Mobile Air Pollution Sensing
CCIoT ‘23

Team: TicToc

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Motivation

Measuring Air Pollution on a Two-Wheeler

- Air pollution is a major concern of the century, and bad air quality is now a danger to not just the environment but to people as individuals too. Bad air is proven to be the cause of many respiratory diseases.
- People riding two-wheelers as part of their daily routine are especially susceptible to air pollution related hazards.
- A biker cannot control air quality around them but can at least try to avoid areas with poor air quality.
- This project intends to provide an IoT based solution to this problem.
- A mobile node capable of sensing standard air quality related parameters and pushing them to the internet allowing further analysis and alert system is the primary vision.
- The system can then be extended to provide services for the masses by the masses, just like google maps. More about this is mentioned later in the presentation.

Project Overview/Goals

Measuring Air Pollution on a Two-Wheeler

We aim to develop a working IoT node that's mountable on a two-wheeler which performs the following tasks:

- Senses the following:
    - Temperature
    - Humidity
    - PM 2.5 and PM 10
    - CO gas concentration
- Calculate AQI and do analysis of collected data.
- Share and display data on a live dashboard.
- Ideate on potential extension of this project and what an ideal product based on this would look like.

Similar pre-existing projects


Bike-mounted Air device monitors air quality along cyclists' routes

By Ben Coxworth
November 12, 2021

VIEW 3 IMAGES

The SODAQ Air will soon be on Kickstarter SODAQ

https://newatlas.com/bicycles/sodaq-air-bicycle-air-quality-sensor/

https://www.mdpi.com/1424-8220/22/3/1272

Rescoping the project

- We faced reliability and stability issues with the GPS and GSM modules. Thus, we are instead using the user’s cell phone for location data and for communicating with the dashboard.

  This also makes sense in our use case because a biker will obviously carry their phone with them. Moreover, this approach saves power consumption in the node and reduces space complexity too.

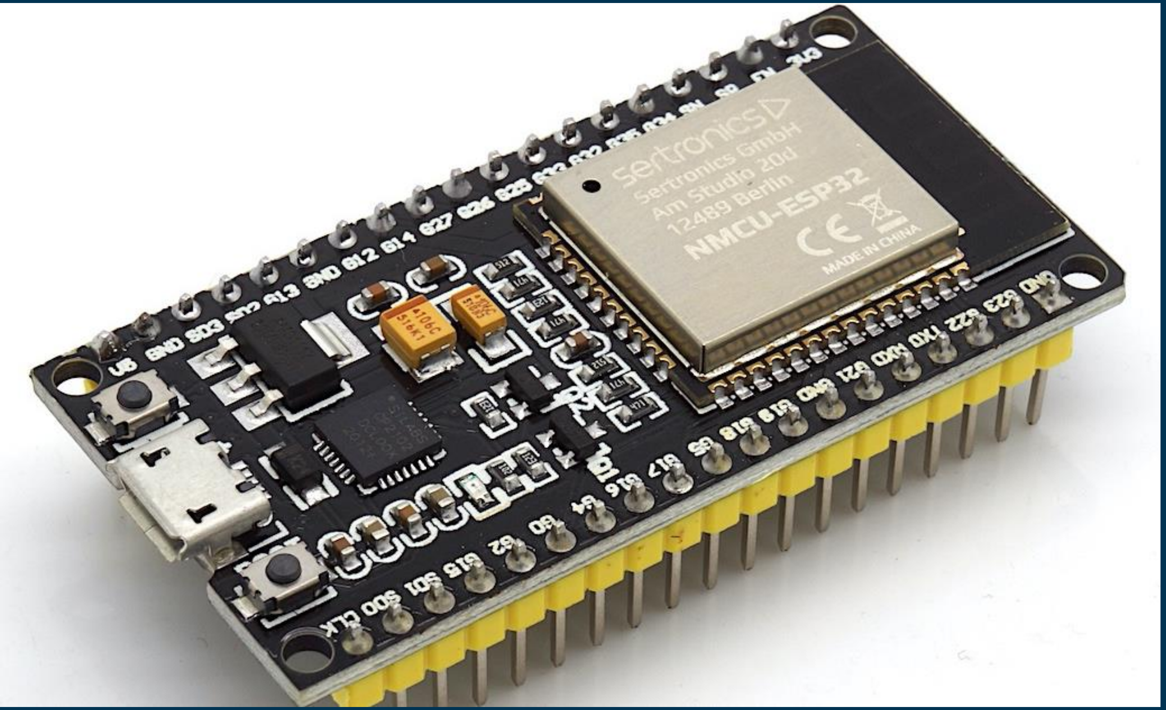
- Used power bank instead of batteries because it’s more reliable and lasts long.

Components

- **Microcontroller:** ESP32
- **Sensors:**
  - *PM 2.5 and PM 10* – Nova SDS011
  - *Temperature and Humidity* – DHT-22
  - *CO gas – MQ-7*
- **Casing:** 3d Printed custom designed case.
- **Location:** from mobile phone.
- **Connectivity:** Wi-Fi hotspot from mobile phone.
- **Power Supply:** Battery (rechargeable power bank)

Microcontroller - NodeMCU ESP32

- NodeMCU uses Arduino IDE, making it easier to use based on previous projects.
- Has supporting libraries for sensors being used.
- Small, lightweight and portable.
- Built-in Wi-Fi support.



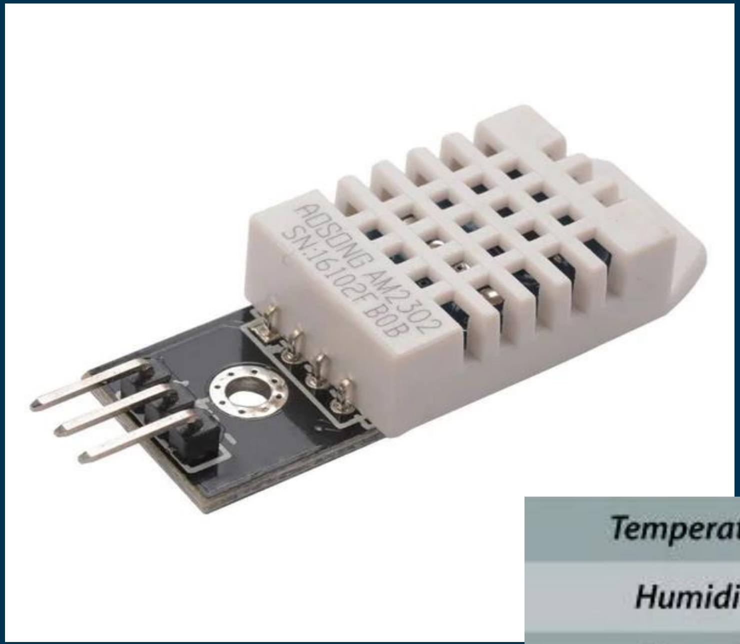
PM Sensor – Nova SDS011

- SDS011 is an optical Particulate Matter sensor.
- Using an optical sensor over a thin-film sensor gives the advantage of the sensor being less susceptible to dust particles affecting its calibration.

1. Measuring output: PM2.5,PM10
2. Range: 0.0-999.9 ug/m3
3. Power supply voltage: 5V
4. Maximum working current: 100mA
5. Particle diameter resolution: Less than 0.3um

Temperature and Humidity Sensor - DHT-22

- DHT22 is a commonly available sensor.
- Good enough ranges and sampling rate.
- Very low power consumption, thus ideal for our application.



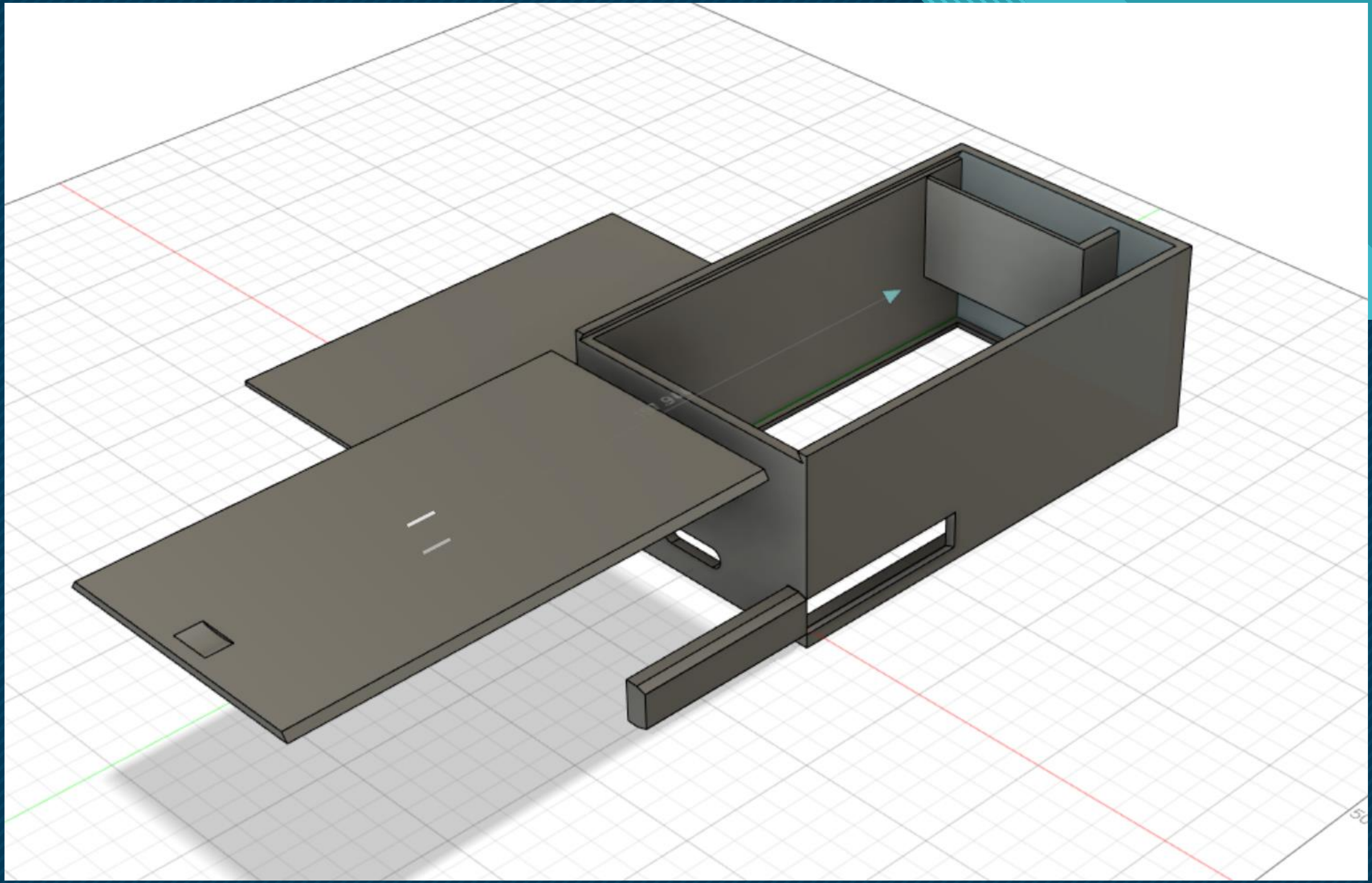
Temperature Range	-40 - 125 °C / ± 0.5 °C
Humidity Range	0 - 100 % / ± 2-5%
Sampling Rate	0.5 Hz (one reading every two seconds)
Body Size	15.1mm x 25mm x 7.7mm
Operating Voltage	3 - 5V
Max Current During Measuring	2.5mA

CO gas sensor – MQ-7

- The analog output voltage, the higher the concentration the higher the voltage.
- Commonly available and inexpensive, long service life and reliable stability.
- Small, lightweight and low power consumption.
- Rapid response and recovery characteristics.
- Max current drawn < 150 mV

Casing

- Custom 3D printed box designed in Fusion 360.
- Provides robust solution to protect the electronics of our node from external deteriorators like excess dust, water, etc.
- Designed carefully to match dimensions required by the circuit components.
- Houses a rechargeable power bank that can be charged inside the box itself, thus no need to frequently open the casing.



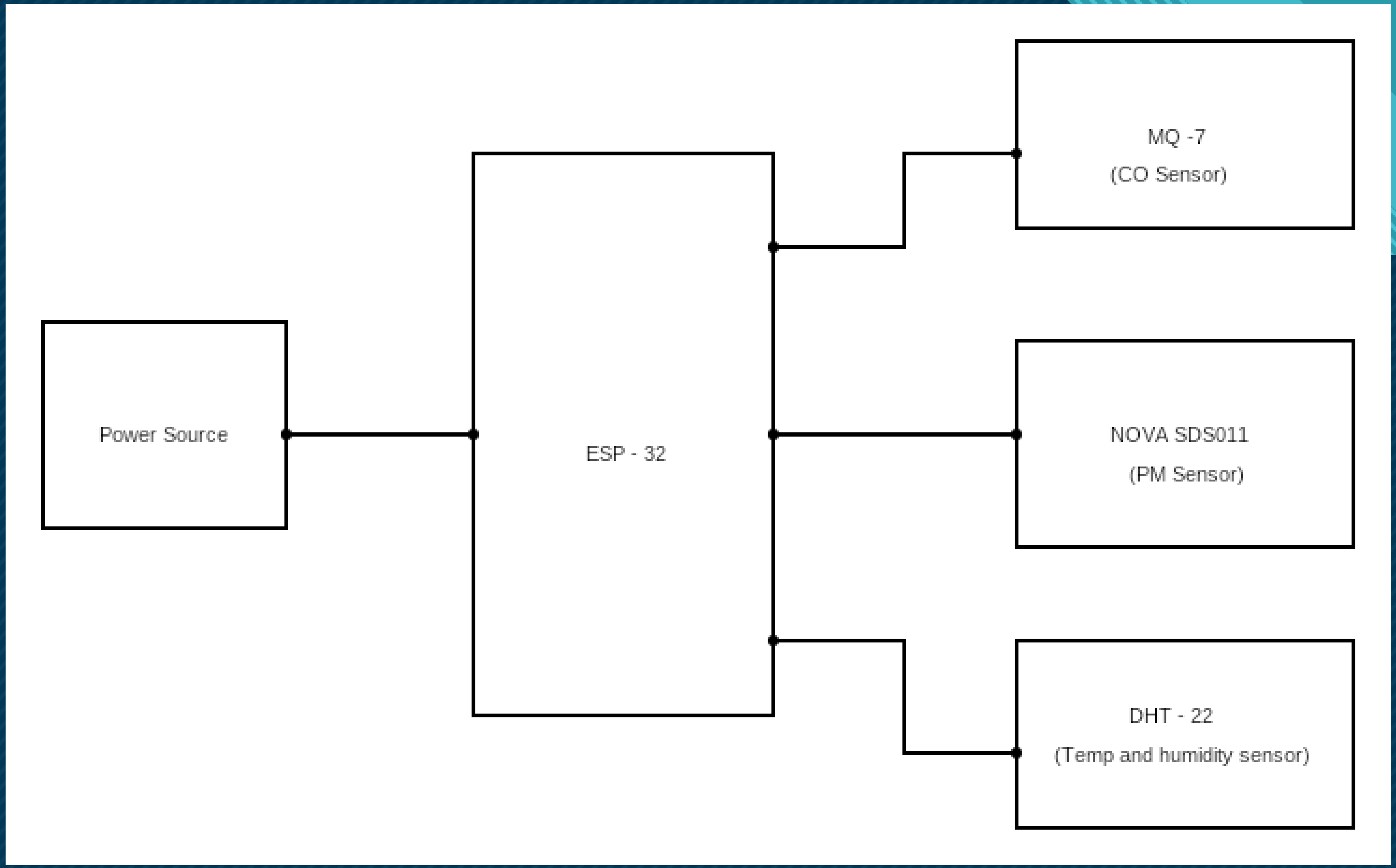
Progress (milestone 23/02/2023)

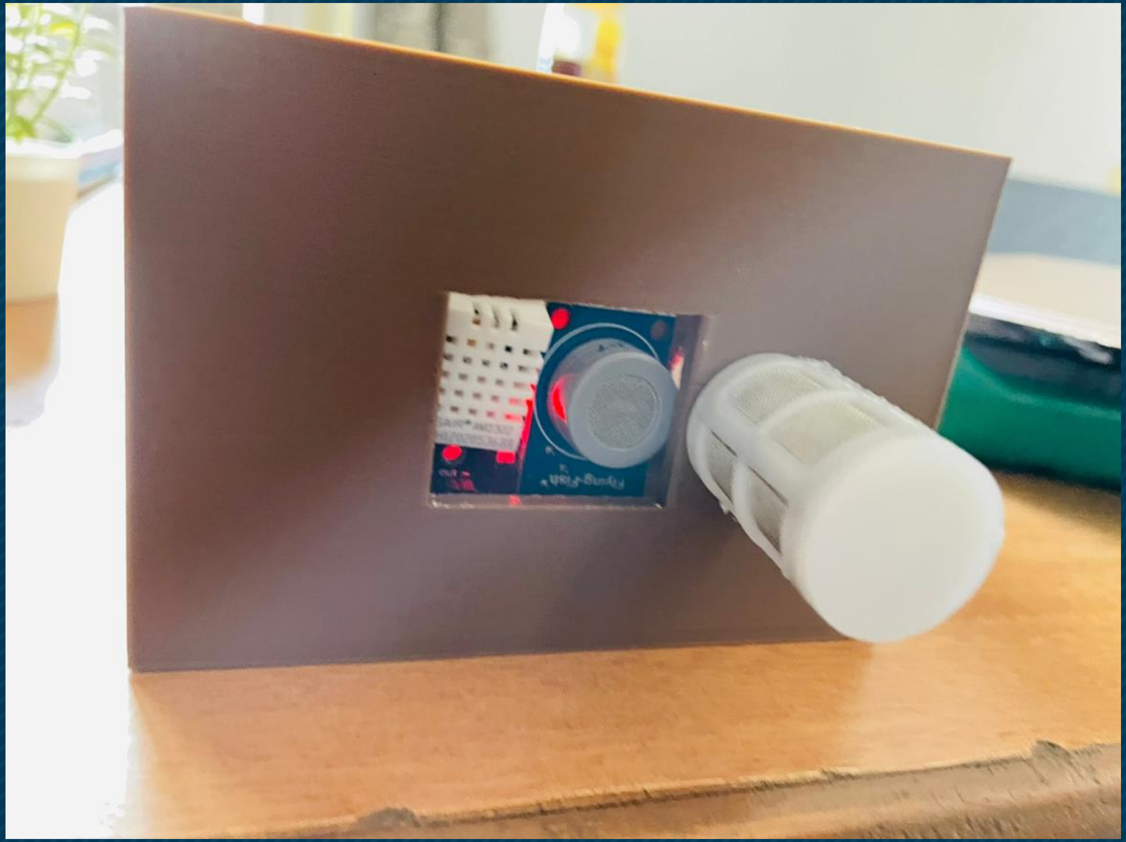
- Removed BMP280 and replaced it with DHT22 for measuring temperature and humidity.
- Integrated CO gas sensor.
- Soldered most of the components onto a PCB board.
- Procured GPS module.
- Awaiting GSM module.
- Collected more data and are ready for calibration whenever initiated.
- Understood working of sensors.

Final implementation

Mobile air quality sensing for two-wheelers

AN IDEA OF THE CIRCUIT





What does this node achieve?

- Senses all the air quality parameters we intended to do in project goals.
- Push the data onto Blynk dashboard which is then made publicly available.
- Analyze data and provide real time AQI value.
- Cross link data with location information and verify correctness while also trying to find a correlation.
- Cross verifying collected data with publicly available data from the internet.
- Reliable and robust build to safely carry on a two-wheeler. User friendly.

Power consumption and battery life estimation

- Maximum power consumption of ESP32 microcontroller in active mode use is ~ 200mA at 3.3V. So that’s 0.66W
- Max power consumed by sensors:
  - Nova: 100mA * 5V = 0.5W
  - DHT22: 2.5mA * 3-5V = ~ 0.01W
  - MQ7: ~ 100mA * 5V = ~ 0.5W
  - Therefore, total power consumed by sensors = ~ 1W
- The power bank we are using is of 10,000mAh.
  Total power consumed by node = ~1.66W
- Idea battery life = (10000 mAh / 1000) / (1.66W / 5V) = ~30 hours
- However, due to heat dissipation, conversion loss and such practical issues, the realized battery life might be around 20-25 hrs.

Data Analysis

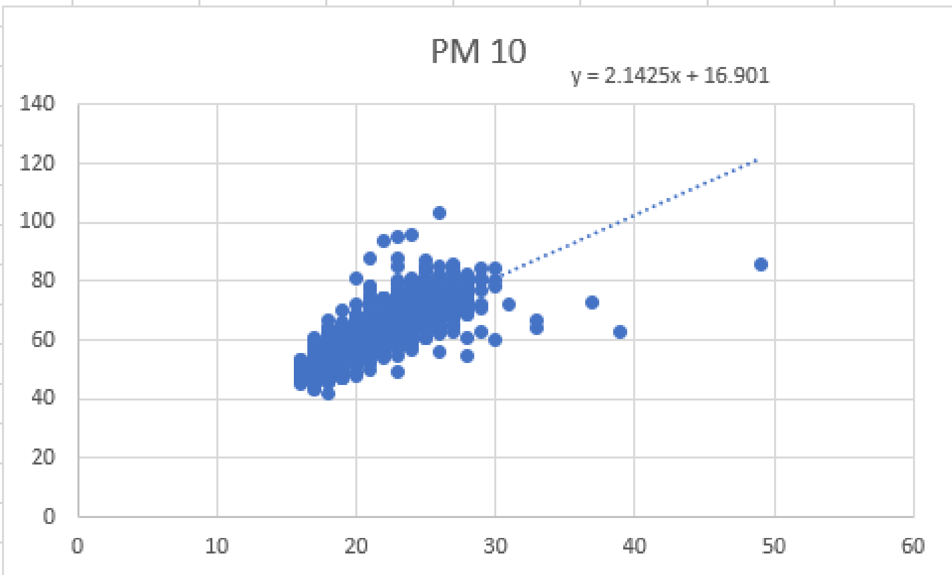
Connecting the dots

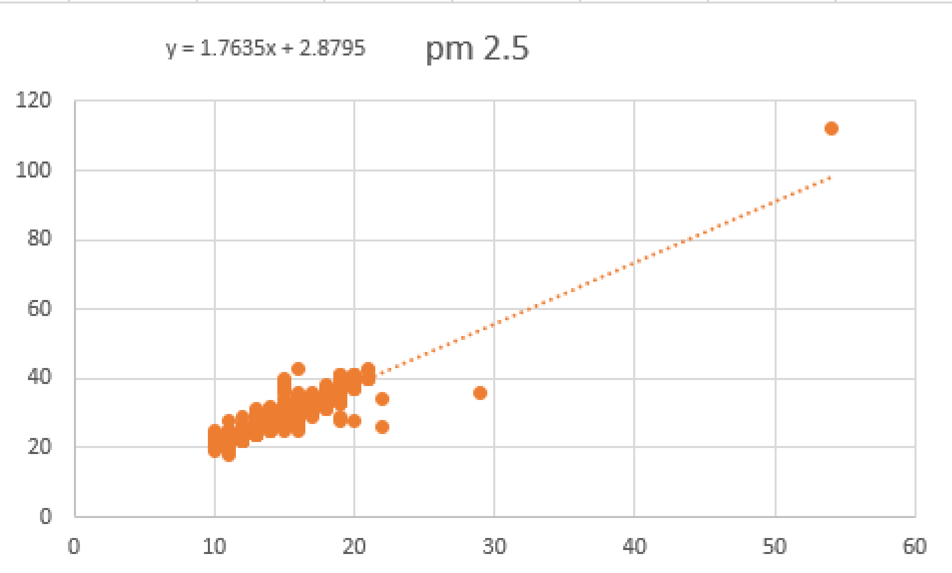
Calibration

Linear regression has been implemented to calibrate readings from our pm sensor

(nova sds011)

- After filtering out a few extreme data points ,i.e sorting through initial data for reliable values
- A linear regression equation was generated ,relating expected values to observed values
- This is easily performed through excel or by means of sklearn, panda libraries available through python.

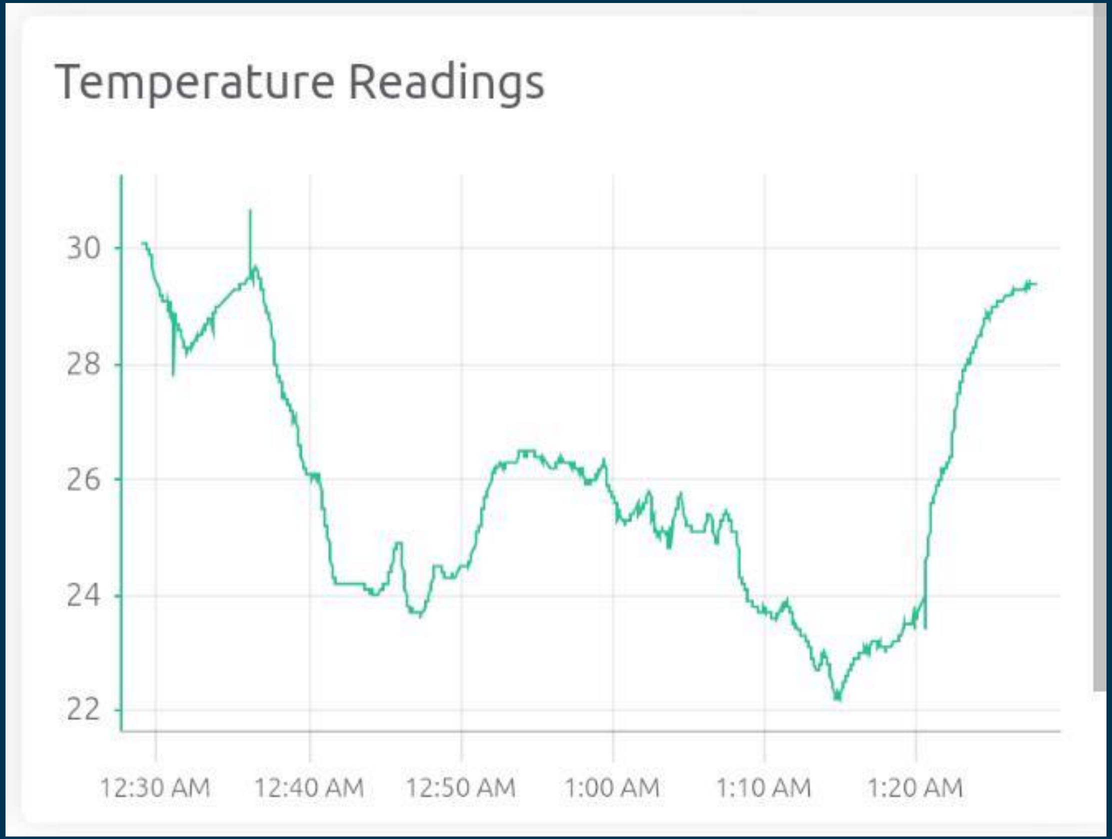




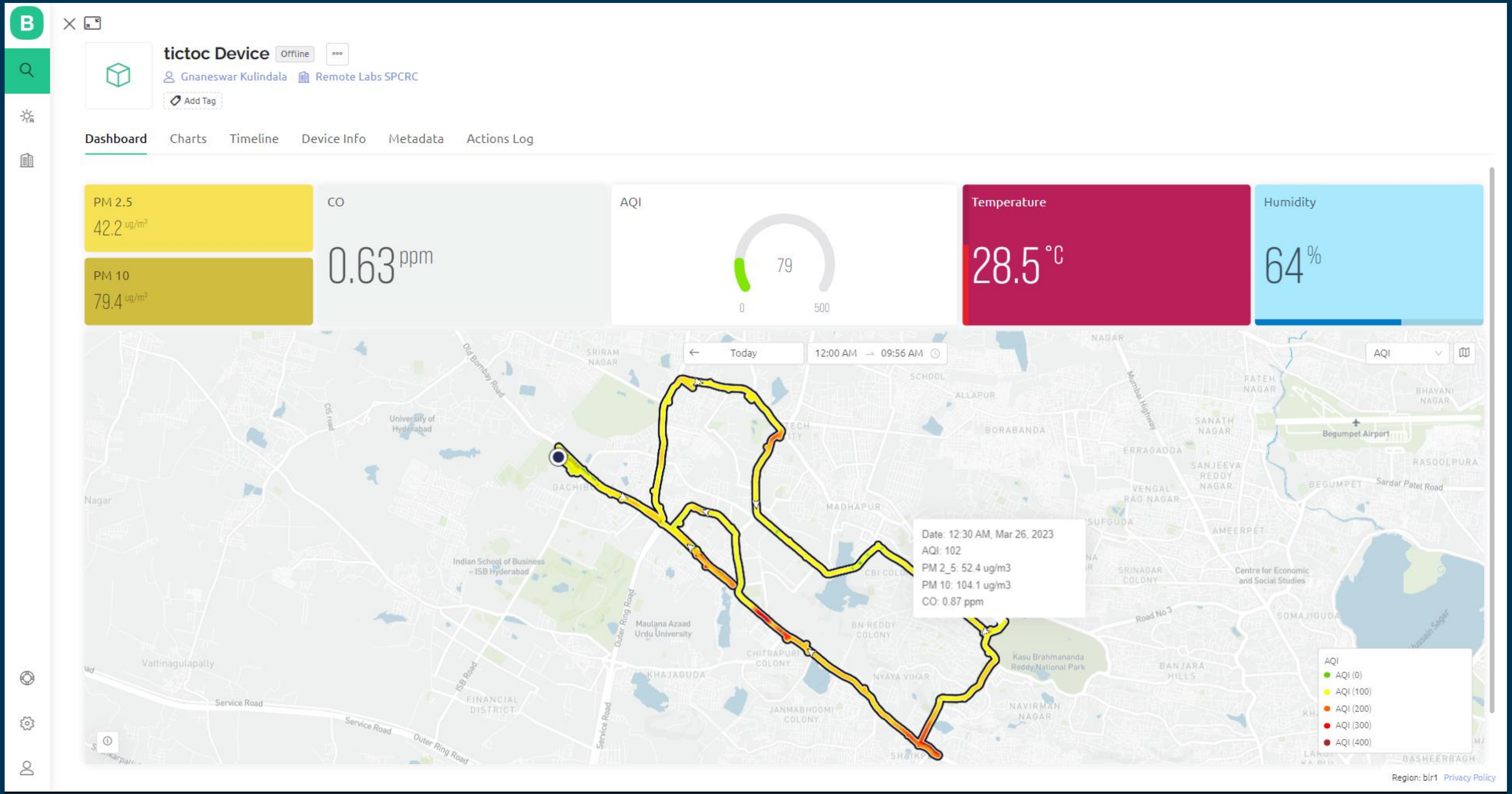
PM readings

1. In campus (outdoors)
2. Left campus on our two-wheeler (bike)
3. Spike in DLF street. As expected because of increased pollution from so many food stalls and also dust.
4. Another spike at a traffic signal.
5. Back to campus. These levels match with levels in (1) thus reassuring consistency of the node.

Temperature readings also follow



Geographical Overview




tictoc Device
Offline
Gnaneswar Kulindala
Remote Labs SPCRC
Add Tag
Dashboard
Charts
Timeline
Device Info
Metadata
Actions Log
Latest
Last Hour
6 Hours
1 Day
1 Week
1 Month
3 Months
Custom
PM Readings
PM 2_5
PM 10
CO Readings
Humidity Readings
Temperature Readings
11:50 PM
12:00 AM
12:10 AM
12:20 AM
12:30 AM
12:40 AM
12:50 AM
1:00 AM

Further Ideation

Extrapolating ideas to vision

Possible extensions to our project: The vision of an end to end solution

- We can monitor personalized locations – get alerts (“wear a mask today”)
- Long term study of specific areas –
- Rate and grade areas based on long term analysis – can inform authorities to look into matter in case of consistently bas readings
  – public good.
- Suggest alternate routes to regular destinations in case of a bad route

Contributions

- Brahad Kokad
  - Designed 3D model and integrated circuit elements in the 3D print.
  - Contributed in ideation, helped in data collection and made PPT.
- Aniketh Parkala
  - Calibrated sensors using linear regression & helped with dashboard.
  - Drove the bike for data collection.
  - Soldering circuit onto PCB.
- Gnaneswar Kulindala
  - Designed the dashboard and adapted code for the same.
  - Calculations of AQI and map data interface.
  - Got android location API working for GPS through phone.
  - Helped in data collection.
- Abhinav Marri
  - Initial working of the sensors.
  - Building/designing of the final hardware circuit.
  - Data collection and background research.

Thank You