 GMT

{
    "Datetime": "2018/03/17 20:44:47",
    "Toggle": "Off"
}
Kams-MacBook-Air:~ Kam$ curl -i -H "Content-Type:application/json" -X POST -d '{"toggle":1}' http://192.168.1.200:8080/assignment10/api/led/1
HTTP/1.0 200 OK
Content-Type: application/json
Content-Length: 59
Server: Werkzeug/0.11.15 Python/3.5.3
Date: Sun, 18 Mar 2018 03:45:03 GMT

{
    "Datetime": "2018/03/17 20:45:02",
    "Toggle": "On"
}
Kams-MacBook-Air:~ Kam$ |
```

```
Kam — bash — 101x33
"Sensor Information": "Sensor Readings"
}
Kams-MacBook-Air:~ Kam$ curl -i -H "Content-Type:application/json" -X GET http://192.168.1.200:8080/assignment10/api/sensors
HTTP/1.0 200 OK
Content-Type: application/json
Content-Length: 203
Server: Werkzeug/0.11.15 Python/3.5.3
Date: Sun, 18 Mar 2018 03:45:11 GMT

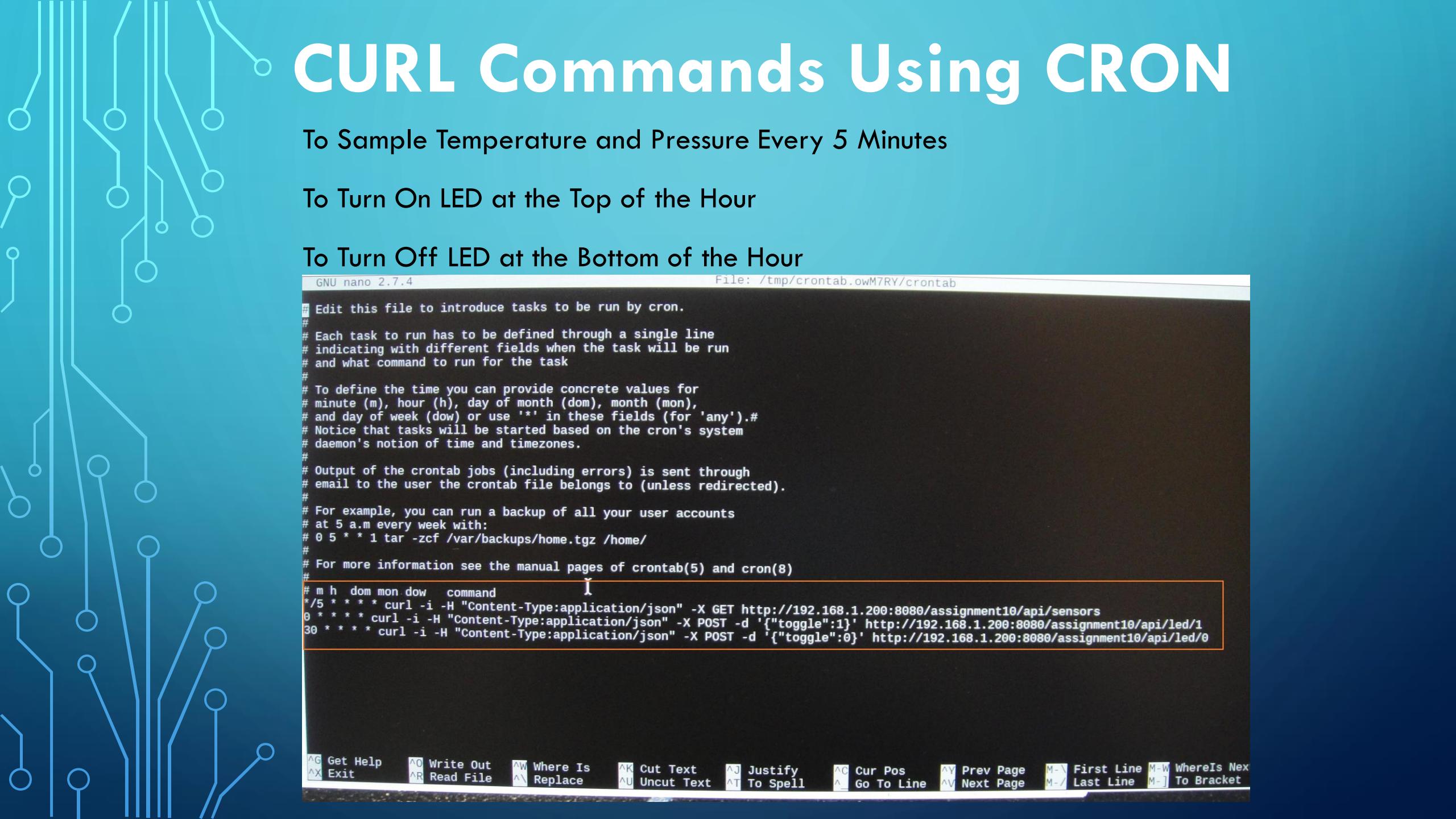
{
    "Sensors": {
        "Current Date and Time": "2018/03/17 20:45:10",
        "Current Pressure": "1017.29 mbar",
        "Current Temperature": "24.54 degC",
        "Sensor Information": "Sensor Readings"
    }
}
Kams-MacBook-Air:~ Kam$ |
```

CURL Commands Using CRON

To Sample Temperature and Pressure Every 5 Minutes

To Turn On LED at the Top of the Hour

To Turn Off LED at the Bottom of the Hour



```
GNU nano 2.7.4                                         File: /tmp/crontab.owM7RY/crontab

# Edit this file to introduce tasks to be run by cron.
#
# Each task to run has to be defined through a single line
# indicating with different fields when the task will be run
# and what command to run for the task
#
# To define the time you can provide concrete values for
# minute (m), hour (h), day of month (dom), month (mon),
# and day of week (dow) or use '*' in these fields (for 'any').#
# Notice that tasks will be started based on the cron's system
# daemon's notion of time and timezones.
#
# Output of the crontab jobs (including errors) is sent through
# email to the user the crontab file belongs to (unless redirected).
#
# For example, you can run a backup of all your user accounts
# at 5 a.m every week with:
# 0 5 * * 1 tar -zcf /var/backups/home.tgz /home/
#
# For more information see the manual pages of crontab(5) and cron(8)
#
# m h dom mon dow   command
*/5 * * * * curl -i -H "Content-Type:application/json" -X GET http://192.168.1.200:8080/assignment10/api/sensors
0 * * * * curl -i -H "Content-Type:application/json" -X POST -d '{"toggle":1}' http://192.168.1.200:8080/assignment10/api/led/1
30 * * * * curl -i -H "Content-Type:application/json" -X POST -d '{"toggle":0}' http://192.168.1.200:8080/assignment10/api/led/0

Get Help   ^O Write Out   ^W Where Is   ^K Cut Text   ^J Justify   ^C Cur Pos   ^Y Prev Page   M-^ First Line M-W WhereIs Next
^X Exit    ^R Read File   ^X Replace   ^U Uncut Text  ^T To Spell   ^G Go To Line  ^V Next Page   M-/ Last Line  M-] To Bracket
```

CURL Commands Using CRON

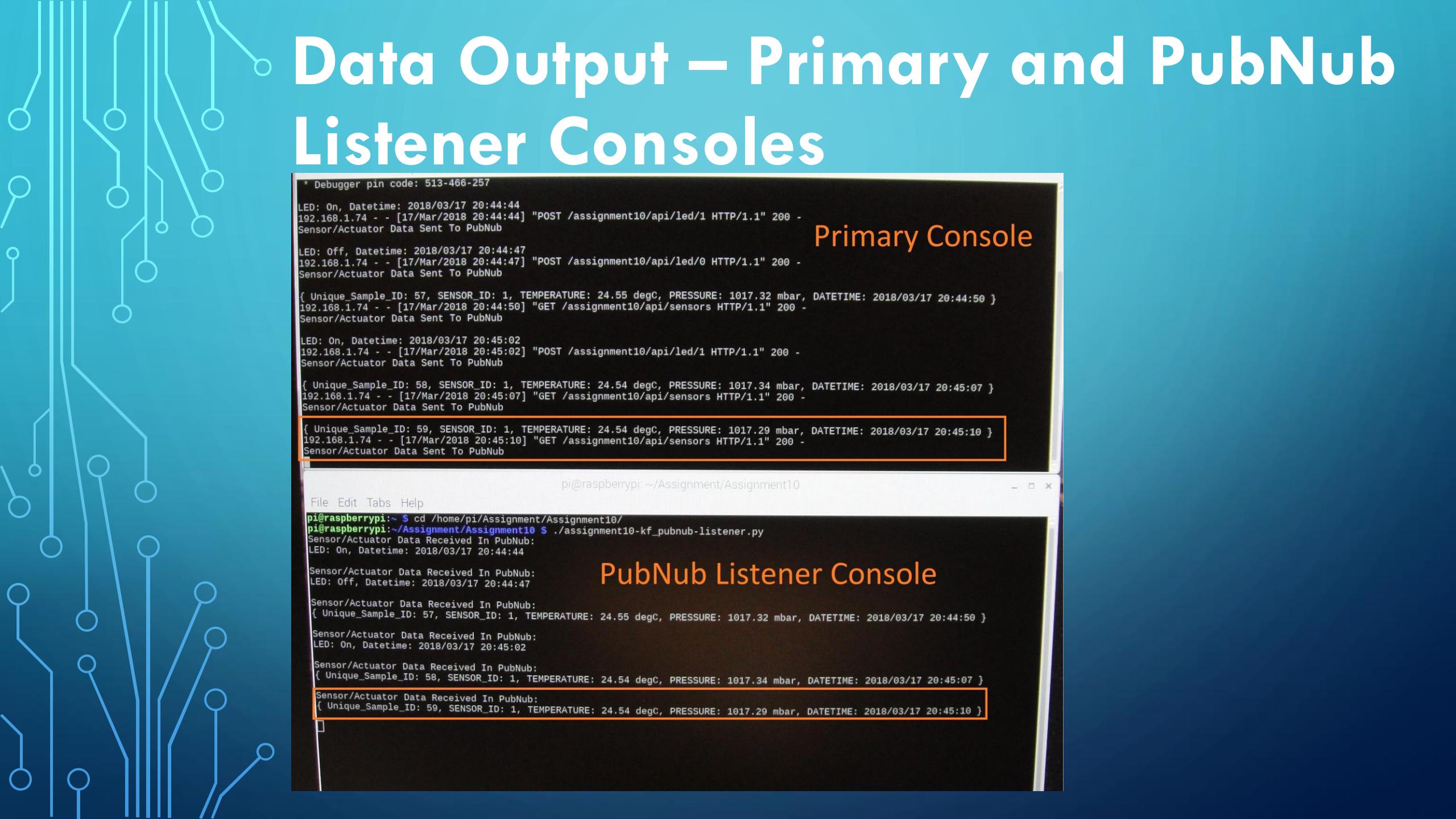
Sensor Log

```
{ Unique_Sample_ID: 1, SENSOR_ID: 1, TEMPERATURE: 24.47 degC, PRESSURE: 1013.71 mbar, DATETIME: 2018/03/15 19:00:01 }
LED: On, Datetime: 2018/03/15 19:00:03
{ Unique_Sample_ID: 2, SENSOR_ID: 1, TEMPERATURE: 24.45 degC, PRESSURE: 1013.80 mbar, DATETIME: 2018/03/15 19:05:01 }
{ Unique_Sample_ID: 3, SENSOR_ID: 1, TEMPERATURE: 24.38 degC, PRESSURE: 1013.78 mbar, DATETIME: 2018/03/15 19:10:01 }
{ Unique_Sample_ID: 4, SENSOR_ID: 1, TEMPERATURE: 24.52 degC, PRESSURE: 1013.83 mbar, DATETIME: 2018/03/15 19:15:01 }
{ Unique_Sample_ID: 5, SENSOR_ID: 1, TEMPERATURE: 24.46 degC, PRESSURE: 1013.64 mbar, DATETIME: 2018/03/15 19:20:01 }
{ Unique_Sample_ID: 6, SENSOR_ID: 1, TEMPERATURE: 24.45 degC, PRESSURE: 1013.56 mbar, DATETIME: 2018/03/15 19:25:01 }
LED: Off, Datetime: 2018/03/15 19:30:02
{ Unique_Sample_ID: 7, SENSOR_ID: 1, TEMPERATURE: 24.44 degC, PRESSURE: 1013.49 mbar, DATETIME: 2018/03/15 19:30:02 }
{ Unique_Sample_ID: 8, SENSOR_ID: 1, TEMPERATURE: 24.46 degC, PRESSURE: 1013.45 mbar, DATETIME: 2018/03/15 19:35:01 }
{ Unique_Sample_ID: 9, SENSOR_ID: 1, TEMPERATURE: 24.46 degC, PRESSURE: 1013.50 mbar, DATETIME: 2018/03/15 19:40:02 }
{ Unique_Sample_ID: 10, SENSOR_ID: 1, TEMPERATURE: 24.44 degC, PRESSURE: 1013.49 mbar, DATETIME: 2018/03/15 19:45:01 }
{ Unique_Sample_ID: 11, SENSOR_ID: 1, TEMPERATURE: 24.43 degC, PRESSURE: 1013.56 mbar, DATETIME: 2018/03/15 19:50:01 }
{ Unique_Sample_ID: 12, SENSOR_ID: 1, TEMPERATURE: 24.46 degC, PRESSURE: 1013.53 mbar, DATETIME: 2018/03/15 19:55:01 }
LED: On, Datetime: 2018/03/15 20:00:02
{ Unique_Sample_ID: 13, SENSOR_ID: 1, TEMPERATURE: 24.34 degC, PRESSURE: 1013.40 mbar, DATETIME: 2018/03/15 20:00:02 }
{ Unique_Sample_ID: 14, SENSOR_ID: 1, TEMPERATURE: 24.38 degC, PRESSURE: 1013.42 mbar, DATETIME: 2018/03/15 20:05:01 }
{ Unique_Sample_ID: 15, SENSOR_ID: 1, TEMPERATURE: 24.30 degC, PRESSURE: 1013.53 mbar, DATETIME: 2018/03/15 20:10:01 }
{ Unique_Sample_ID: 16, SENSOR_ID: 1, TEMPERATURE: 24.23 degC, PRESSURE: 1013.49 mbar, DATETIME: 2018/03/15 20:15:01 }
{ Unique_Sample_ID: 17, SENSOR_ID: 1, TEMPERATURE: 24.35 degC, PRESSURE: 1013.53 mbar, DATETIME: 2018/03/15 20:20:01 }
{ Unique_Sample_ID: 18, SENSOR_ID: 1, TEMPERATURE: 24.34 degC, PRESSURE: 1013.62 mbar, DATETIME: 2018/03/15 20:25:01 }
LED: Off, Datetime: 2018/03/15 20:30:02
{ Unique_Sample_ID: 19, SENSOR_ID: 1, TEMPERATURE: 24.36 degC, PRESSURE: 1013.50 mbar, DATETIME: 2018/03/15 20:30:02 }
{ Unique_Sample_ID: 20, SENSOR_ID: 1, TEMPERATURE: 24.35 degC, PRESSURE: 1013.45 mbar, DATETIME: 2018/03/15 20:35:01 }
{ Unique_Sample_ID: 21, SENSOR_ID: 1, TEMPERATURE: 24.33 degC, PRESSURE: 1013.59 mbar, DATETIME: 2018/03/15 20:40:01 }
{ Unique_Sample_ID: 22, SENSOR_ID: 1, TEMPERATURE: 24.32 degC, PRESSURE: 1013.50 mbar, DATETIME: 2018/03/15 20:45:02 }
{ Unique_Sample_ID: 23, SENSOR_ID: 1, TEMPERATURE: 24.34 degC, PRESSURE: 1013.62 mbar, DATETIME: 2018/03/15 20:50:01 }
{ Unique_Sample_ID: 24, SENSOR_ID: 1, TEMPERATURE: 24.34 degC, PRESSURE: 1013.51 mbar, DATETIME: 2018/03/15 20:55:01 }
LED: On, Datetime: 2018/03/15 21:00:02
{ Unique_Sample_ID: 25, SENSOR_ID: 1, TEMPERATURE: 24.33 degC, PRESSURE: 1013.71 mbar, DATETIME: 2018/03/15 21:00:02 }
{ Unique_Sample_ID: 26, SENSOR_ID: 1, TEMPERATURE: 24.27 degC, PRESSURE: 1013.65 mbar, DATETIME: 2018/03/15 21:05:01 }
{ Unique_Sample_ID: 27, SENSOR_ID: 1, TEMPERATURE: 24.28 degC, PRESSURE: 1013.74 mbar, DATETIME: 2018/03/15 21:10:01 }
{ Unique_Sample_ID: 28, SENSOR_ID: 1, TEMPERATURE: 24.42 degC, PRESSURE: 1013.72 mbar, DATETIME: 2018/03/15 21:15:01 }
{ Unique_Sample_ID: 29, SENSOR_ID: 1, TEMPERATURE: 24.46 degC, PRESSURE: 1013.67 mbar, DATETIME: 2018/03/15 21:20:01 }
{ Unique_Sample_ID: 30, SENSOR_ID: 1, TEMPERATURE: 24.26 degC, PRESSURE: 1013.69 mbar, DATETIME: 2018/03/15 21:25:01 }
LED: Off, Datetime: 2018/03/15 21:30:02
{ Unique_Sample_ID: 31, SENSOR_ID: 1, TEMPERATURE: 24.49 degC, PRESSURE: 1013.77 mbar, DATETIME: 2018/03/15 21:30:02 }
{ Unique_Sample_ID: 32, SENSOR_ID: 1, TEMPERATURE: 24.65 degC, PRESSURE: 1013.84 mbar, DATETIME: 2018/03/15 21:35:02 }
{ Unique_Sample_ID: 33, SENSOR_ID: 1, TEMPERATURE: 24.76 degC, PRESSURE: 1013.97 mbar, DATETIME: 2018/03/15 21:40:01 }
{ Unique_Sample_ID: 34, SENSOR_ID: 1, TEMPERATURE: 24.74 degC, PRESSURE: 1013.81 mbar, DATETIME: 2018/03/15 21:45:01 }
{ Unique_Sample_ID: 35, SENSOR_ID: 1, TEMPERATURE: 24.70 degC, PRESSURE: 1013.72 mbar, DATETIME: 2018/03/15 21:50:01 }
{ Unique_Sample_ID: 36, SENSOR_ID: 1, TEMPERATURE: 24.73 degC, PRESSURE: 1013.69 mbar, DATETIME: 2018/03/15 21:55:02 }
LED: On, Datetime: 2018/03/15 22:00:02
{ Unique_Sample_ID: 37, SENSOR_ID: 1, TEMPERATURE: 24.89 degC, PRESSURE: 1013.62 mbar, DATETIME: 2018/03/15 22:00:02 }
{ Unique_Sample_ID: 38, SENSOR_ID: 1, TEMPERATURE: 24.85 degC, PRESSURE: 1013.58 mbar, DATETIME: 2018/03/15 22:05:01 }
```

Data Output – LCD Display



Data Output – Primary and PubNub Listener Consoles



The image shows two terminal windows side-by-side against a background of blue and white circuit board traces. The left window is titled "Primary Console" and the right window is titled "PubNub Listener Console". Both windows display command-line output from a Raspberry Pi.

Primary Console Output:

```
* Debugger pin code: 513-466-257
LED: On, Datetime: 2018/03/17 20:44:44
192.168.1.74 - - [17/Mar/2018 20:44:44] "POST /assignment10/api/led/1 HTTP/1.1" 200 -
Sensor/Actuator Data Sent To PubNub

LED: Off, Datetime: 2018/03/17 20:44:47
192.168.1.74 - - [17/Mar/2018 20:44:47] "POST /assignment10/api/led/0 HTTP/1.1" 200 -
Sensor/Actuator Data Sent To PubNub

{ Unique_Sample_ID: 57, SENSOR_ID: 1, TEMPERATURE: 24.55 degC, PRESSURE: 1017.32 mbar, DATETIME: 2018/03/17 20:44:50 }
192.168.1.74 - - [17/Mar/2018 20:44:50] "GET /assignment10/api/sensors HTTP/1.1" 200 -
Sensor/Actuator Data Sent To PubNub

LED: On, Datetime: 2018/03/17 20:45:02
192.168.1.74 - - [17/Mar/2018 20:45:02] "POST /assignment10/api/led/1 HTTP/1.1" 200 -
Sensor/Actuator Data Sent To PubNub

{ Unique_Sample_ID: 58, SENSOR_ID: 1, TEMPERATURE: 24.54 degC, PRESSURE: 1017.34 mbar, DATETIME: 2018/03/17 20:45:07 }
192.168.1.74 - - [17/Mar/2018 20:45:07] "GET /assignment10/api/sensors HTTP/1.1" 200 -
Sensor/Actuator Data Sent To PubNub

{ Unique_Sample_ID: 59, SENSOR_ID: 1, TEMPERATURE: 24.54 degC, PRESSURE: 1017.29 mbar, DATETIME: 2018/03/17 20:45:10 }
192.168.1.74 - - [17/Mar/2018 20:45:10] "GET /assignment10/api/sensors HTTP/1.1" 200 -
Sensor/Actuator Data Sent To PubNub
```

PubNub Listener Console Output:

```
pi@raspberrypi:~/Assignment/Assignment10
File Edit Tabs Help
pi@raspberrypi:~ $ cd /home/pi/Assignment/Assignment10/
pi@raspberrypi:~/Assignment/Assignment10 $ ./assignment10-kf_pubnub-listener.py
Sensor/Actuator Data Received In PubNub:
LED: On, Datetime: 2018/03/17 20:44:44

Sensor/Actuator Data Received In PubNub:
{ Unique_Sample_ID: 57, SENSOR_ID: 1, TEMPERATURE: 24.55 degC, PRESSURE: 1017.32 mbar, DATETIME: 2018/03/17 20:44:50 }

Sensor/Actuator Data Received In PubNub:
LED: Off, Datetime: 2018/03/17 20:44:47

Sensor/Actuator Data Received In PubNub:
{ Unique_Sample_ID: 58, SENSOR_ID: 1, TEMPERATURE: 24.54 degC, PRESSURE: 1017.34 mbar, DATETIME: 2018/03/17 20:45:07 }

Sensor/Actuator Data Received In PubNub:
{ Unique_Sample_ID: 59, SENSOR_ID: 1, TEMPERATURE: 24.54 degC, PRESSURE: 1017.29 mbar, DATETIME: 2018/03/17 20:45:10 }
```

Data Output – SQLite3 SELECT Statement

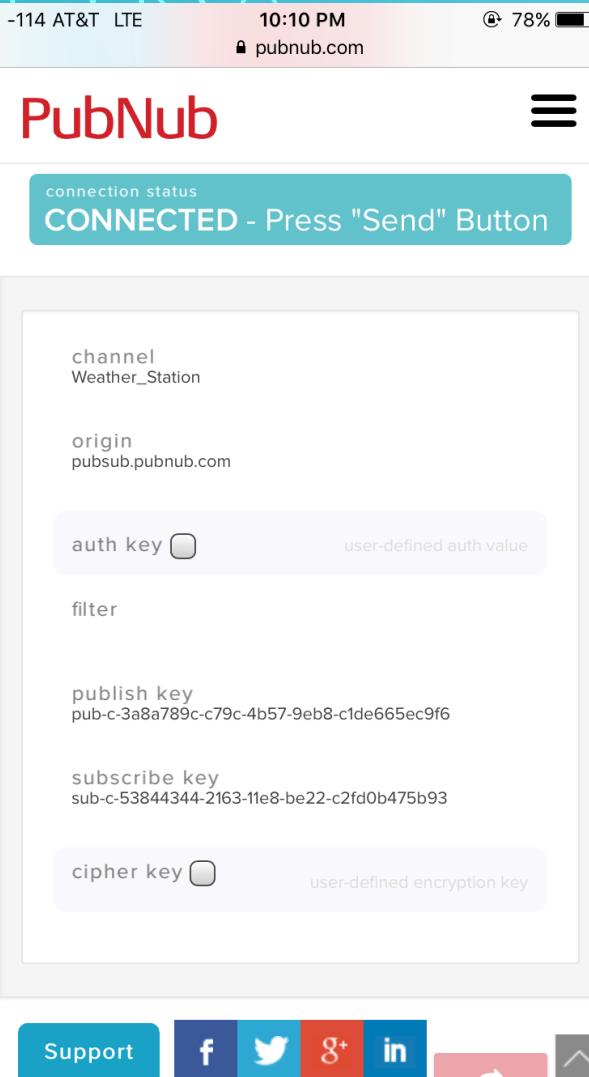
```
{ Unique_Sample_ID: 15, SENSOR_ID: 1, TEMPERATURE: 24.30 degC, PRESSURE: 1013.53 mbar, DATETIME: 2018/03/15 20:10:01 }
{ Unique_Sample_ID: 16, SENSOR_ID: 1, TEMPERATURE: 24.23 degC, PRESSURE: 1013.49 mbar, DATETIME: 2018/03/15 20:15:01 }
{ Unique_Sample_ID: 17, SENSOR_ID: 1, TEMPERATURE: 24.35 degC, PRESSURE: 1013.53 mbar, DATETIME: 2018/03/15 20:20:01 }
{ Unique_Sample_ID: 18, SENSOR_ID: 1, TEMPERATURE: 24.34 degC, PRESSURE: 1013.62 mbar, DATETIME: 2018/03/15 20:25:01 }
{ Unique_Sample_ID: 19, SENSOR_ID: 1, TEMPERATURE: 24.36 degC, PRESSURE: 1013.50 mbar, DATETIME: 2018/03/15 20:30:02 }
{ Unique_Sample_ID: 20, SENSOR_ID: 1, TEMPERATURE: 24.35 degC, PRESSURE: 1013.45 mbar, DATETIME: 2018/03/15 20:35:01 }
{ Unique_Sample_ID: 21, SENSOR_ID: 1, TEMPERATURE: 24.33 degC, PRESSURE: 1013.59 mbar, DATETIME: 2018/03/15 20:40:01 }
{ Unique_Sample_ID: 22, SENSOR_ID: 1, TEMPERATURE: 24.32 degC, PRESSURE: 1013.50 mbar, DATETIME: 2018/03/15 20:45:02 }
{ Unique_Sample_ID: 23, SENSOR_ID: 1, TEMPERATURE: 24.34 degC, PRESSURE: 1013.62 mbar, DATETIME: 2018/03/15 20:50:01 }
{ Unique_Sample_ID: 24, SENSOR_ID: 1, TEMPERATURE: 24.34 degC, PRESSURE: 1013.51 mbar, DATETIME: 2018/03/15 20:55:01 }
{ Unique_Sample_ID: 25, SENSOR_ID: 1, TEMPERATURE: 24.33 degC, PRESSURE: 1013.71 mbar, DATETIME: 2018/03/15 21:00:02 }
{ Unique_Sample_ID: 26, SENSOR_ID: 1, TEMPERATURE: 24.27 degC, PRESSURE: 1013.65 mbar, DATETIME: 2018/03/15 21:05:01 }
{ Unique_Sample_ID: 27, SENSOR_ID: 1, TEMPERATURE: 24.28 degC, PRESSURE: 1013.74 mbar, DATETIME: 2018/03/15 21:10:01 }
{ Unique_Sample_ID: 28, SENSOR_ID: 1, TEMPERATURE: 24.42 degC, PRESSURE: 1013.72 mbar, DATETIME: 2018/03/15 21:15:01 }
{ Unique_Sample_ID: 29, SENSOR_ID: 1, TEMPERATURE: 24.46 degC, PRESSURE: 1013.67 mbar, DATETIME: 2018/03/15 21:20:01 }
{ Unique_Sample_ID: 30, SENSOR_ID: 1, TEMPERATURE: 24.26 degC, PRESSURE: 1013.69 mbar, DATETIME: 2018/03/15 21:25:01 }
{ Unique_Sample_ID: 31, SENSOR_ID: 1, TEMPERATURE: 24.49 degC, PRESSURE: 1013.77 mbar, DATETIME: 2018/03/15 21:30:02 }
{ Unique_Sample_ID: 32, SENSOR_ID: 1, TEMPERATURE: 24.65 degC, PRESSURE: 1013.84 mbar, DATETIME: 2018/03/15 21:35:02 }
{ Unique_Sample_ID: 33, SENSOR_ID: 1, TEMPERATURE: 24.76 degC, PRESSURE: 1013.97 mbar, DATETIME: 2018/03/15 21:40:01 }
{ Unique_Sample_ID: 34, SENSOR_ID: 1, TEMPERATURE: 24.74 degC, PRESSURE: 1013.81 mbar, DATETIME: 2018/03/15 21:45:01 }
{ Unique_Sample_ID: 35, SENSOR_ID: 1, TEMPERATURE: 24.70 degC, PRESSURE: 1013.72 mbar, DATETIME: 2018/03/15 21:50:01 }
{ Unique_Sample_ID: 36, SENSOR_ID: 1, TEMPERATURE: 24.73 degC, PRESSURE: 1013.69 mbar, DATETIME: 2018/03/15 21:55:02 }
{ Unique_Sample_ID: 37, SENSOR_ID: 1, TEMPERATURE: 24.89 degC, PRESSURE: 1013.62 mbar, DATETIME: 2018/03/15 22:00:02 }
{ Unique_Sample_ID: 38, SENSOR_ID: 1, TEMPERATURE: 24.85 degC, PRESSURE: 1013.58 mbar, DATETIME: 2018/03/15 22:05:01 }
{ Unique_Sample_ID: 39, SENSOR_ID: 1, TEMPERATURE: 24.87 degC, PRESSURE: 1013.54 mbar, DATETIME: 2018/03/15 22:10:22 }
{ Unique_Sample_ID: 40, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.58 mbar, DATETIME: 2018/03/15 22:10:25 }
{ Unique_Sample_ID: 41, SENSOR_ID: 1, TEMPERATURE: 24.88 degC, PRESSURE: 1013.55 mbar, DATETIME: 2018/03/15 22:10:28 }
{ Unique_Sample_ID: 42, SENSOR_ID: 1, TEMPERATURE: 24.88 degC, PRESSURE: 1013.58 mbar, DATETIME: 2018/03/15 22:10:29 }
{ Unique_Sample_ID: 43, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.60 mbar, DATETIME: 2018/03/15 22:10:31 }
{ Unique_Sample_ID: 44, SENSOR_ID: 1, TEMPERATURE: 24.88 degC, PRESSURE: 1013.60 mbar, DATETIME: 2018/03/15 22:10:33 }
{ Unique_Sample_ID: 45, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.54 mbar, DATETIME: 2018/03/15 22:10:59 }
{ Unique_Sample_ID: 46, SENSOR_ID: 1, TEMPERATURE: 24.87 degC, PRESSURE: 1013.59 mbar, DATETIME: 2018/03/15 22:11:01 }
{ Unique_Sample_ID: 47, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.58 mbar, DATETIME: 2018/03/15 22:11:03 }
{ Unique_Sample_ID: 48, SENSOR_ID: 1, TEMPERATURE: 24.87 degC, PRESSURE: 1013.54 mbar, DATETIME: 2018/03/15 22:11:05 }
{ Unique_Sample_ID: 49, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.58 mbar, DATETIME: 2018/03/15 22:11:07 }
{ Unique_Sample_ID: 50, SENSOR_ID: 1, TEMPERATURE: 24.87 degC, PRESSURE: 1013.59 mbar, DATETIME: 2018/03/15 22:11:08 }
{ Unique_Sample_ID: 51, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.57 mbar, DATETIME: 2018/03/15 22:11:09 }
{ Unique_Sample_ID: 52, SENSOR_ID: 1, TEMPERATURE: 24.87 degC, PRESSURE: 1013.54 mbar, DATETIME: 2018/03/15 22:11:11 }
{ Unique_Sample_ID: 53, SENSOR_ID: 1, TEMPERATURE: 24.87 degC, PRESSURE: 1013.59 mbar, DATETIME: 2018/03/15 22:11:12 }
{ Unique_Sample_ID: 54, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.53 mbar, DATETIME: 2018/03/15 22:11:13 }
{ Unique_Sample_ID: 55, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.52 mbar, DATETIME: 2018/03/15 22:11:15 }
{ Unique_Sample_ID: 56, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.62 mbar, DATETIME: 2018/03/15 22:11:16 }
{ Unique_Sample_ID: 57, SENSOR_ID: 1, TEMPERATURE: 24.55 degC, PRESSURE: 1017.32 mbar, DATETIME: 2018/03/17 20:44:50 }
{ Unique_Sample_ID: 58, SENSOR_ID: 1, TEMPERATURE: 24.54 degC, PRESSURE: 1017.34 mbar, DATETIME: 2018/03/17 20:45:07 }
{ Unique_Sample_ID: 59, SENSOR_ID: 1, TEMPERATURE: 24.54 degC, PRESSURE: 1017.29 mbar, DATETIME: 2018/03/17 20:45:10 }
```

pi@raspberrypi:~/Assignment/Assignment10 \$

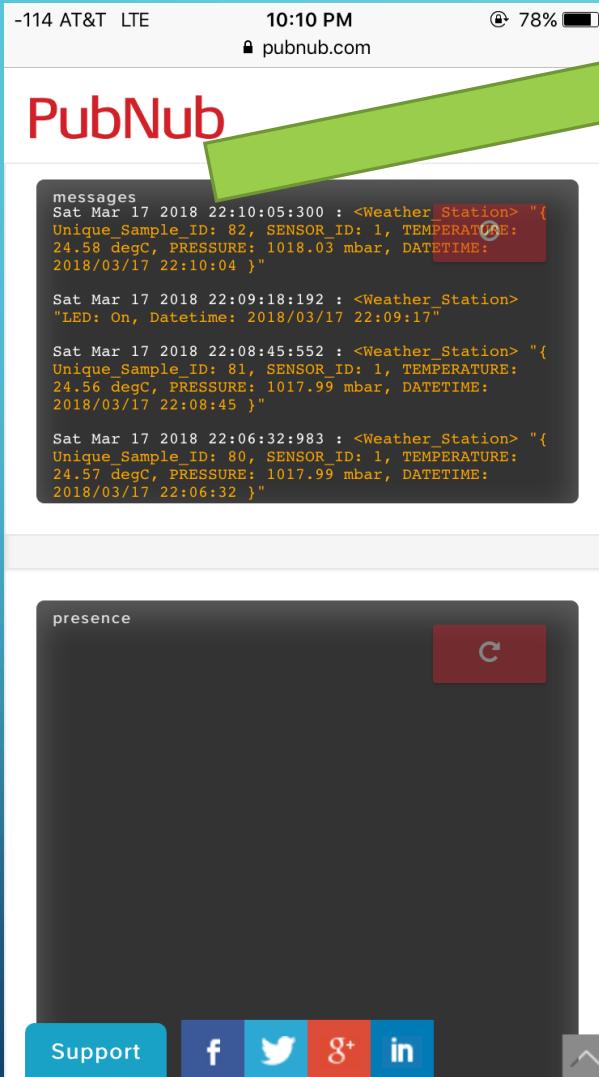
Data Output – Log File as a Backup

```
File Edit Search Options Help
{ Unique_Sample_ID: 25, SENSOR_ID: 1, TEMPERATURE: 24.33 degC, PRESSURE: 1013.71 mbar, DATETIME: 2018/03/15 21:00:02 }
{ Unique_Sample_ID: 26, SENSOR_ID: 1, TEMPERATURE: 24.27 degC, PRESSURE: 1013.65 mbar, DATETIME: 2018/03/15 21:05:01 }
{ Unique_Sample_ID: 27, SENSOR_ID: 1, TEMPERATURE: 24.28 degC, PRESSURE: 1013.74 mbar, DATETIME: 2018/03/15 21:10:01 }
{ Unique_Sample_ID: 28, SENSOR_ID: 1, TEMPERATURE: 24.42 degC, PRESSURE: 1013.72 mbar, DATETIME: 2018/03/15 21:15:01 }
{ Unique_Sample_ID: 29, SENSOR_ID: 1, TEMPERATURE: 24.46 degC, PRESSURE: 1013.67 mbar, DATETIME: 2018/03/15 21:20:01 }
{ Unique_Sample_ID: 30, SENSOR_ID: 1, TEMPERATURE: 24.26 degC, PRESSURE: 1013.69 mbar, DATETIME: 2018/03/15 21:25:01 }
LED: Off, Datetime: 2018/03/15 21:30:02
{ Unique_Sample_ID: 31, SENSOR_ID: 1, TEMPERATURE: 24.49 degC, PRESSURE: 1013.77 mbar, DATETIME: 2018/03/15 21:30:02 }
{ Unique_Sample_ID: 32, SENSOR_ID: 1, TEMPERATURE: 24.65 degC, PRESSURE: 1013.84 mbar, DATETIME: 2018/03/15 21:35:02 }
{ Unique_Sample_ID: 33, SENSOR_ID: 1, TEMPERATURE: 24.76 degC, PRESSURE: 1013.97 mbar, DATETIME: 2018/03/15 21:40:01 }
{ Unique_Sample_ID: 34, SENSOR_ID: 1, TEMPERATURE: 24.74 degC, PRESSURE: 1013.81 mbar, DATETIME: 2018/03/15 21:45:01 }
{ Unique_Sample_ID: 35, SENSOR_ID: 1, TEMPERATURE: 24.70 degC, PRESSURE: 1013.72 mbar, DATETIME: 2018/03/15 21:50:01 }
{ Unique_Sample_ID: 36, SENSOR_ID: 1, TEMPERATURE: 24.73 degC, PRESSURE: 1013.69 mbar, DATETIME: 2018/03/15 21:55:02 }
LED: On, Datetime: 2018/03/15 22:00:02
{ Unique_Sample_ID: 37, SENSOR_ID: 1, TEMPERATURE: 24.89 degC, PRESSURE: 1013.62 mbar, DATETIME: 2018/03/15 22:00:02 }
{ Unique_Sample_ID: 38, SENSOR_ID: 1, TEMPERATURE: 24.85 degC, PRESSURE: 1013.58 mbar, DATETIME: 2018/03/15 22:05:01 }
{ Unique_Sample_ID: 39, SENSOR_ID: 1, TEMPERATURE: 24.87 degC, PRESSURE: 1013.54 mbar, DATETIME: 2018/03/15 22:10:22 }
{ Unique_Sample_ID: 40, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.58 mbar, DATETIME: 2018/03/15 22:10:25 }
{ Unique_Sample_ID: 41, SENSOR_ID: 1, TEMPERATURE: 24.88 degC, PRESSURE: 1013.55 mbar, DATETIME: 2018/03/15 22:10:28 }
{ Unique_Sample_ID: 42, SENSOR_ID: 1, TEMPERATURE: 24.88 degC, PRESSURE: 1013.58 mbar, DATETIME: 2018/03/15 22:10:29 }
{ Unique_Sample_ID: 43, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.60 mbar, DATETIME: 2018/03/15 22:10:31 }
{ Unique_Sample_ID: 44, SENSOR_ID: 1, TEMPERATURE: 24.88 degC, PRESSURE: 1013.60 mbar, DATETIME: 2018/03/15 22:10:33 }
LED: Off, Datetime: 2018/03/15 22:10:40
LED: Off, Datetime: 2018/03/15 22:10:43
LED: On, Datetime: 2018/03/15 22:10:49
LED: Off, Datetime: 2018/03/15 22:10:52
LED: On, Datetime: 2018/03/15 22:10:55
LED: Off, Datetime: 2018/03/15 22:10:57
{ Unique_Sample_ID: 45, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.54 mbar, DATETIME: 2018/03/15 22:10:59 }
{ Unique_Sample_ID: 46, SENSOR_ID: 1, TEMPERATURE: 24.87 degC, PRESSURE: 1013.59 mbar, DATETIME: 2018/03/15 22:11:01 }
{ Unique_Sample_ID: 47, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.58 mbar, DATETIME: 2018/03/15 22:11:03 }
{ Unique_Sample_ID: 48, SENSOR_ID: 1, TEMPERATURE: 24.87 degC, PRESSURE: 1013.54 mbar, DATETIME: 2018/03/15 22:11:05 }
{ Unique_Sample_ID: 49, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.58 mbar, DATETIME: 2018/03/15 22:11:07 }
{ Unique_Sample_ID: 50, SENSOR_ID: 1, TEMPERATURE: 24.87 degC, PRESSURE: 1013.59 mbar, DATETIME: 2018/03/15 22:11:08 }
{ Unique_Sample_ID: 51, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.57 mbar, DATETIME: 2018/03/15 22:11:09 }
{ Unique_Sample_ID: 52, SENSOR_ID: 1, TEMPERATURE: 24.87 degC, PRESSURE: 1013.54 mbar, DATETIME: 2018/03/15 22:11:11 }
{ Unique_Sample_ID: 53, SENSOR_ID: 1, TEMPERATURE: 24.87 degC, PRESSURE: 1013.59 mbar, DATETIME: 2018/03/15 22:11:12 }
{ Unique_Sample_ID: 54, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.53 mbar, DATETIME: 2018/03/15 22:11:13 }
{ Unique_Sample_ID: 55, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.52 mbar, DATETIME: 2018/03/15 22:11:15 }
{ Unique_Sample_ID: 56, SENSOR_ID: 1, TEMPERATURE: 24.86 degC, PRESSURE: 1013.62 mbar, DATETIME: 2018/03/15 22:11:16 }
LED: On, Datetime: 2018/03/17 20:44:44
LED: Off, Datetime: 2018/03/17 20:44:47
{ Unique_Sample_ID: 57, SENSOR_ID: 1, TEMPERATURE: 24.55 degC, PRESSURE: 1017.32 mbar, DATETIME: 2018/03/17 20:44:50 }
LED: On, Datetime: 2018/03/17 20:45:02
{ Unique_Sample_ID: 58, SENSOR_ID: 1, TEMPERATURE: 24.54 degC, PRESSURE: 1017.34 mbar, DATETIME: 2018/03/17 20:45:07 }
{ Unique_Sample_ID: 59, SENSOR_ID: 1, TEMPERATURE: 24.54 degC, PRESSURE: 1017.29 mbar, DATETIME: 2018/03/17 20:45:10 }
```

Data Output – PubNub on Cellphone Out of Network (On The Go)



A screenshot of a smartphone displaying the PubNub mobile application. The top status bar shows signal strength (-114 AT&T LTE), time (10:10 PM), and battery level (78%). The app header reads "PubNub". Below it, a teal button says "CONNECTED - Press 'Send' Button". The main interface shows configuration fields for "channel" (Weather_Station), "origin" (pubsub.pubnub.com), "auth key" (input field), "filter" (input field), "publish key" (pub-c-3a8a789c-c79c-4b57-9eb8-c1de665ec9f6), "subscribe key" (sub-c-53844344-2163-11e8-be22-c2fd0b475b93), and "cipher key" (input field). At the bottom are "Support" and social media links for Facebook, Twitter, Google+, and LinkedIn.



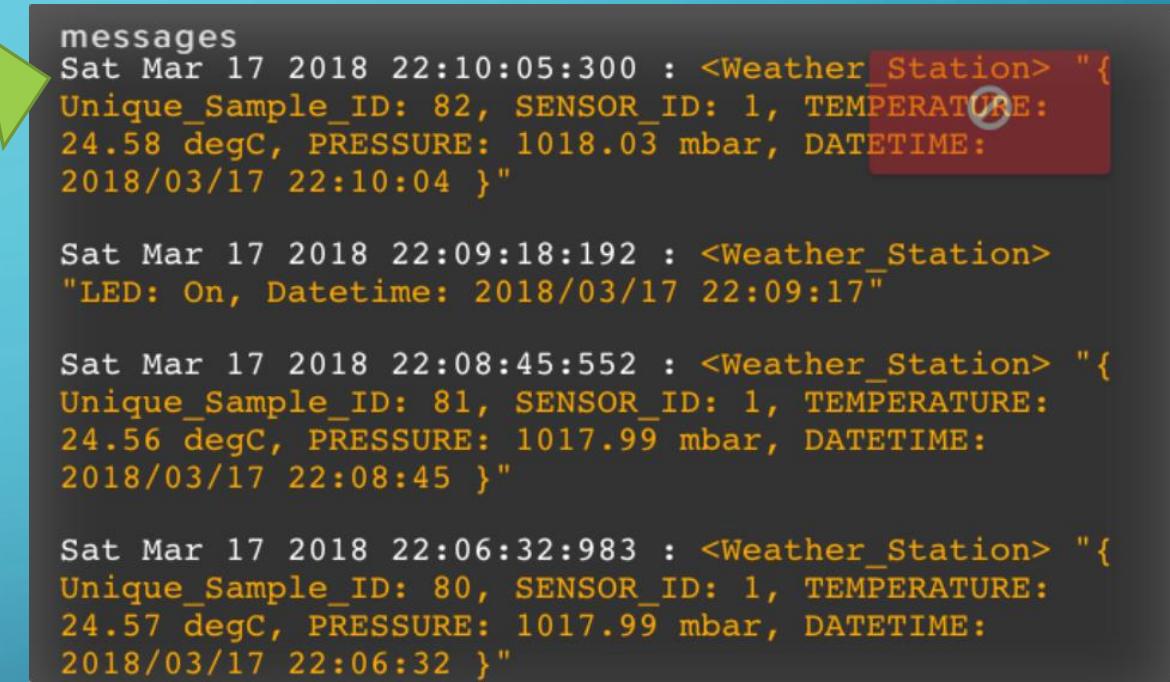
A screenshot of the same smartphone screen, but now showing data output. A large green arrow points from the left side of the screen towards the right, indicating the flow of data. The data is displayed in a "messages" section. It shows five log entries from a "Weather_Station" channel. The entries include timestamp, message type (<Weather_Station>), Unique_Sample_ID, SENSOR_ID, TEMPERATURE, LED status, and DATETIME.

```
messages
Sat Mar 17 2018 22:10:05:300 : <Weather_Station> "{Unique_Sample_ID: 82, SENSOR_ID: 1, TEMPERATURE: 24.58 degC, PRESSURE: 1018.03 mbar, DATETIME: 2018/03/17 22:10:04 }"

Sat Mar 17 2018 22:09:18:192 : <Weather_Station> "LED: On, Datetime: 2018/03/17 22:09:17"

Sat Mar 17 2018 22:08:45:552 : <Weather_Station> "{Unique_Sample_ID: 81, SENSOR_ID: 1, TEMPERATURE: 24.56 degC, PRESSURE: 1017.99 mbar, DATETIME: 2018/03/17 22:08:45 }"

Sat Mar 17 2018 22:06:32:983 : <Weather_Station> "{Unique_Sample_ID: 80, SENSOR_ID: 1, TEMPERATURE: 24.57 degC, PRESSURE: 1017.99 mbar, DATETIME: 2018/03/17 22:06:32 }"
```



A terminal window or command-line interface showing the received data. The data is identical to what was shown on the smartphone screen, with five log entries from a "Weather_Station" channel. Each entry includes a timestamp, message type (<Weather_Station>), Unique_Sample_ID, SENSOR_ID, TEMPERATURE, LED status, and DATETIME.

```
messages
Sat Mar 17 2018 22:10:05:300 : <Weather_Station> "{Unique_Sample_ID: 82, SENSOR_ID: 1, TEMPERATURE: 24.58 degC, PRESSURE: 1018.03 mbar, DATETIME: 2018/03/17 22:10:04 }"

Sat Mar 17 2018 22:09:18:192 : <Weather_Station> "LED: On, Datetime: 2018/03/17 22:09:17"

Sat Mar 17 2018 22:08:45:552 : <Weather_Station> "{Unique_Sample_ID: 81, SENSOR_ID: 1, TEMPERATURE: 24.56 degC, PRESSURE: 1017.99 mbar, DATETIME: 2018/03/17 22:08:45 }"

Sat Mar 17 2018 22:06:32:983 : <Weather_Station> "{Unique_Sample_ID: 80, SENSOR_ID: 1, TEMPERATURE: 24.57 degC, PRESSURE: 1017.99 mbar, DATETIME: 2018/03/17 22:06:32 }"
```

SQLite3 Schema (DB Browser)

Database Structure Browse Data Edit Pragmas Execute SQL

Create Table Create Index Modify Table Delete Table

Name	Type	Schema
Tables (1)		
SENSORS_TABLE		CREATE TABLE SENSORS_TABLE (SENSOR_ID INTEGER, TEMPERATURE REAL, PRESSURE REAL, DATETIME TEXT)
SENSOR_ID	INTEGER	'SENSOR_ID' INTEGER
TEMPERATURE	REAL	'TEMPERATURE' REAL
PRESSURE	REAL	'PRESSURE' REAL
DATETIME	TEXT	'DATETIME' TEXT
Indices (0)		
Views (0)		
Triggers (0)		

New Database Open Database Write Changes Revert Changes

Database Structure Browse Data Edit Pragmas Execute SQL

Table: SENSORS_TABLE

	SENSOR_ID	TEMPERATURE	PRESSURE	DATETIME
1	1	26.3830445144325	1013.34938938896	2018/03/10 15:13:16
2	1	26.3535505878041	1013.42898084689	2018/03/10 15:13:53
3	1	26.3633818955161	1013.34163031477	2018/03/10 15:13:56
4	1	26.3584662415145	1013.38530593308	2018/03/10 15:13:58
5	1	26.3437192812562	1013.30785245908	2018/03/10 15:14:00
6	1	26.3535505878041	1013.37694464854	2018/03/10 15:14:25
7	1	26.3535505878041	1013.37694464854	2018/03/10 15:15:31
8	1	26.3437192812562	1013.33387007807	2018/03/10 15:15:33
9	1	26.3535505878041	1013.35092658429	2018/03/10 15:15:35
10	1	26.2650688707828	1013.25145766833	2018/03/10 15:22:06
11	1	26.2699845192546	1013.28583318986	2018/03/10 15:22:09
12	1	26.2601532226021	1013.16472000666	2018/03/10 15:22:11
13	1	26.2601532226021	1013.21674818555	2018/03/10 15:22:12
14	1	26.2749001680175	1013.32020917816	2018/03/10 15:22:13
15	1	26.2749001680175	1013.26817960198	2018/03/10 15:22:14
16	1	26.2798158170714	1013.30255559678	2018/03/10 15:22:17
17	1	26.2650688707828	1013.27747203109	2018/03/10 15:22:21
18	1	26.2749001680175	1013.24216484881	2018/03/10 15:24:19
19	1	26.2994784161972	1013.25828783514	2018/03/10 15:25:06

Temperature and Pressure Statistics

Tabulated With SQLite3 MIN, AVG, MAX Functions Using
“render_template” Method within Flask Web Framework

<http://192.168.1.200:8080/final/api/dashboard>

From 192.168.1.200:8080

Welcome To The Weather Station!
Check The Weather Before You Go Out.

OK

Weather Station Dashboard

This is a webpage that displays Temperature and Pressure Statistics.

Current Date and Time Stamp: 2018/03/20 00:40:09.

Total Samples of Temperature	33	Datetime of Samples Taken
Minimum Temperature (degC)	24.44	2018/03/20 00:18:06
Average Temperature (degC)	26.07	N/A
Maximum Temperature (degC)	32.19	2018/03/20 00:22:27

Total Samples of Pressure	33	Datetime of Samples Taken
Minimum Pressure (degC)	1015.19	2018/03/20 00:23:23
Average Pressure (degC)	1015.27	N/A
Maximum Pressure (degC)	1015.36	2018/03/20 00:17:53

Number of Samples Statistics are Calculated from

Temperature and Pressure Statistics

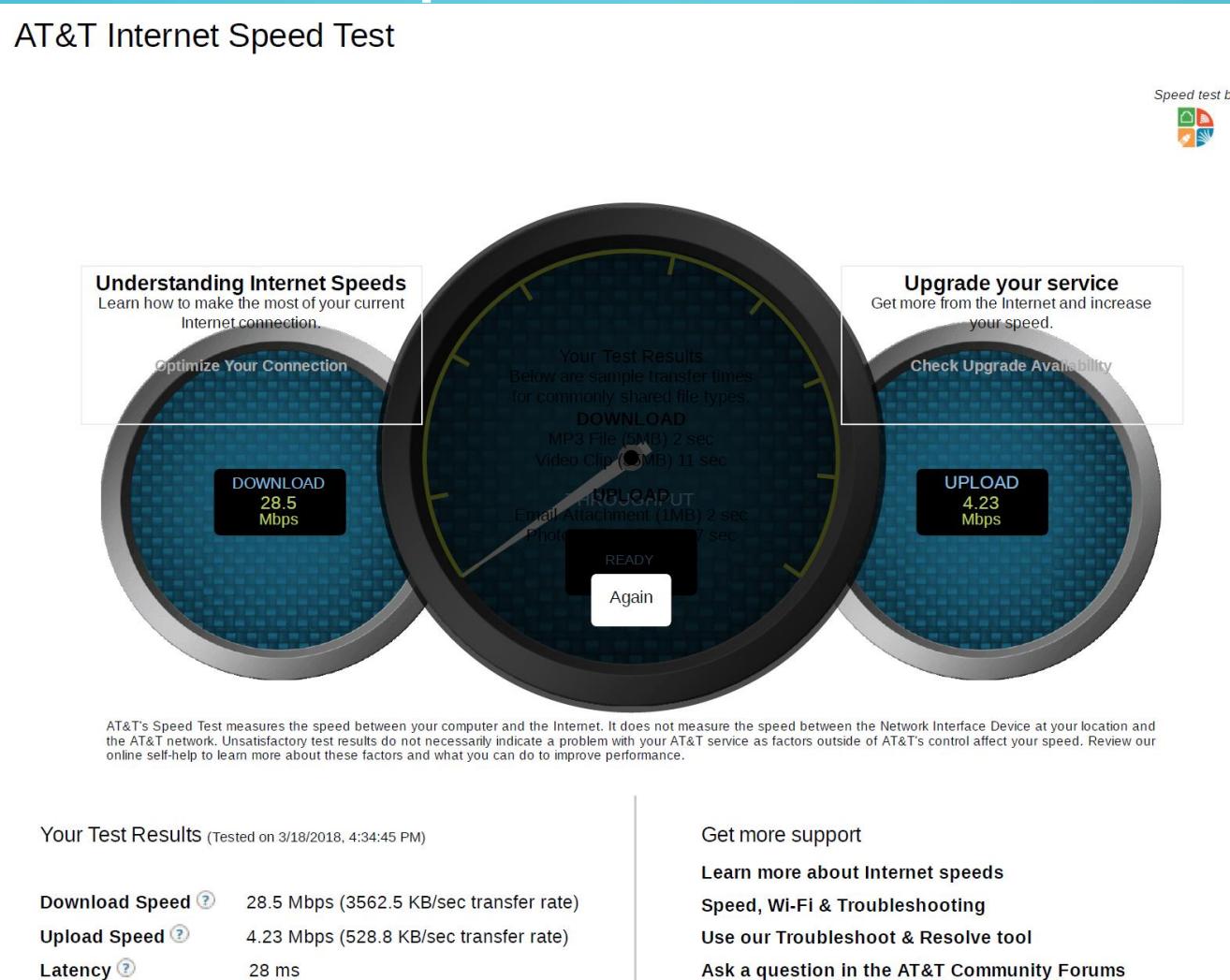
Using SQLite3 MIN, AVG, MAX Functions on Primary Console

```
pi@raspberrypi:~/Assignment/Final $ ./final-kf_db_statistics.py
Number of Samples Statistics  
are Calculated from
----- TEMPERATURE Statistics of 33 Samples -----
MINIMUM TEMPERATURE: 24.44 degC DATETIME: 2018/03/20 00:18:06
AVERAGE TEMPERATURE: 26.07 degC
MAXIMUM TEMPERATURE: 32.19 degC DATETIME: 2018/03/20 00:22:27
Number of Samples Statistics  
are Calculated from
----- PRESSURE Statistics of 33 Samples -----
MINIMUM PRESSURE: 1015.19 mbar DATETIME: 2018/03/20 00:23:23
AVERAGE PRESSURE: 1015.27 mbar
MAXIMUM PRESSURE: 1015.36 mbar DATETIME: 2018/03/20 00:17:53
pi@raspberrypi:~/Assignment/Final $
```

Network/Interface Technologies

Ethernet Upload and Download Speed

AT&T Internet Speed Test



Network/Interface Technologies

IP: 192.168.1.200, Port: 8080

Gateway/Router: 192.168.1.254

Subnet Mask: 255.255.255.0

USB: Keyboard, Mouse

HDMI: Video Output

GPIO, I²C (SCL, SDA): Sensor/Actuator Drive

3.3V, 5V: ICs, LCD Back Light



Network/Interface Technologies

Physical Layer: Ethernet

Network Layer: IPv4

Data Format: JSON

Application: RESTful, Flask, HTTP GET & POST, SQLite3, PubNub

Programming: Python, SQLite3, CURL, Linux, HTML, CSS, JS



Questions and Answers

Thank You