CS 432 Machine-to-Machine (M2M) Systems

Smartifiers

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What is our SmartRoads?

Providing safer roads for the drivers

- Dynamically adjusting the speed limit for that road.
- Traffic density will be 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.

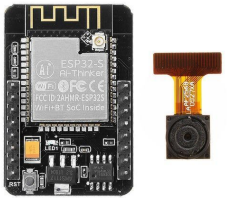
Project Leader & AI Specialist

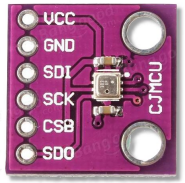
Number	Name	Price ($)
1	ESP32-CAM WiFi	15,73
1	BME280 I2C	5,23
2	1x8 Header	0,14
1	1x4 Header	0,045
1	1x6 Header	0,056
1	5x5 Prototyping Board	0,17

Total = $21.3

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

Total = $150





Cost Estimations

Unit Expenses
Product Cost: $21.3 per edge-node
Electricity Cost: $0.11 monthly per edge-node
Maintenance Cost: $5 per edge-node
Cloud Cost: $150 monthly per server instance

* 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.

* In the final iteration, we will use Raspberry Pi for computation. Therefore, electricity cost and product cost will be changed.

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 x $21.3	= **$2,758,179**

Total Expenses per year

Cloud Cost:	516 x $150 x 12	= $77,400 yearly (to serve edge-nodes)
	23,157 x $150 x12	= $41,682,600 yearly (to serve users)
Total Cloud Cost:	$77,400 + $41,682,600	= $42,611,400 yearly
Maintenance Cost:	129,492 x $5	= $647,460 yearly
Electricity Cost:	129,492 x $0.11	= $14,244 yearly
Total Cost:		= **$43,273,104**

Tax: $82,000,40 x %18 = 14,760,007,2 yearly

Business gains

Income

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

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

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

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

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

Total: $82,000,040

Revenue per year

$82,000,040 - $43,273,104 - $14,760,007 = $23,967,929

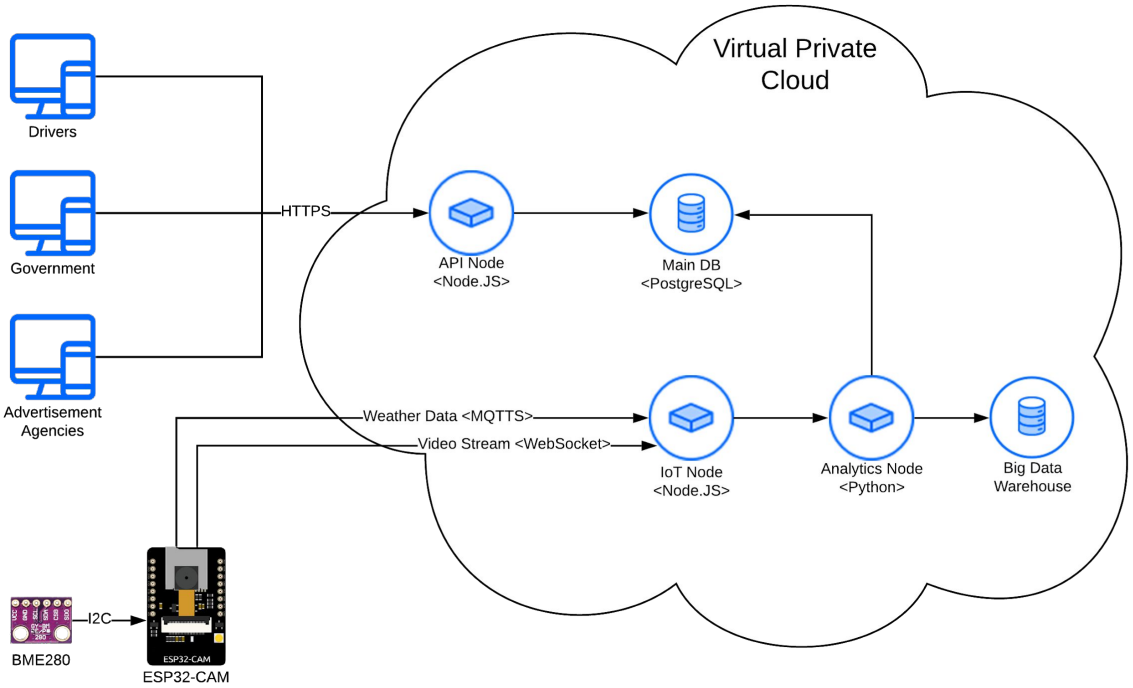
%40 of revenue for investor = $9,587,172

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

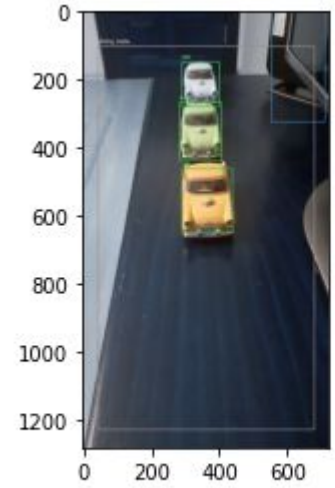
%60 of revenue for developers = $14,380,757 will share between group members equally.

Therefore, each member takes $3,595,189 per year.

General Architecture



Counting Cars



Number of cars in the image is 3

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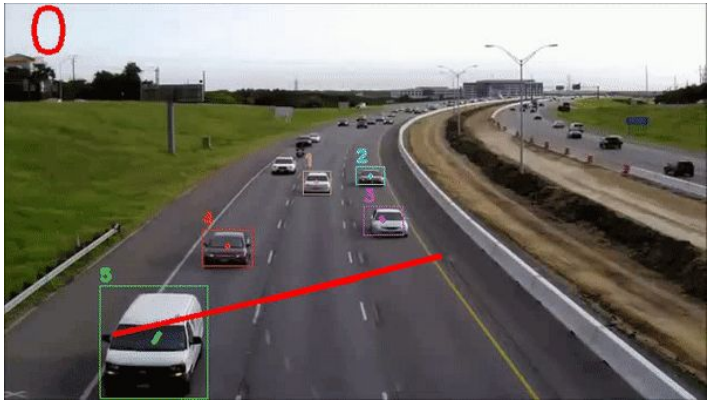
YOLO Object Counting API
Real-time object counting API with YOLO and SORT algorithm

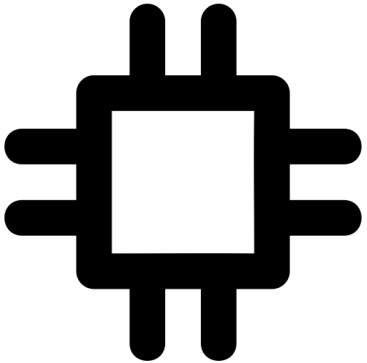


- In the final iteration, we will use Raspberry Pi for computation.

Hardware Specialist & Node Programmer

Three parts of the Node Device

Microcontroller



Weather Sensor

Vehicle Counter

Hardware Specialist & Node Programmer

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.

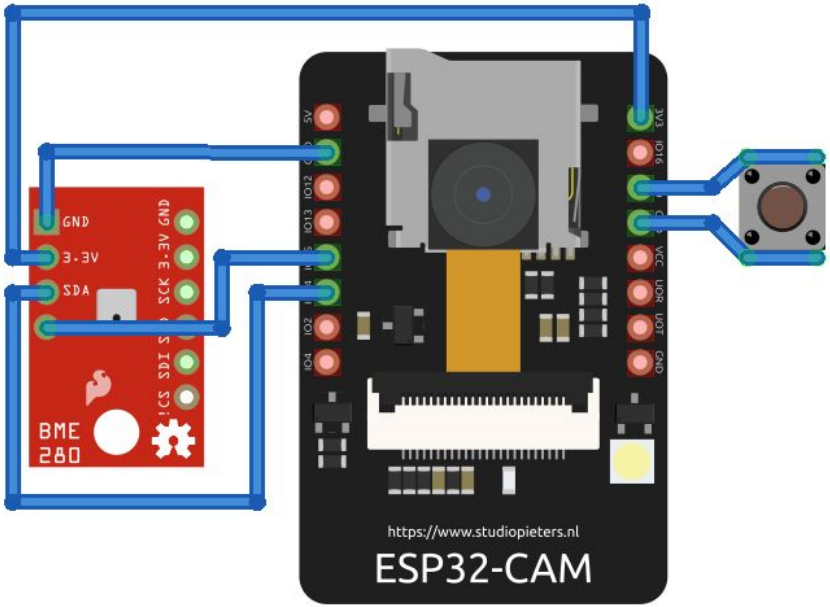
Vehicle Counter: **Onboard camera** of ESP32-CAM.

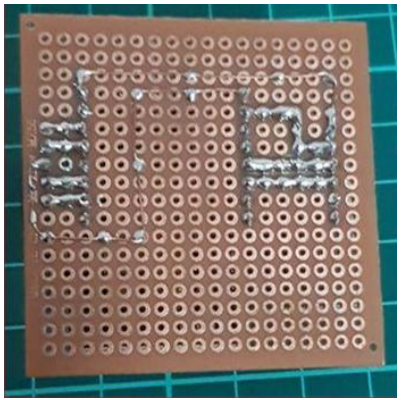
Hardware Specialist & Node Programmer

Demo-Ready Node:

- ESP32-CAM
- BME280

Hardware Specialist & Node Programmer





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

Hardware Specialist & Node Programmer

Libraries used in Firmware:

- SparkFunBME280
- ArduinoJson
- ArduinoWebSockets
- PubSubClient

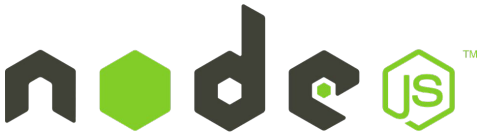
Hardware Specialist & Node Programmer

Partition scheme of firmware:

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

Integration & Backend Programmer

- **Node.js vs Spring Boot?**
  - Node.js has low-memory utilization
  - Node.js is non-blocking because It works asynchronous
  - JavaScript Community growing rapidly



Integration & Backend Programmer

- **MQTT vs HTTP?**
  - In 3G networks, the throughput of MQTT is 93 times faster than HTTP's[1]
  - MQTT Protocol ensures high delivery guarantees
  - MQTT Protocol is easy to use (short specification)
  - MQTT Protocol requires less energy

[1] Serozhenko, Marina. "MQTT vs. HTTP: Which One Is the Best for IoT?" *Medium*, MQTT Buddy, 20 Mar. 2017, medium.com/mqtt-buddy/mqtt-vs-http-which-one-is-the-best-for-iot-c868169b3105.

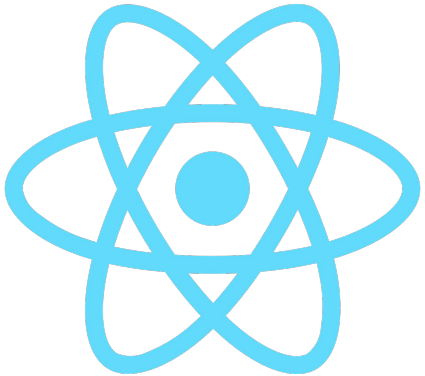
Integration & Backend Programmer

- **WebSocket**
  - We choose to use WebSocket for real time video frame transferring
  - MQTT and HTTP is not sufficient because of header data repetition
  - MQTT is not sufficient for big data transfer

Analytics & Frontend Developer

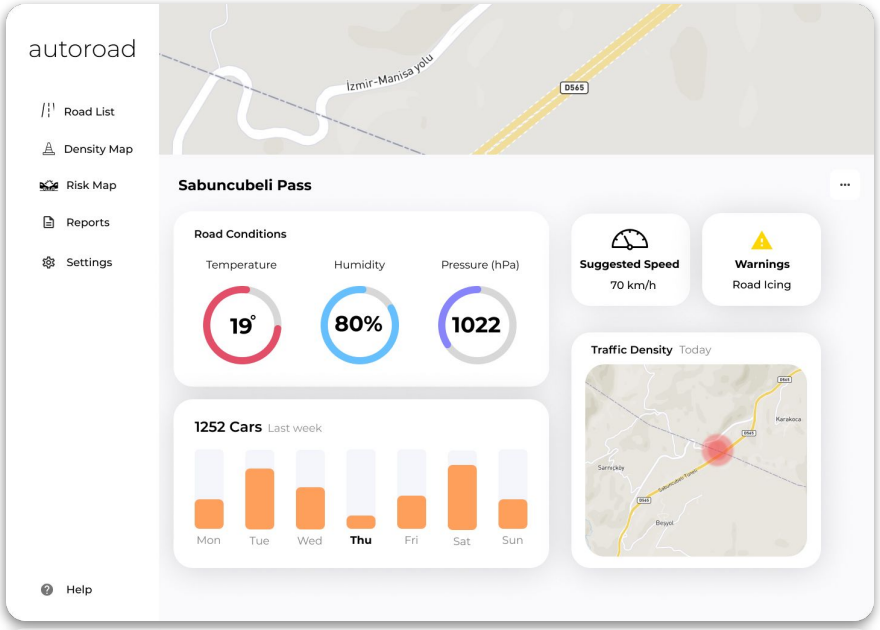
Drivers: Mobile

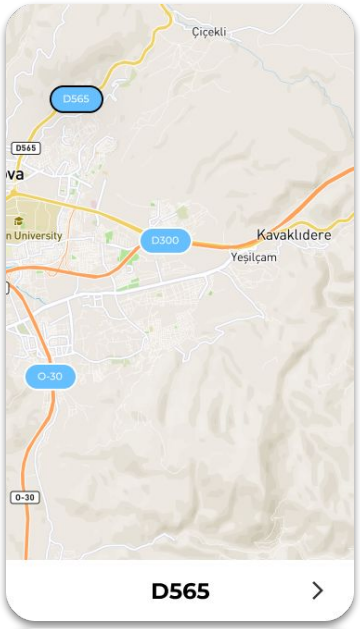
Traffic Service Providers, KGM, EGM and Advertising Agencies: Web

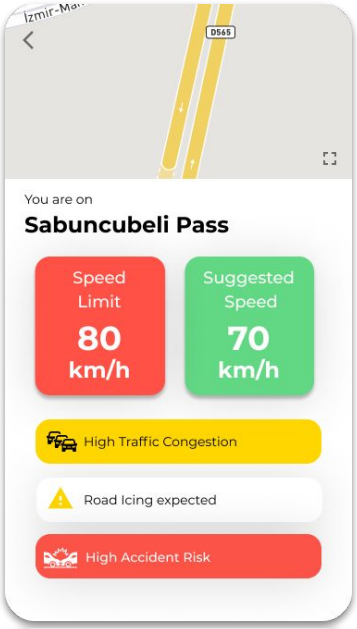


mapbox

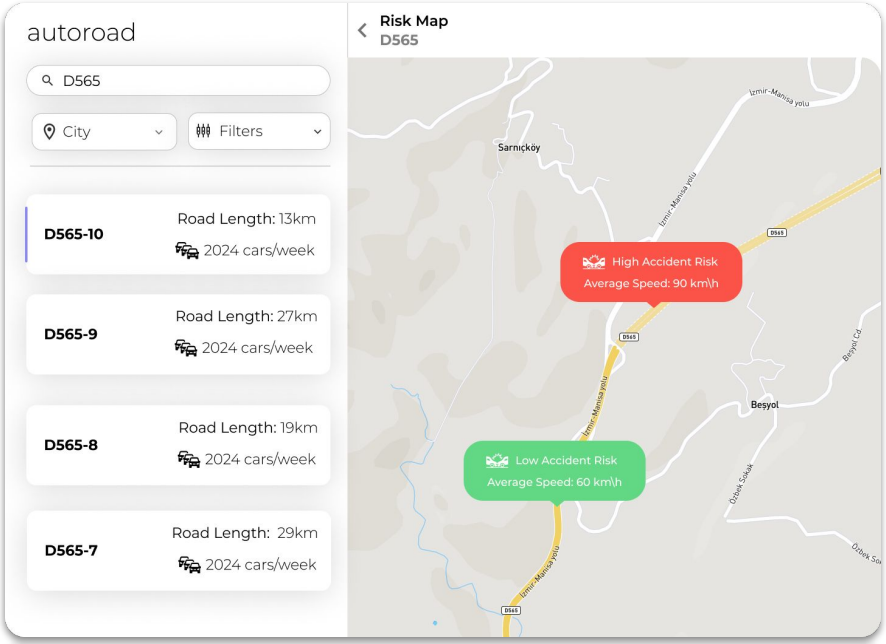
Analytics & Frontend Developer

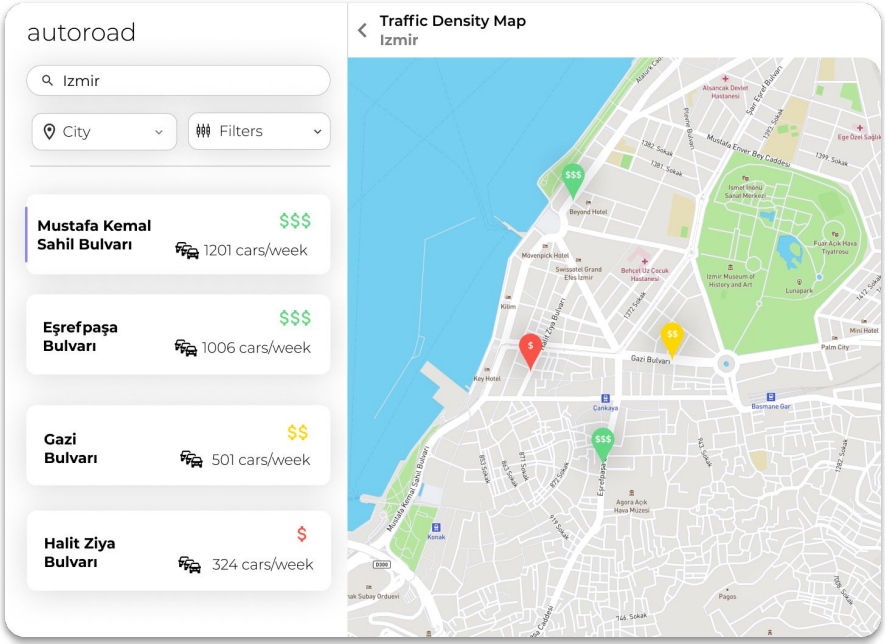






Analytics & Frontend Developer





Analytics & Frontend Developer