



CS432

Final Presentation

What is our SmartRoads?

Providing safer roads for the drivers

- Dynamically adjusting the speed limit for that road.
- Traffic density is detected via computer vision.
- The optimal vehicle speed limit will be determined by measuring the air and road conditions such as temperature, air pressure and humidity of the area.
- The smart traffic signs that are adjusted according to this data will be displayed on the sign for the drivers.



Business

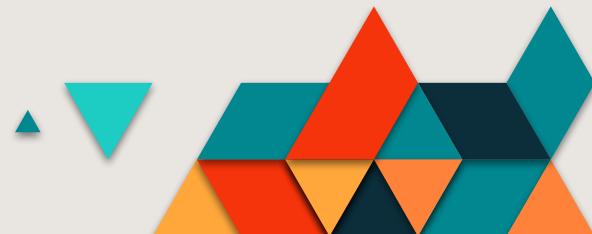
Drivers



Traffic Service Providers

Advertising Agencies

KGM & EGM

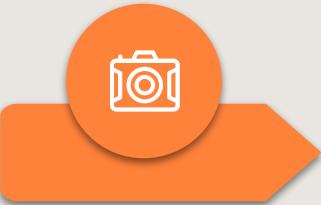


SWOT Analysis



STRENGTHS

Comprehensive data collection.
New features can be easily integrated.
Project cost is reasonable and low when we compare to other market products.



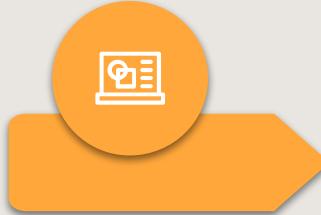
WEAKNESSES

Project is related with government, some bureaucracy needs time.
To setup hardware products, there is need for time and human resource.
Remote working environment due to COVID-19.



OPPORTUNITIES

Experienced team members on their fields.
Long development time due to COVID-19.

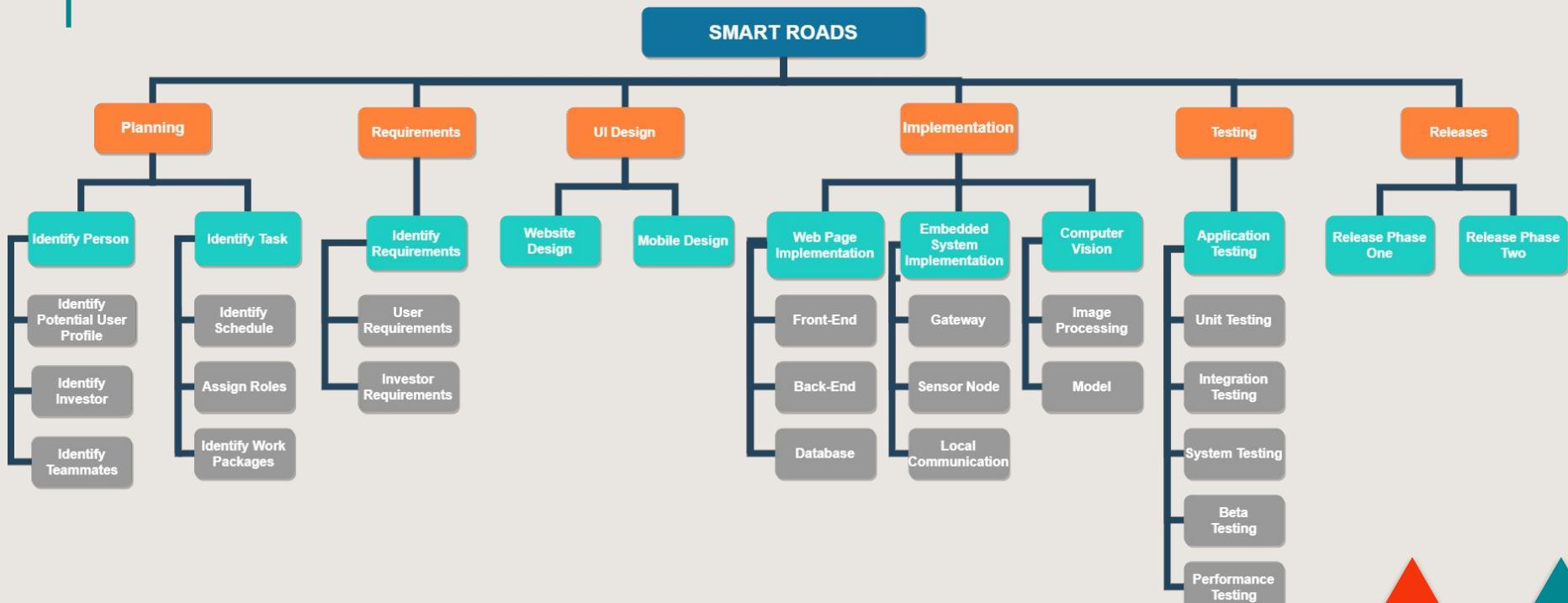


THREATS

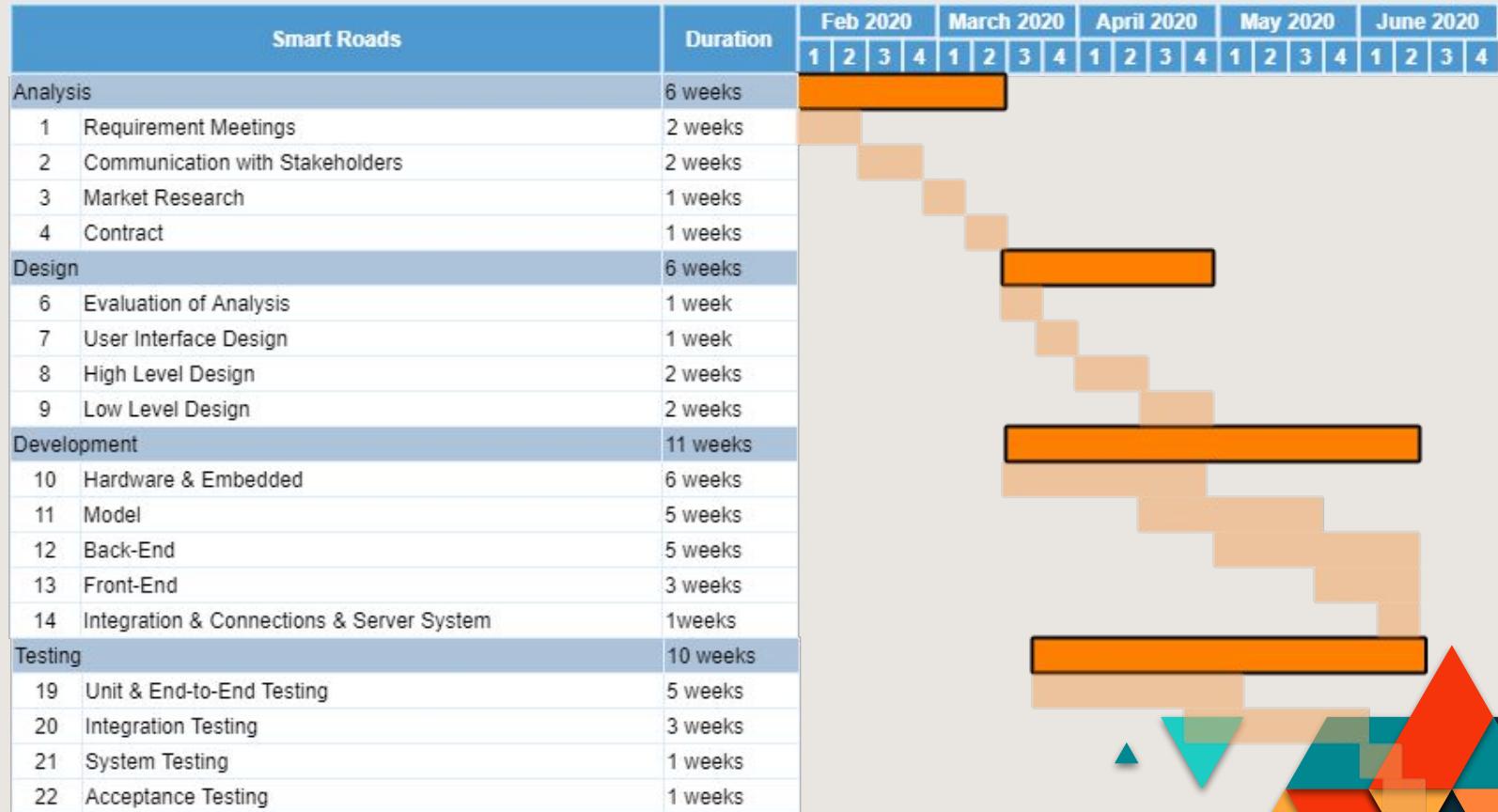
The government's regulations can causes problems.
Reachability of hardware products causes problems because of road and weather conditions.



Work Breakdown Structure



Schedule



What we use?

Number	Name	Price (\$)
1	ESP32-CAM WiFi	15,73
1	BME280 I2C	5,23
2	1x8 Header	0,14
1	1x4 Header	0,045
1	1x6 Header	0,056
1	5x5 Prototyping Board	0,17

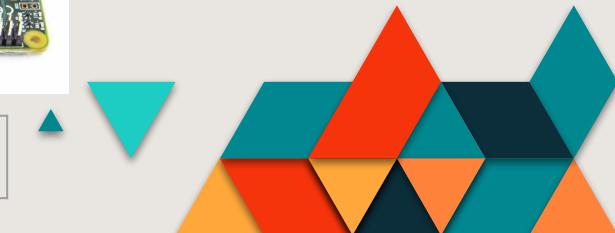
Total = \$21.3

Service	Cost	Aggregated
Virtual Machine	\$40/month/instance	\$120
Database	\$15/month/cluster	\$30

Total = \$150



1	Raspberry Pi 3B+	\$30,61
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Cost Estimations

Unit Expenses

Product Cost: \$21.3 per edge-node

Electricity Cost for Unit Product: \$0.11 monthly per edge-node

Electricity Cost for Raspberry Pi 3B+: \$1.83 per year

Maintenance Cost: \$5 per edge-node

Cloud Cost: \$150 monthly per server instance

Compute Power Cost: \$30,61 per 2km

Data Transfer Cost: \$2,33 per month per Rpi

* We determined that 1 instance of server setup (3VM + 1DB) can handle 500 edge-nodes.

* We determined that 1 instance of server setup (3VM + 1DB) can handle 300 users.

* Data network usage cost will be added after experimentation steps.

Constants

Registered traffic users at Turkey: 23,156,975

* We assume %30 of registered traffic users will use the app (6,947,092.5)

Roads at Turkey: 64,746 km

Edge-nodes per km: 2

* Therefore, we need 129,492 edge-nodes in total.

Advertisement in app: \$5 per install

Tax: %18 KDV for income

Traffic data cost: \$1 per km per day



Business Expenses

Initial Expenses

Raw Material: $129,492 \times \$21.3$

= \$2,758,180

Compute Power Cost: $(64,746 / 2) \times \$30.61$

= \$990,937.53

Total Expenses per year

Cloud Cost: $516 \times \$150 \times 12$
 $23,157 \times \$150 \times 12$

= \$77,400 yearly (to serve edge-nodes)
= \$41,682,600 yearly (to serve users)

Data Transfer Cost: $\$27,89 \times 32373$

= \$904,540 yearly

Total Cloud Cost: $\$77,400 + \$41,682,600$

= \$42,611,400 yearly

Maintenance Cost: $129,492 \times \$5$

= \$647,460 yearly

Electricity Cost for Unit Product: $129,492 \times \$0.11$

= \$14,244 yearly

Electricity Cost for Raspberry Pi 3B+: $\$1.83 \times (64,746 / 2) = \$ 59,189$ per year

Total Cost:

= **\$45,227,770.53**

Tax: $\$82,000,40 \times \%18 = \$14,760,007.2$ yearly



Business Expenses

Income

* Raw material and installation costs will be paid by the government.

Government (KGM, EGM): $129,492 \times \$21.3 = \$2,758,180$ (will pay installation cost)

Advertising in app: $6,947,093 \times \$5 = \$34,735,460$ yearly

Traffic Service Providers: $64,746 \times \$1 \times 365 = \$23,632,290$ yearly

Advertisement Agencies: $64,746 \times \$1 \times 365 = \$23,632,290$ yearly

Total: \$82,000,040

Revenue per year

$\$82,000,040 - \$45,227,770.53 - \$14,760,007 = \$22,012,267.47$

%40 of revenue for investor = \$8,804,904.988

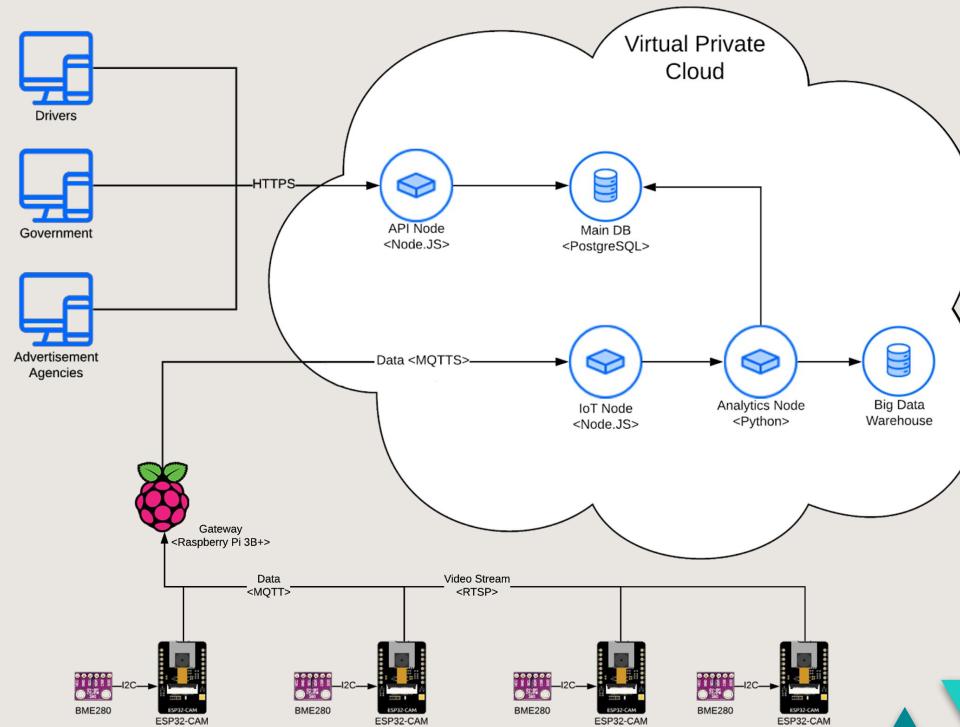
Investor can make profit after **6 years**.

%60 of revenue for developers = \$13,207,360.482 will share between group members equally.

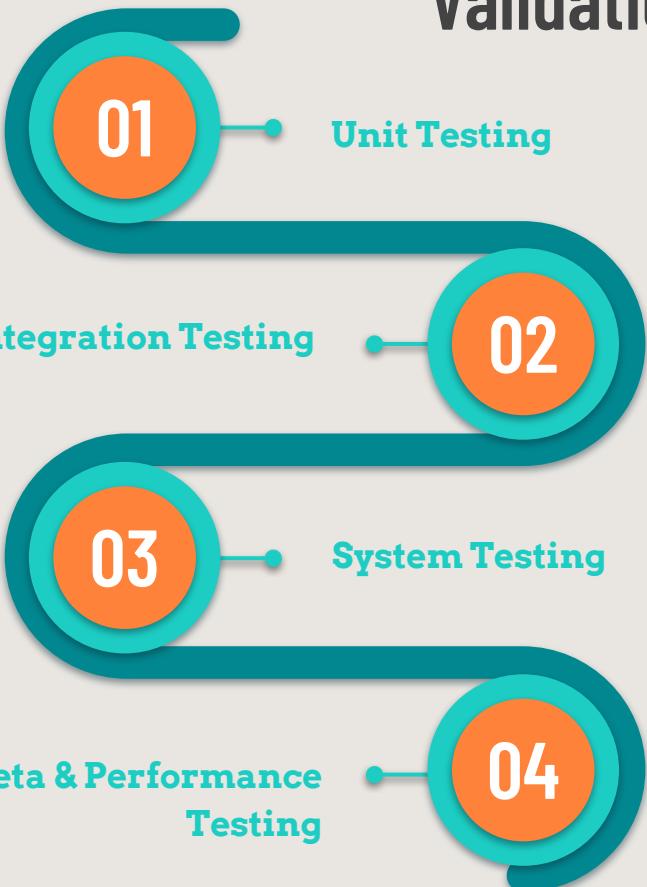
Therefore, each member takes \$3,301,840 per year.



General Architecture



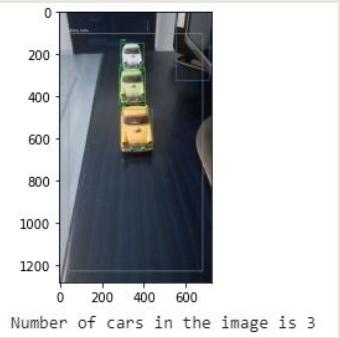
Validation & Verification



Journey of Vehicle Counting

Real-time frame by frame

Frame by frame causes counting faults because of losing frames.



01

02

03

04

Vehicle counting and speed estimation YOLO Sort API

Although it provides extra features, execution time is really problem. The cause of problem is YOLO object detection has performance problems.



YOLO Object Counting API

Due to great size of API and its dependencies, execution time is very long.



Vehicle Counter

Within our trials, this is best practice because of light dependencies and clean code. Only dependencies are dlib and cv2.



Final program makes use of background subtraction and multiple object tracking via dlib correlation tracker to count cars.



According to investigations, for other API's, especially for YOLO based object detection systems, we need an **accelerator** in our hardware stack.

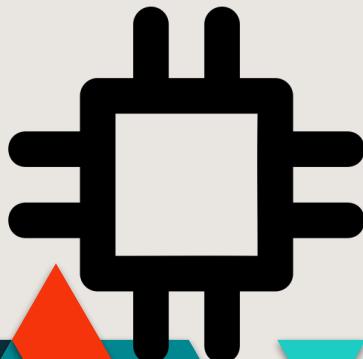
Computer Vision

Solution: Intel® Neural Compute Stick 2

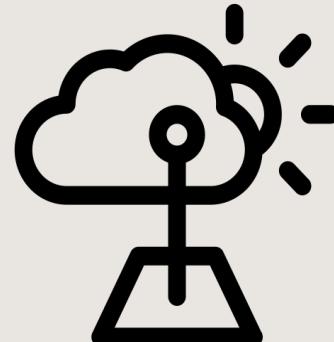


Three parts of the Node Device

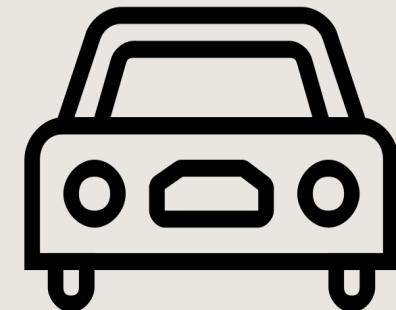
Microcontroller



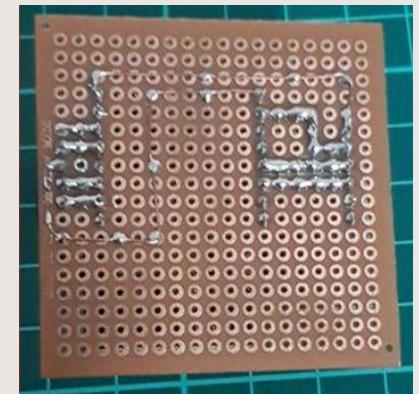
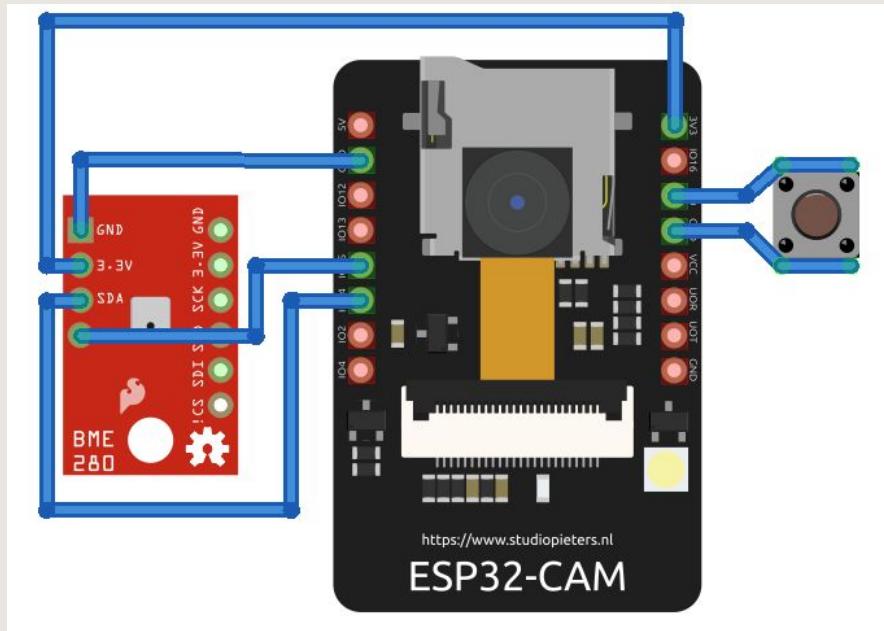
Weather Sensor



Vehicle Counter



Hardware



* To communicate with **BME280**, **I²C** pins are set for **SDA** and **SCL** as **14** and **15** accordingly.

We started with...

Microcontroller: **Atmega328p** for the microcontroller with a GPRS Module.

Weather Sensor: **BME280** as the weather sensor to collect temperature, air pressure, humidity.

Vehicle Counter: **HC-SR04** Ultrasonic Sensor.

and ended on...

Microcontroller: **ESP32-CAM** for the microcontroller.

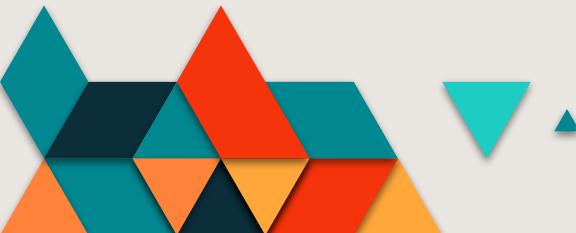
Weather Sensor: **BME280** as the weather sensor to collect temperature, air pressure, humidity.

Vehicle Counter: **Onboard camera** of ESP32-CAM.



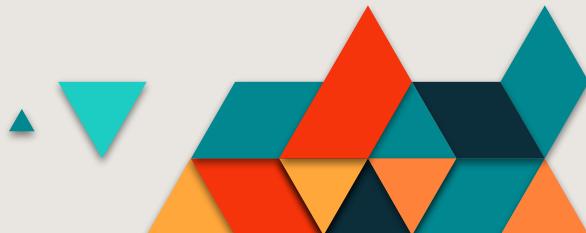
Libraries used in Firmware

- SparkFunBME280
- ArduinoJson
- ArduinoWebSockets
- PubSubClient



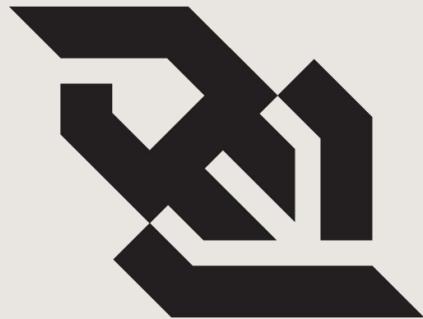


Partition scheme of firmware:

- 1.9 MB for program code
 - 1.9 MB for OTA updates
 - 190 KB SPIFFS memory
- 

Integration & Backend: Design Choices

- MQTT Protocol requires less energy.
- Node.js has low-memory utilization.



Database Design



Backend Documentation

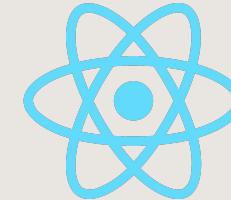
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POSTMAN



PWA



User Interface



**Progressive Web
App**



**Drivers
Mobile**



**Traffic Service
Providers, KGM & EGM
and Advertising
Agencies**
Web



Technologies
React,
Mapbox, Google Maps



THANKS!

