**UNIVERSITY OF PERADENIYA**
**FACULTY OF ENGINEERING**
**DEPARTMENT OF COMPUTER ENGINEERING**

# PROJECT DESIGN DOCUMENT

# Networked and Automated Weather Monitoring and Alerting System

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# Table of Contents

# USER MANUAL

# Introduction

Weather conditions and climate changes must be logged and analyzed by relevant authorities like meteorological department each day. They take relevant actions observing those records obtained all over the island. But in the current manual system they collect information only from main cities and taking responses manually takes much time and effort.

So in this unified project we develop a system that can be used to collect information from much many places allover Sri Lanka using an embedded system kept in those locations. The locations may be places in each district close to sea, rivers, reservoirs, tanks and other areas. The data are wind speed, rainfall, humidity, temperature.

All those data taken from those sensors, are sent to a central server and processed there. If there are extreme weather cases that public must be warned, it will be notified through web application. The process is very quicker than manual method. So the damages due to extreme weather is reduced as well as meteorological department will have newest data from all over the country.

The live situation of the places can be viewed through the application.

# Safety Instructions

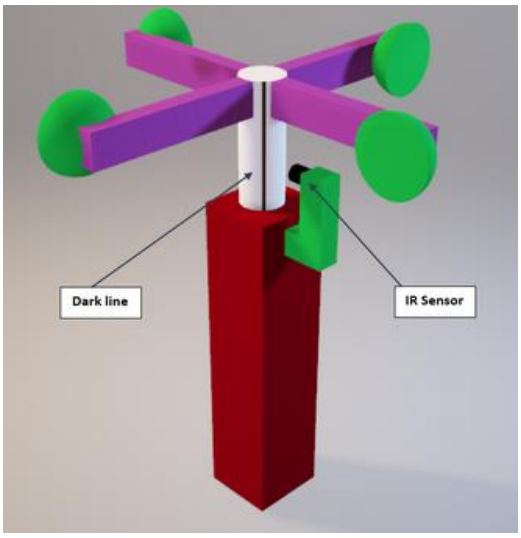
Read carefully and thoroughly through this manual as it contains important safety instructions that will prevent potential damages to the product and users

- This Device need 12 volts power supply. Do not provide more than 12 volts or less than 12 volts.
- This device has a sensitive GSM module. So do not keep the device near heavy temperatures that will damage it.
- This device is made to keep in an outdoor open place. So take steps to avoid lightning damages.
- In any instant do not open the control system, while using.
- Do not keep the device in unstable places. Falling it can cause damages to device as well as people.

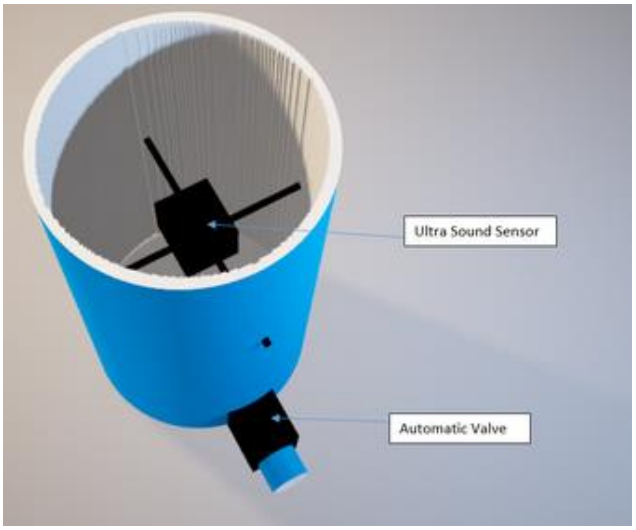
# Get Started

- Firstly Install the Embedded systems in the places you need to keep monitoring the weather data.
- Place the SIM card in the GSM module correctly.
- Make sure the place is an open area where no interference to weather.
- Give 12 volt power supply to the systems.
- Now your embedded devices will start working until power is there.
- Now log into the web application and go to settings.
- Select add location and manually add the locations you installed the devices giving their latitude, longitude, name and the id of the device.
- Now reload the web application and you will see the locations in the summary map of main page. If that is so you have successfully configured the devices.
- Now you can monitor the weather using the web application.

# Embedded System

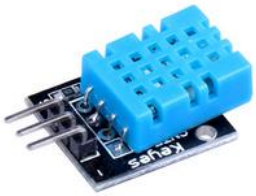



(A)

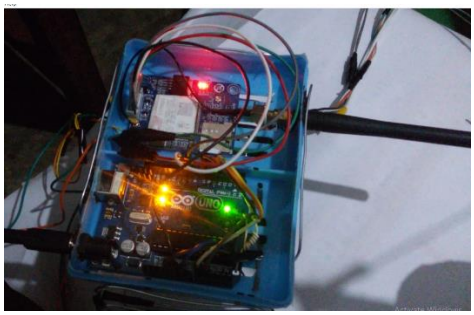



(B)


(C)



(D)



(E)

**(A) - Wind measuring part**

**(B) - Rainfall measuring part**

**(C) - Rain Status measuring sensor**

**(D) - Temperature/Humidity Sensor**

**(E) - Control System (Microcontroller/GSM module)**

# Web Application


## Summary Page

This page gives the Summary of the Weather parameters Temperature, Humidity, Wind Speed, and Rain Fall of all locations where embedded devices are registered.

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This button says that the page is LIVE. That means the summary is changed automatically when weather changes.

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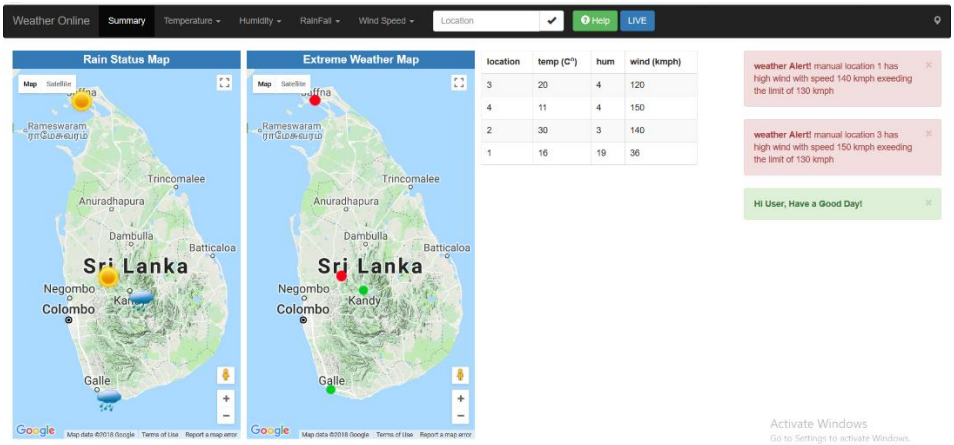
This is the view of the summary page.




- No need to specify a location to view summary because it depend on all locations.
- There are two maps of Sri Lanka in the page.
- The first map gives the Rain Status Map it gives the live data of all locations island wide whether it is raining or not.
- If a specific location is shown as  it says that it is raining in that location. When the icon is  it says that the location has no rain at the moment.
- The icons change automatically when the situation changes. So users can view the rain status of the island at any moment.
- The second map gives the extreme weather map of Sri Lanka. It denote any place with an extreme condition with a red dot  and no extreme case with a green dot 

**The extreme cases are**

Having temperature >= 40 °C or <= 10 °C

Having wind speed >= 130 kmph

Having rainfall >= 100mm.

So the table next to maps give the latest data for all locations. Users can explore the data in the tables.

Right to the table is the notification panel.


Notification Panel give the latest notifications of extreme cases of weather with a beep sound. The notification consist of the extreme case, the location as well as the limit.

## Today's Chart Page

This page gives the relevant weather variation chart in that day.

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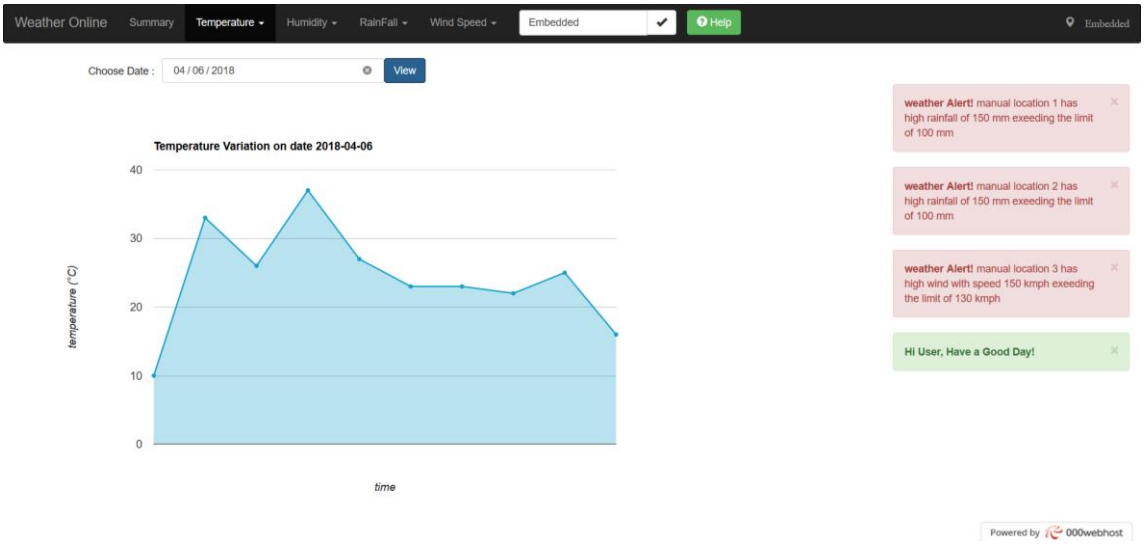
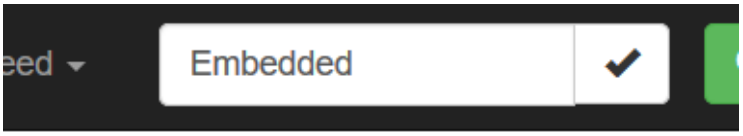
This button says that the page is LIVE. That means the summary is changed automatically when weather changes.

---

This is the view of the today's chart page.



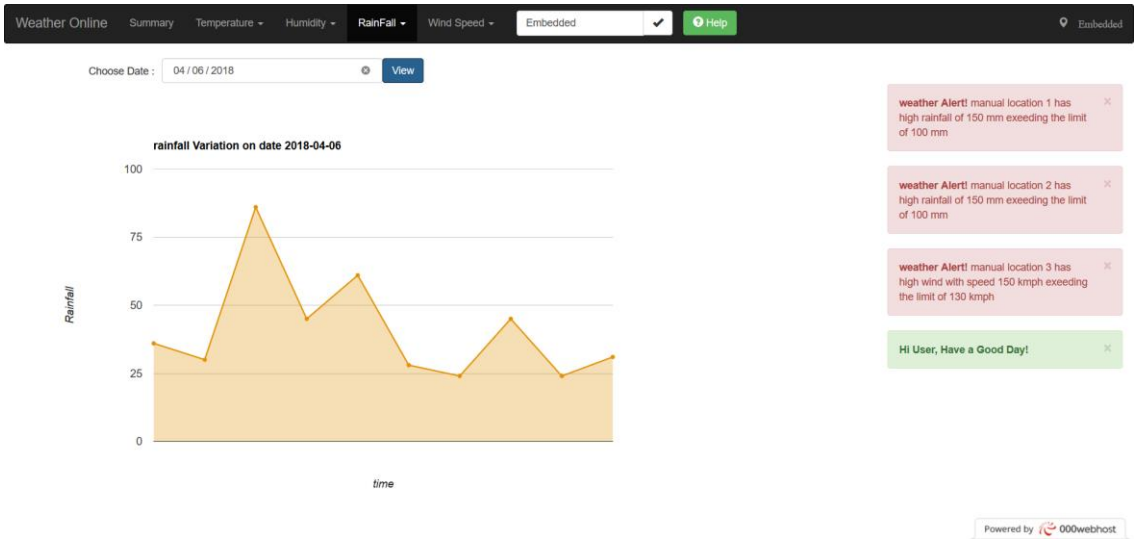

**Prior to view the today's chart, user must select the location which he want to view using the drop down list at location selecting box and press the tick.**



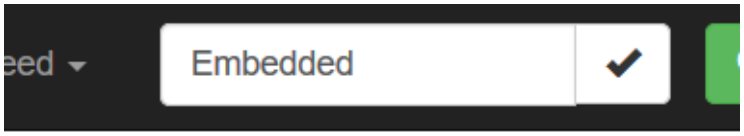

## Chart by day Page

This page gives the complete relevant weather variation chart in a given date.

This is the view of the chart by day page.




**Prior to view the chart by day, user must select the location which he want to view using the drop down list at location selecting box and press the tick.**

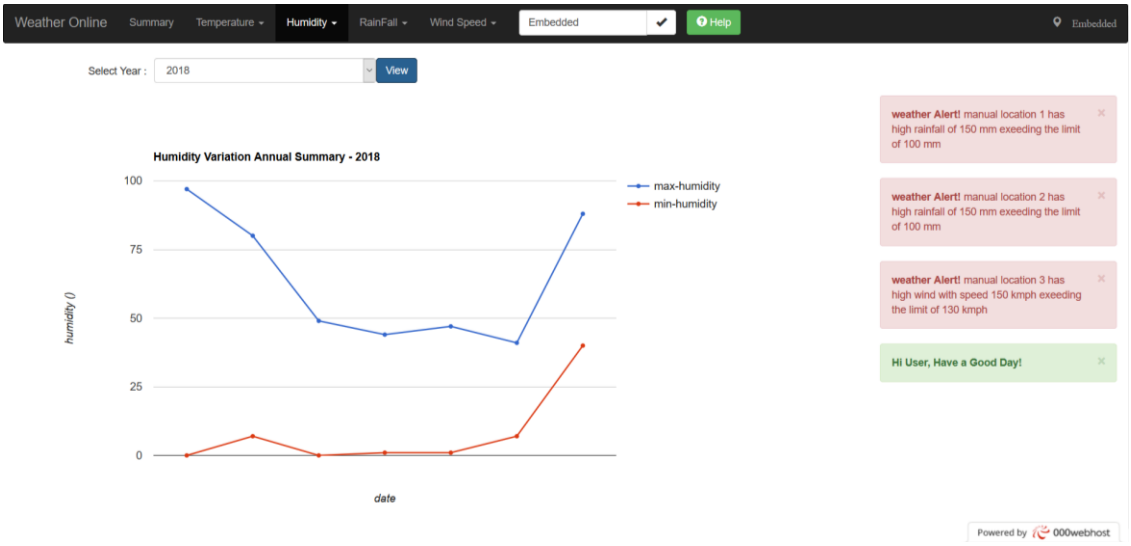



## Annual Summary Page

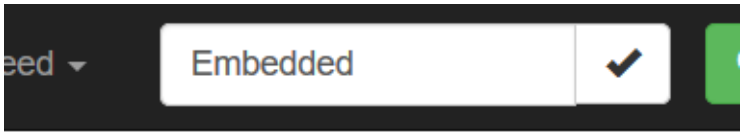
This page gives the annual summary of a weather parameter, throughout the year, day wise.

The maximum value of any day, minimum value of any day, and their variation can be viewed through it.

This is the view of Annual Summary page.




**Prior to view the Annual Summary, user must select the location which he want to view using the drop down list at location selecting box and press the tick.**



# Troubleshooting

**If the system doesn’t work as expected.**

- **Check the power connection. Check whether the power ratings are correct.**
- **Check whether the GSM module has the SIM correctly placed.**
- **Change the SIM card.**
- **Make sure the IR sensor of wind speed measuring system is adjusted correctly. If not adjust it such that it directs perpendicular to the black/white surface.**

# Specifications

| | |
|---|---|
| **Voltage** | **12 V** |
| **Current** | **1 A** |
| **Power** | **12 W** |
| **Weight** | **500g** |
| **Height** | **55cm** |

# Technical Note

# Chapter 1 - Background of the Project

## Background of the Project

Weather conditions and climate changes must be logged and analyzed by relevant authorities like meteorological department each day. They take relevant actions observing those records obtained all over the island. But in the current manual system they collect information only from main cities and taking responses manually takes much time and effort.

So in this unified project we develop a system that can be used to collect information from much many places allover Sri Lanka using an embedded system kept in those locations. The locations may be places in each district close to sea, rivers, reservoirs, tanks and other areas. The data are wind speed, rain status, rainfall, humidity, temperature etc.

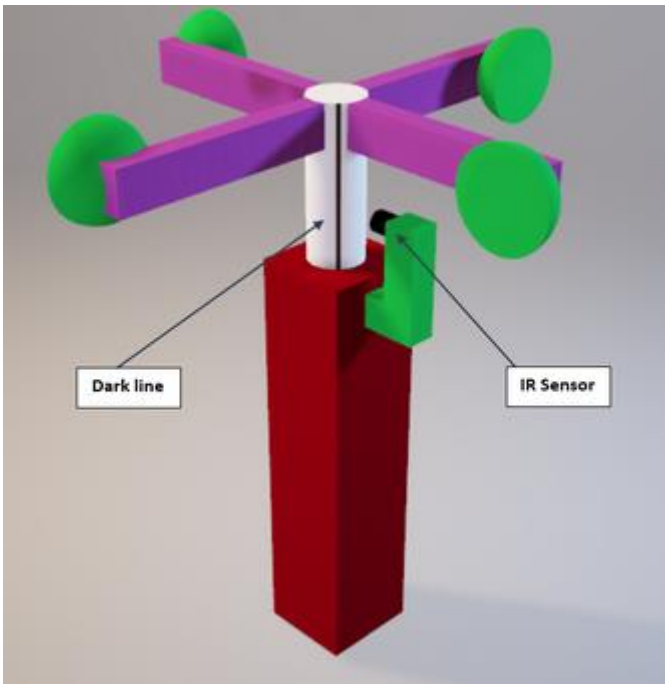
All those data taken from those sensors, are sent to a central server and processed there. If there are extreme weather cases, public must be warned. So the web application gives instant alerts to its users including relevant central authorities as well as regional authorities. The process is very quicker than manual method. So the damages due to extreme weather is reduced as well as meteorological department will have newest data from all over the country.

# Chapter 2 - Plans and Designs

## a Hardware Design

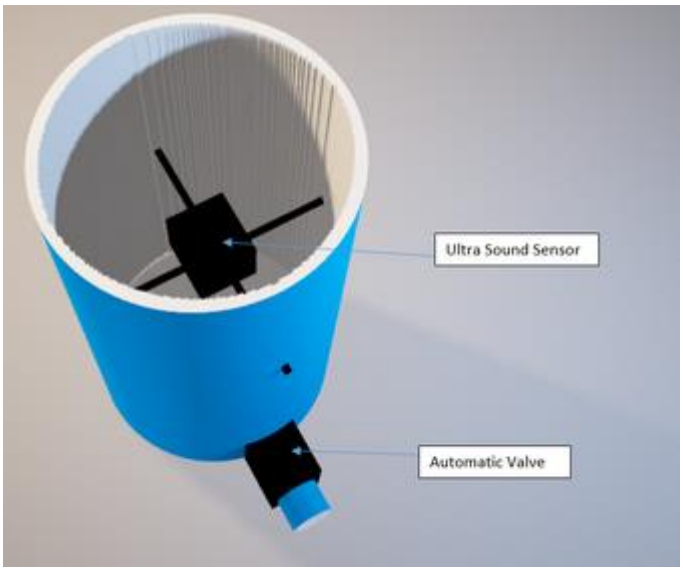
- **Wind Speed Sensing System**
  - This is a wind Vane that rotates with wind. We are making a mechanism using IR sensor to get the time taken to complete a full cycle by vane. The wind speed is calculated using that data.

  - The model wind vane expected to be build is given below.




Infrared barrier module is the IR sensor we are planning to use. It emits infra-red waves and monitor the reflected rays. It can identify black and white screens.

- **Rainfall measuring System**
  - This has a cylindrical vessel with fixed cross section that collects rain water and measure the water level using an ultrasound sensor kept few cm below top of the vessel. Sensor not having at top most is to avoid water drops to go away hitting the sensor.
  - Also this has a automatic valve to remove water daily after reporting to server, based on the sonar sensor reading.
  - Also this has a rain sensor to identify whether it is raining or not.
  - Below is the model of the system.

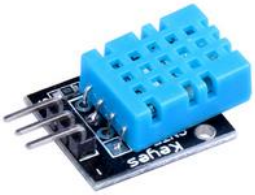



This is the ultrasonic sensor we are planning to use (HC-SR04)

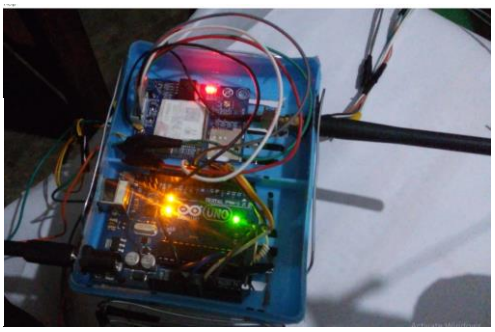
This is the automatic valve we are using. It is a plastic solenoid valve

- **Rainfall Status Sensor**
  - This is a single sensor that sense whether it is raining or not.
  - For that we use rain drop sensor given below.

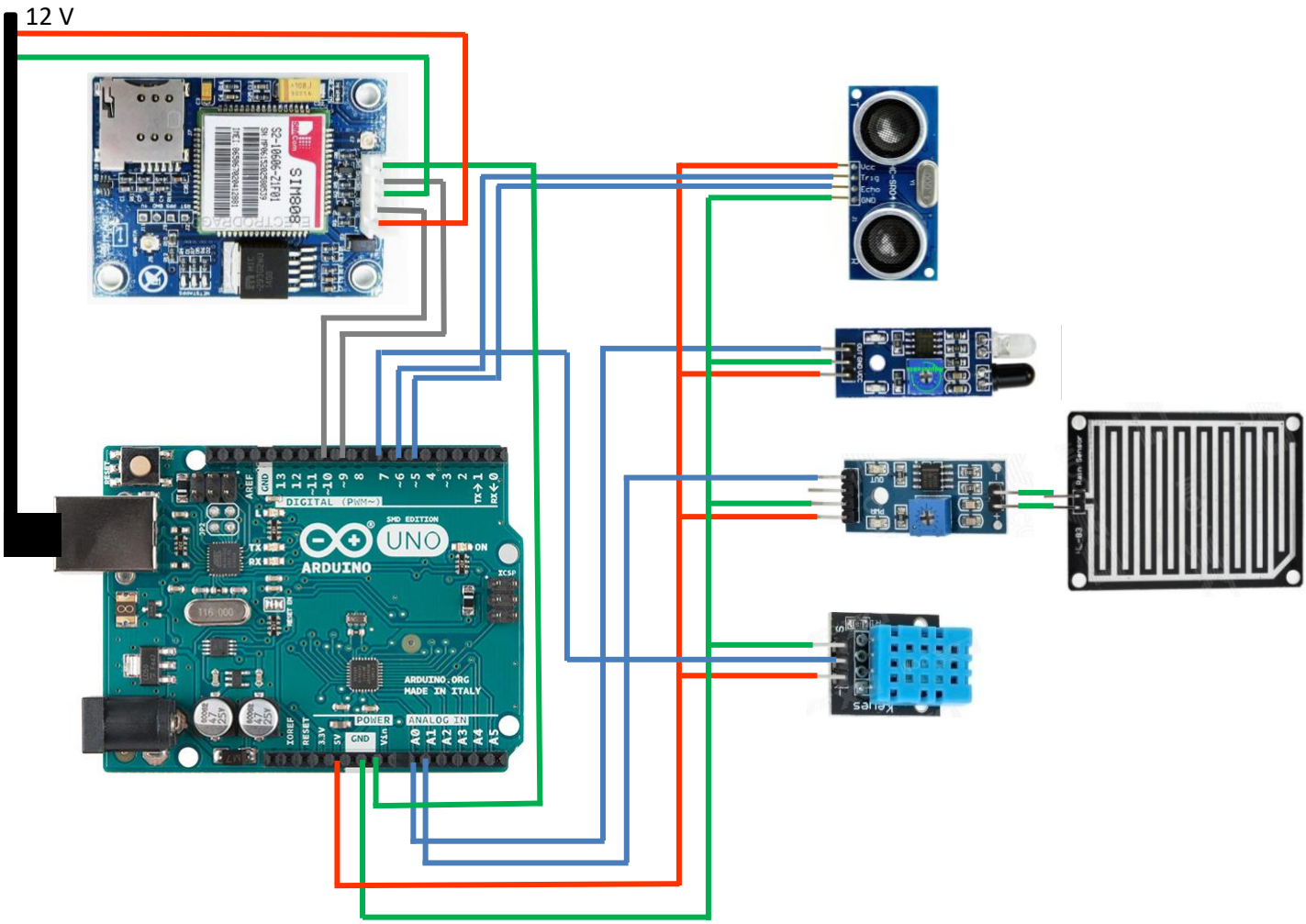

- **Temperature and Humidity measuring System**
  - This is a single sensor that sense temperature and humidity.
  - For that we use Humidity and Temperature DHT11 Module in below picture.



- **Microcontroller + GSM Module**
  - We use Atmega328p microcontroller for each node connecting all the above mentioned sub parts.
  - We will use ARDUINO UNO board which has Atmega328p microcontroller
  - As we need the embedded unit at places normally we can't expect WIFI access, we decided to use a GSM module to send data collected to the central server.
  - So the GSM module we are using is sim808 module.

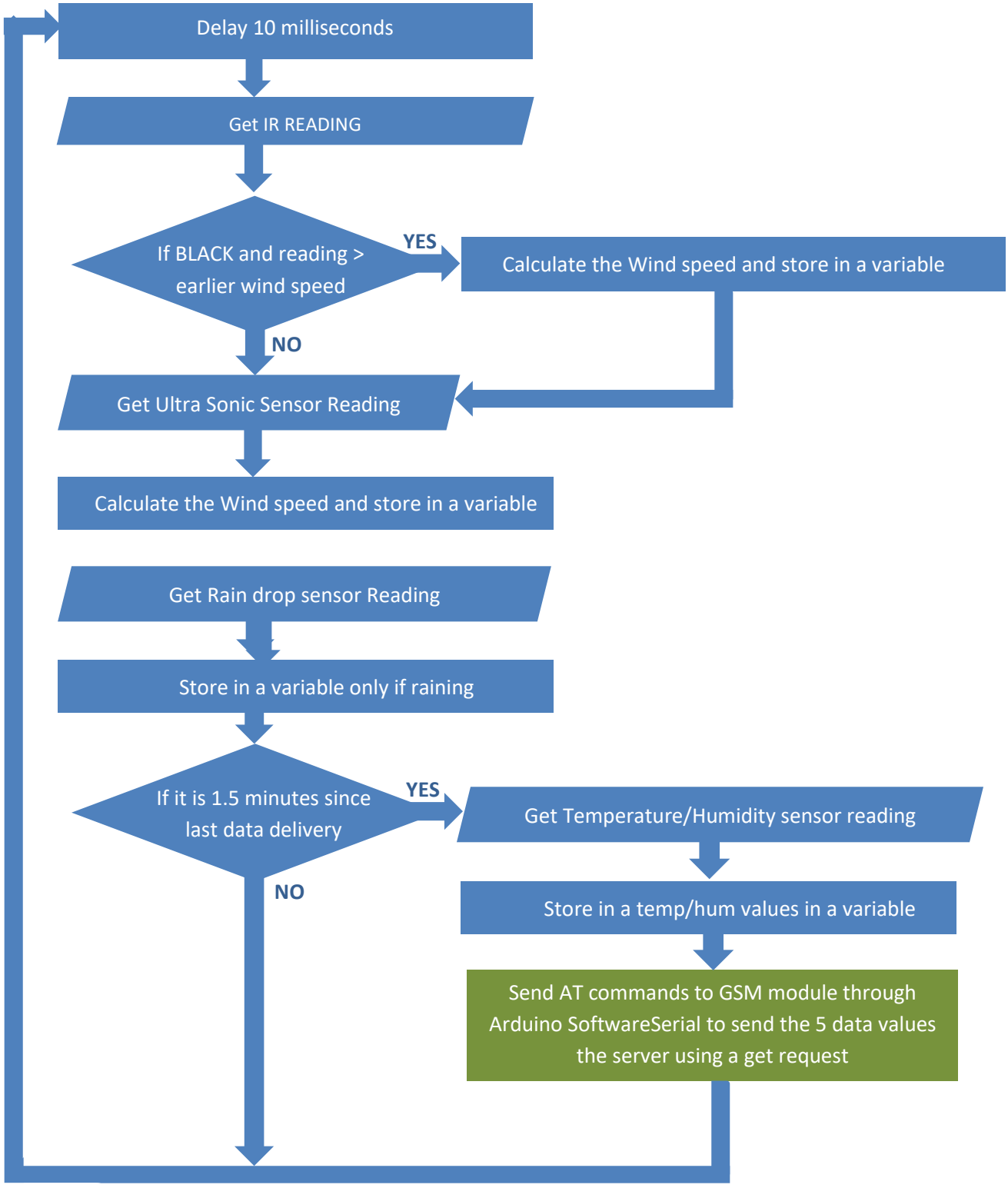



## Circuit Diagram



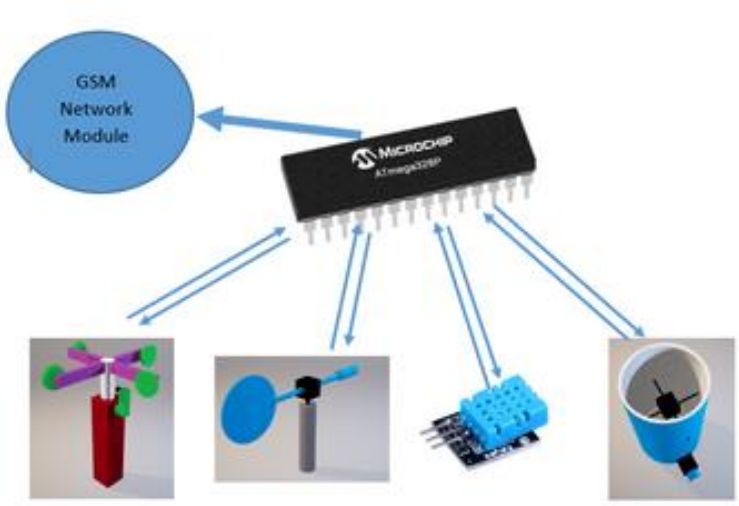
## b Embedded software design

Technology - ARDUINO

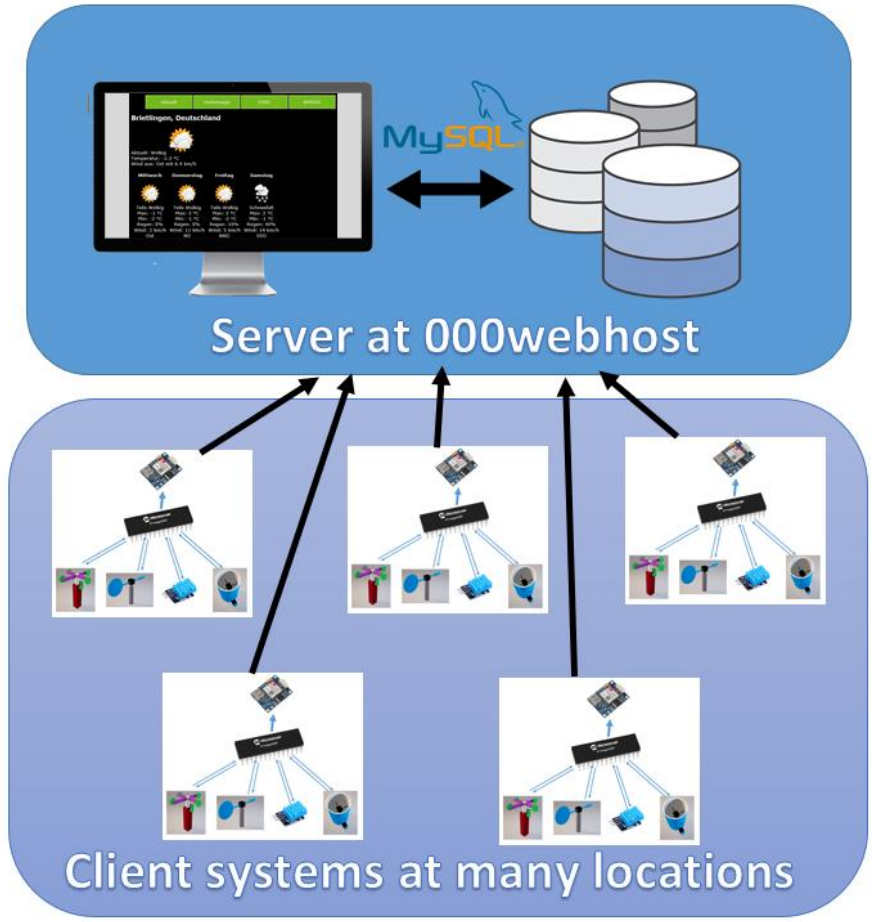


# C Network Design

This is the architecture of a single node. There are many such nodes in the network.



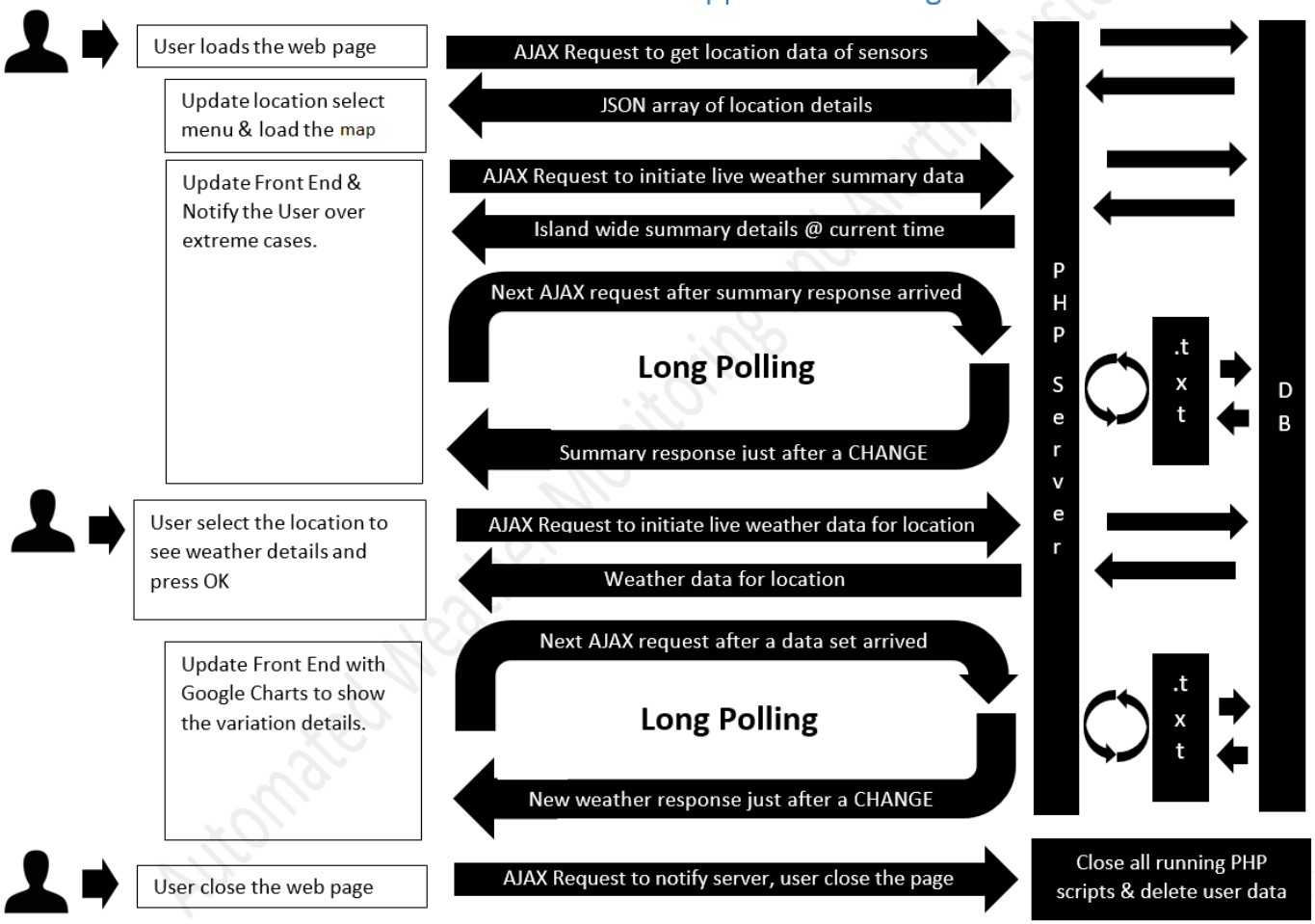

So the complete network diagram is given below



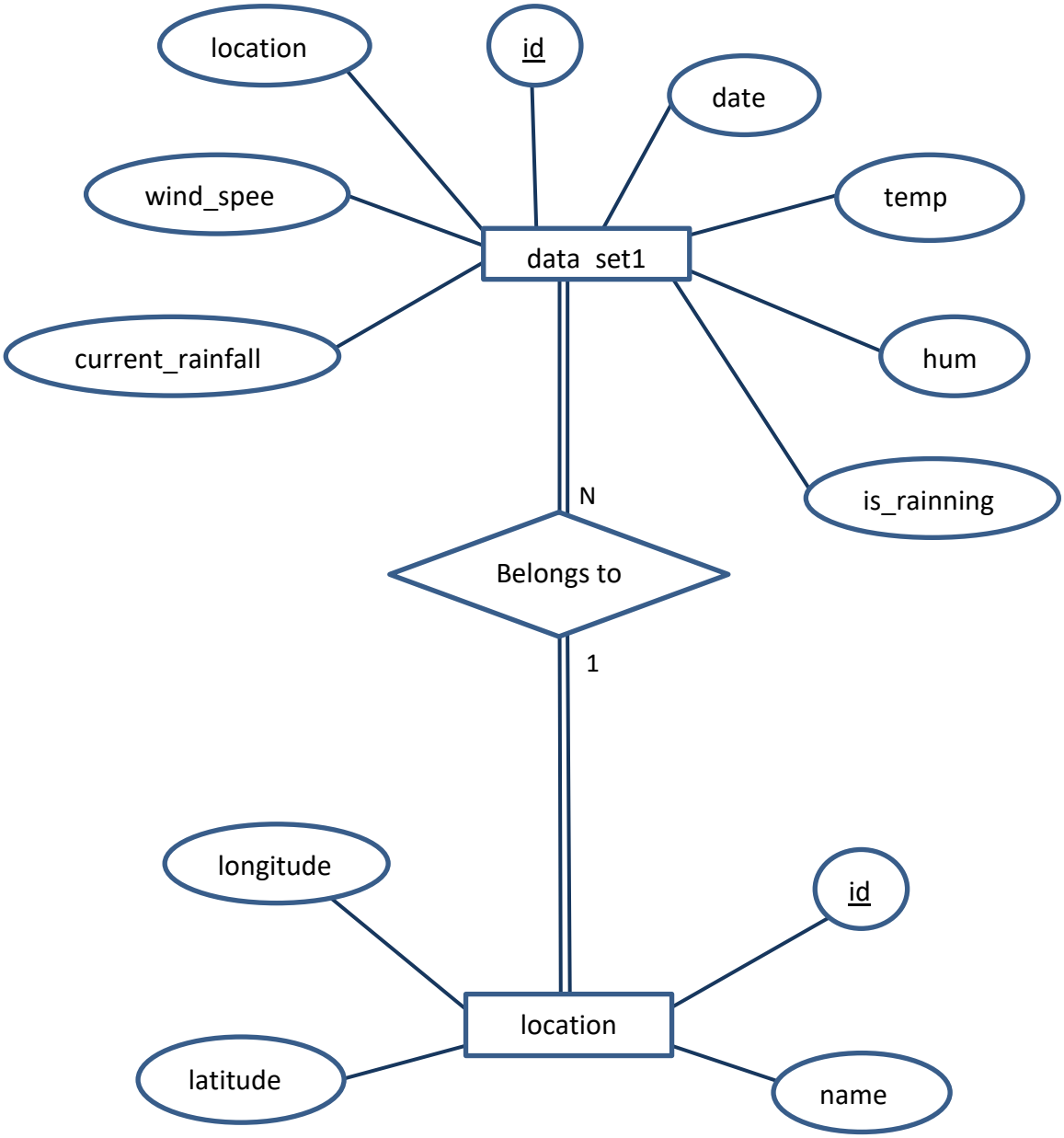
## d Back-end and front-end web application software design

Technologies -


### Back – End of the Web Application -Design

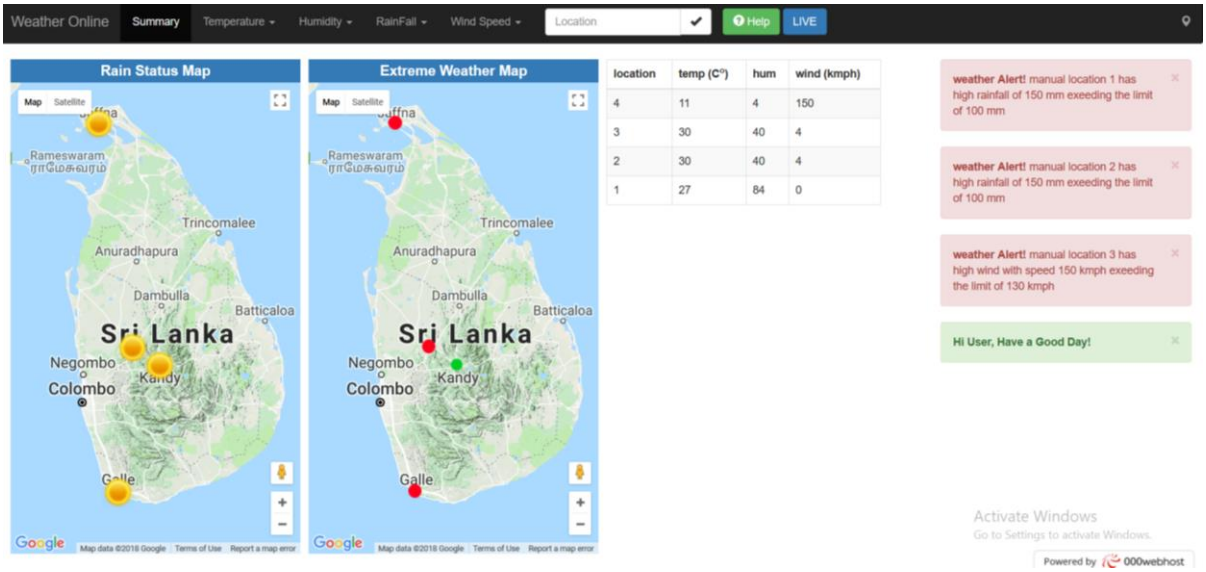


# Database Design – ER diagram



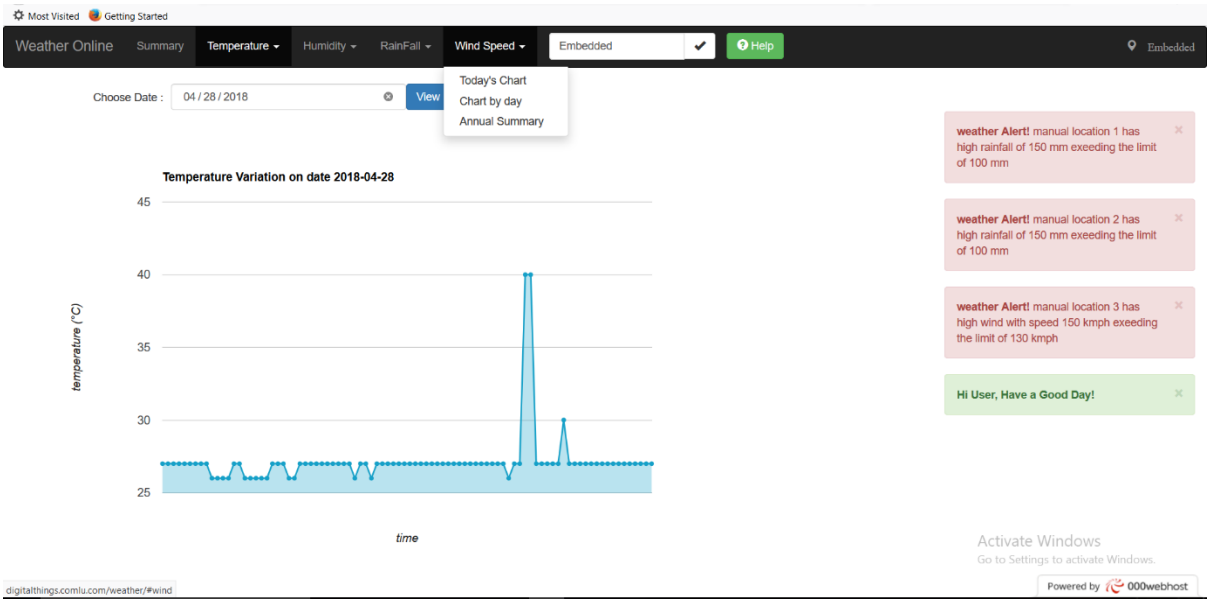
# Front End Design

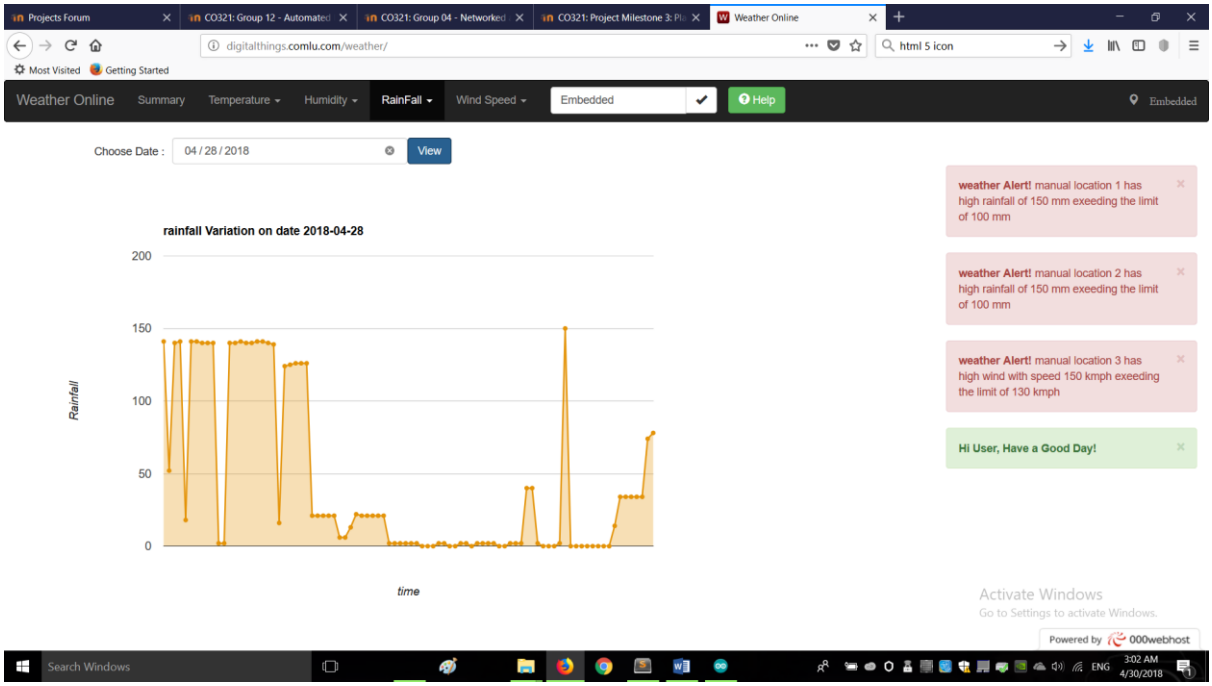
This is the front end of our system, summary page. This is the front end of our system. This map auto updates according to data given by server.




After selecting the location, Users can view the 4 parameters of that location with many details as charts.

- Live variation chart of the day.
- Variation chart of any day in history.
- Annual summary chart that gives the variation of maximum value of all days.



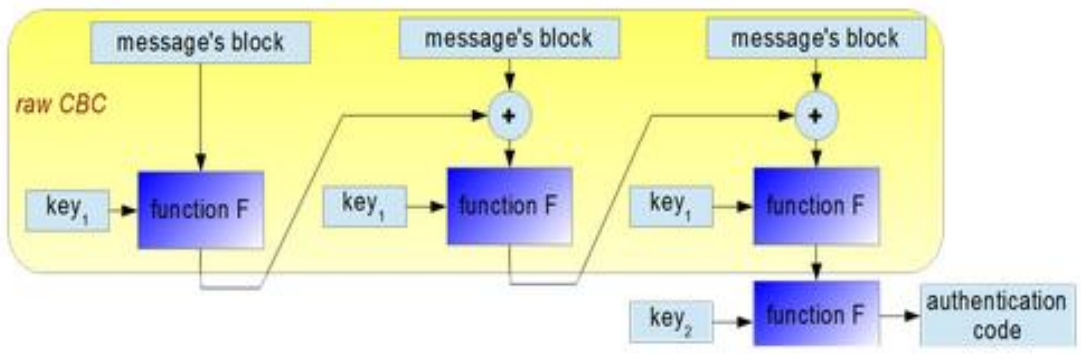



**Live notifications of extreme weather cases will notify the web app users (targeted authorities) with a BEEP sound.**

## e Security features design

- Unauthorized third party should not be allowed to manipulate the system. Reliability and accuracy of data must be maintained.
- As the very important data are sent to the central server from systems in rural places, the security of data is a fact to consider much. As stated by the examiners of Project Milestone 1 in comments, data encryption is not required in this case because we not need to hide data from anyone. Only thing we need is to protect data from being changed externally. So we are going to use MAC -Message authentication code for the requirement.

"A message authentication code (often called MAC) is a block of a few bytes that is used to authenticate a message. The receiver can check this block and be sure that the message hasn't been modified by the third party." - http://www.crypto-it.net/eng/theory/mac.html




CBC MAC - procedure

# MAC Algorithm

MAC = [ (h + s - t)*w + r ] mod ( k )

Temperature = t
Humidity = h
Rain Status = s
Wind Speed = w
Rainfall = r
Key = k

MAC is sent with weather data and in server it is rechecked and if it is correct only data is accepted.

# Chapter 3 - Implementation

## a Power Consumption

Following power consumption calculations are based on the relevant power parameters from data sheets of the equipment.

Ultrasonic Ranging Module HC - SR04

| | |
|---|---|
| Working Voltage | DC 5 V |
| Working Current | 15mA |

Reference - http://www.micropik.com/PDF/HCSR04.pdf

IR Obstacle Sensor

| | |
|---|---|
| Working Voltage | DC 5 V |
| Working Current | 43mA |

Reference - https://wiki.eprolabs.com/index.php?title=IR_Obstacle_Sensor

Temperature and humidity module - DHT11

| | |
|---|---|
| Working Voltage | DC 5 V |
| Working Current | 1mA |

Reference - http://www.micropik.com/PDF/dht11.pdf

Raindrop Sensor

| | |
|---|---|
| Working Voltage | DC 5 V |
| Working Current | 0.5mA |

Reference - https://www.elabpeers.com/raindrop-sensor.html

SIM808 GSM module

| | |
|---|---|
| Working Voltage | DC 12 V |
| Working Current | 2-500mA |

Reference - http://www.communica.co.za/Content/Catalog/Documents/D3649704255.pdf

Arduino UNO

| | |
|---|---|
| Working Voltage | DC 12 V |
| Working Current | 34.4mA |

Reference - https://www.gadgetmakersblog.com/arduino-power-consumption/

Total voltage supplied to the System = 12 V

Total estimated current drawn to the system = 34.4mA + 0.5mA + 43mA + 15mA + 1mA + 500mA

**= 593.9 mA**

Therefore estimated power consumption = V*I

$= 12 * 593.9 * 10^{-3}$ W

= 7.13 W

## b Data Storage

The project's central server is located remotely at http://digitalthings.comlu.com/weather which is a free hosting service offered by www.000webhost.com

Server is a php server.

Following is the file hierarchy of the relevant server location

- weather
  - -beep
    - -beep.mp3
    - -beep.wav
  - -icons
    - -green.png
    - -icon.png
    - -location.png
    - -nodata.png
    - -rain.png
    - -red.png
    - -sun.png
  - -locations
    - -1.txt
    - -2.txt
    - -3.txt
    - -4.txt
    - -location_count.txt
  - -conn.php
  - -dataset1.php

- -hum_chart_annual.php
- -humChartByDate.php
- -index.php
- -locations.php
- -rain_chart_annual.php
- -rainChartByDate.php
- -summary.php
- -summary.txt
- -temp_chart_annual.php
- -tempchart1.php
- -tempChartByDate.php
- -wind_chart_annual.php
- -windChartByDate.php

## Server Limitations

**Reference - https://www.000webhost.com/forum/t/rate-limiting-policy/73635**

Since the webhost is on a free hosting there are limitations. According to the given reference, limitations that effect this project are follows.

1. 30 concurrent connections *(per database)*
2. max_queries_per_hour = 15000 *(DB read)*
3. max_updates_per_hour = 5000 *(DB write)*

So in the embedded software implementation the minimum gap between two consecutive data set deliveries is 1 min. But normally it takes more than 1 min due to execution time of the Arduino code.

But considering the maximum concurrent connection limit, the number of locations must be less than 30 to guarantee that all data sets will be updated in database without a problem.

So if n is the number of locations, no of concurrent web application users must be 30-n assuming all connections they make happen same instant. (Worst Case)

For 30 connections, total automatic queries is 30 x 60 x 2 = 3600 in an hour (Worst Case) .So there are (15000-3600)/30 = 380 queries left for each connection in an hour.

So a web application user must keep number of weather data searches in a less amount than 380 in an hour to ensure the functioning of the application.

The maximum update queries will not exceed 5000 with 30 locations even, as 30 x 60 < 5000

The calculations are done for worst cases.

# Chapter 4 - Third party software components

## Google Charts by Google Developers

Google charts API was used to present the data over history as a line chart.

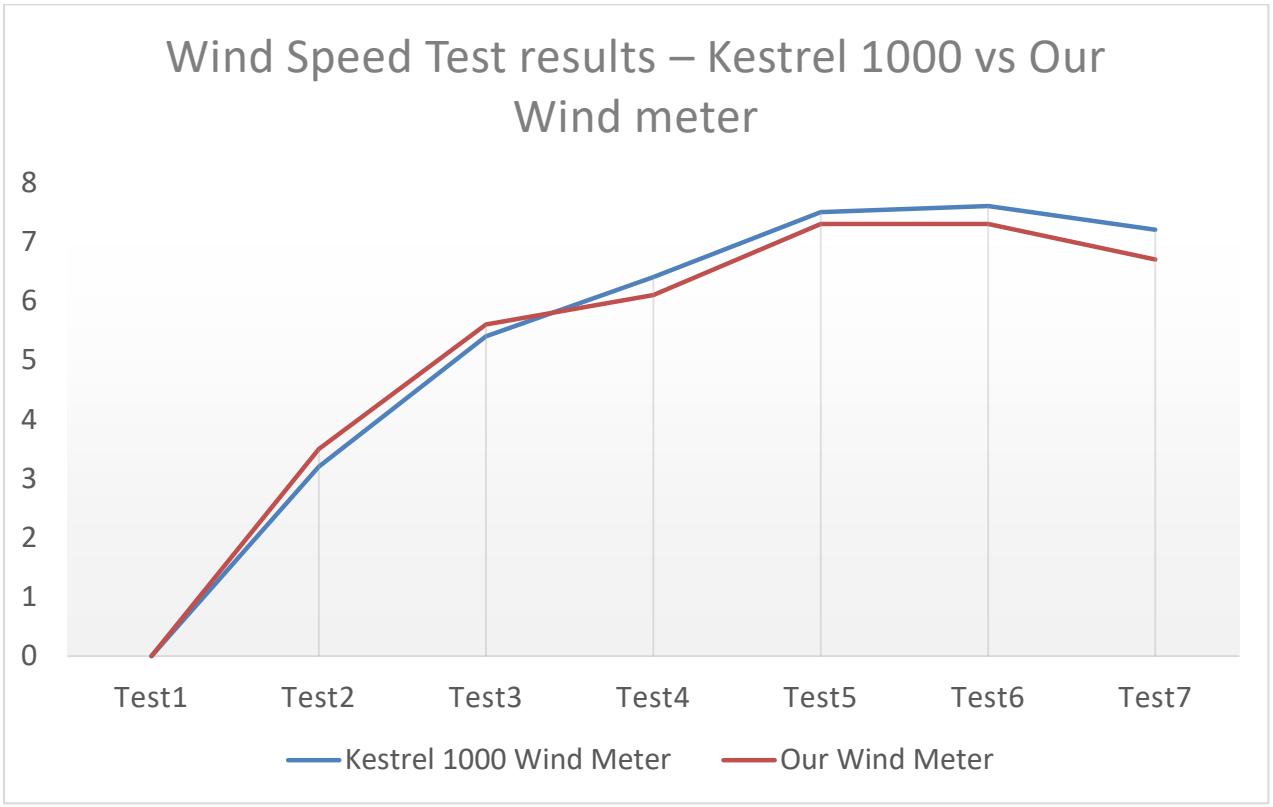
## Bootstrap

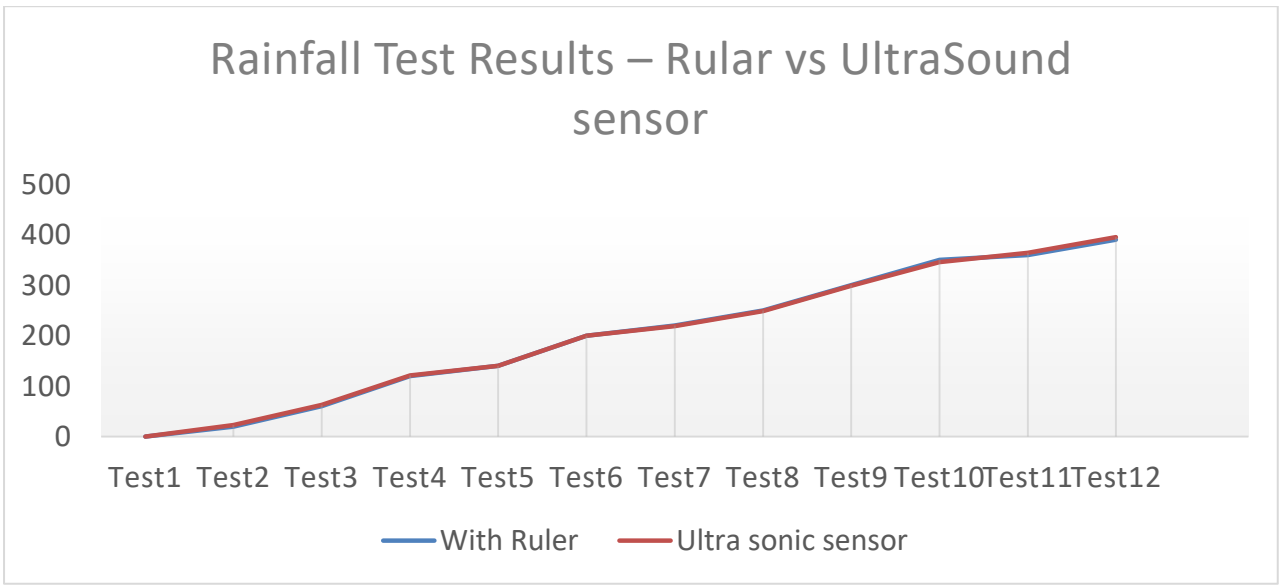
Bootstrap framework used for the front end to be more responsive and nice.

## Google Maps by Google Developers

Google maps API was used to present the summary weather data of all locations in two maps.

# Test-Results




| | Min | Max | Accuracy |
|---|---|---|---|
| Rainfall | 0 mm | 390 mm | ±3 mm |
| Wind | 0.257 kmph | - | ±0.3 kmph |
| Temperature | 0° C | 50 °C | ±2 °C |
| Humidity | 20 % | 80 % | ±5 % |