# Smart Cities: Traffic Monitoring System

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## Introduction

Traffic congestion is one of the most serious problems in big cities and it has made people's lives more difficult. Thirty years ago, there were fewer cars on the street and people did not suffer from traffic. [1] Today, however, streets are full of cars, buses and trucks. This phenomenon leads to negative economic, social and environmental consequences.

One possible countermeasure to this problem is traffic management. The idea is to use intelligent transportation systems which guide the traffic and control it, in order to avoid traffic congestions. [2] However, these intelligent systems need to collect data about the current situation of the traffic in different road segments. Sensors are required to fulfill this task.

Our idea to help with this problem, is to create a device which is embedded in the vehicles and allows to acquire their exact location and direction. The location information of each vehicle is sent to a centralized system (DB + server). As a result, traffic management official authorities can create a full location map of all the vehicles that are currently travelling in different road segments. The embedded device transmits live location information and thus the backend system can generate an up-to-date map of all vehicle locations.

Furthermore, we upgraded the system with a machine learning solution, which allows to predict possible traffic situation on specific road segments. Combining live data (acquired from the created prototype) with historical data (collected from different sources + saved data of the prototype), creates the possibility to better predict whether severe traffic situations can happen and thus alert vehicle drivers to avoid certain road segments, during real-time.

## Practical Applicability of the Project

The system that was developed aims to serve two main use cases:

1. The primary focus is collecting live vehicle location data for traffic monitoring and managing authorities. In order, to monitor and control the traffic in different road segments, data for the current traffic conditions are required. Thus, this system allows to collect all necessary location and direction data for travelling vehicles. Authorities can have a clear view of the number of the vehicles travelling, possible traffic situations or traffic congestions, at real-time.
2. The second applicability, is related to the end-user: vehicle drivers. By predicting possible traffic situations (based on the combination of live and historical data), drivers can be alerted to avoid affected road segments, and find alternative paths. This allows to further expand the traffic congestion and improve the situation. As a result, this traffic monitoring system can be expanded to a "Traffic Monitoring and Managing System".

## Conceptual Approach & Architecture

The core of the system is a device, built with a Raspberry Pi single-board microcomputer with a Linux OS. It is required to get the data from the sensors and transmit them via an internet connection to the backend centralized system. A GPS sensor provides location information of the vehicle. Additionally, a Gyro sensor and an accelerometer are required to determine the vehicle direction, in order to have information of its possible track direction. The power source for the device can be provided from the vehicle electrical system, but for the prototype a battery is used. Node-RED was used to develop the software logic of the Raspberry PI microcomputer. A node to read data from the GPS module is used. It allows to connect to GPS daemon and fetch the location data transmitted from the sensor. To read data from the gyroscope/accelerometer a python script was written, wrapped in a node.

This proposed solution from our team, required the development of a server-side system which collects the data from the devices and stores them. It consists of the server, which is responsible for the application logic, and the database which stores the received information from the devices. The communication between the components (Raspberry PI with sensors) and the server-side system is based on a REST communication architecture.

A frontend solution is used to display the live traffic information in a map. As a summary, firstly the device will be the source of vehicle location information and transmits it to the server, secondly the server will process the received information and save it in the database, and finally the information stored in the database will be presented graphically for the user in a map.

The following diagram, depicts the system's architecture:

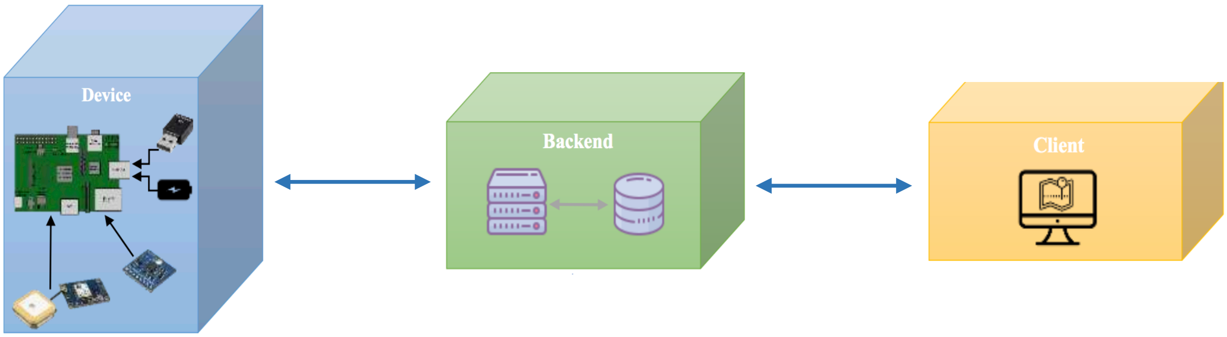


**Figure 1.** System Architecture

To provide added value also for the end-users of the traffic situations, vehicle drivers, we combined this system with a machine learning solution. Using Azure ML, we trained a simple predictive model, based on some historic data, which allows to predict possible traffic situations, based on the specific road segment, the presence or not of a junction in the segment, and some other features. As a result, due to the combination of live data from the sensors (and the whole system) and historic data analysed with the help of ML model, it is possible to better predict possible traffic situations and alert the drivers to avoid certain road segments. This idea can be integrated with car navigators, to improve their accuracy on traffic notifications, and suggestions for alternative travel paths. The following schema, represents the Azure ML Studio flow used to train the predictive model:

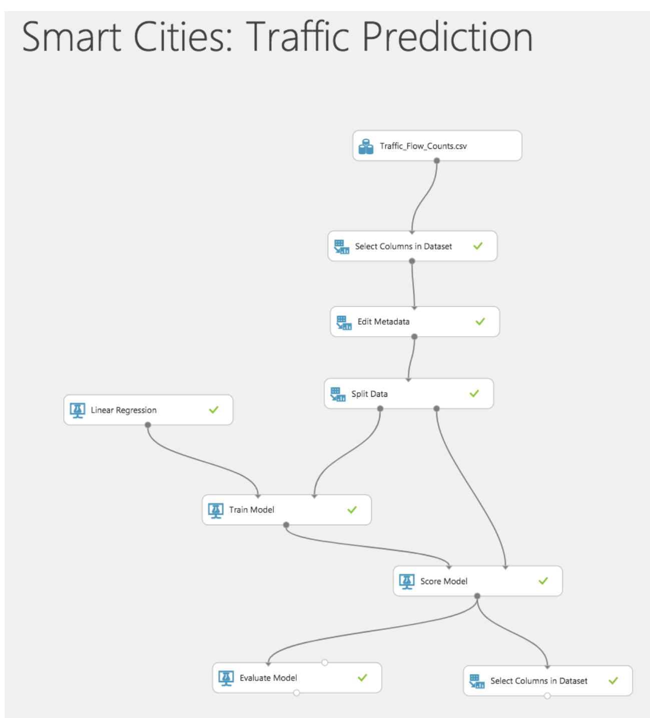


**Figure 2.** Azure ML Studio Flow

## IoT Sensors Used

For the creation of the prototype the following sensors were used:

- GPS Module – location sensor.
- Gyro sensor – orientation sensor.
- Accelerometer – orientation sensor.

## Circuit Diagram

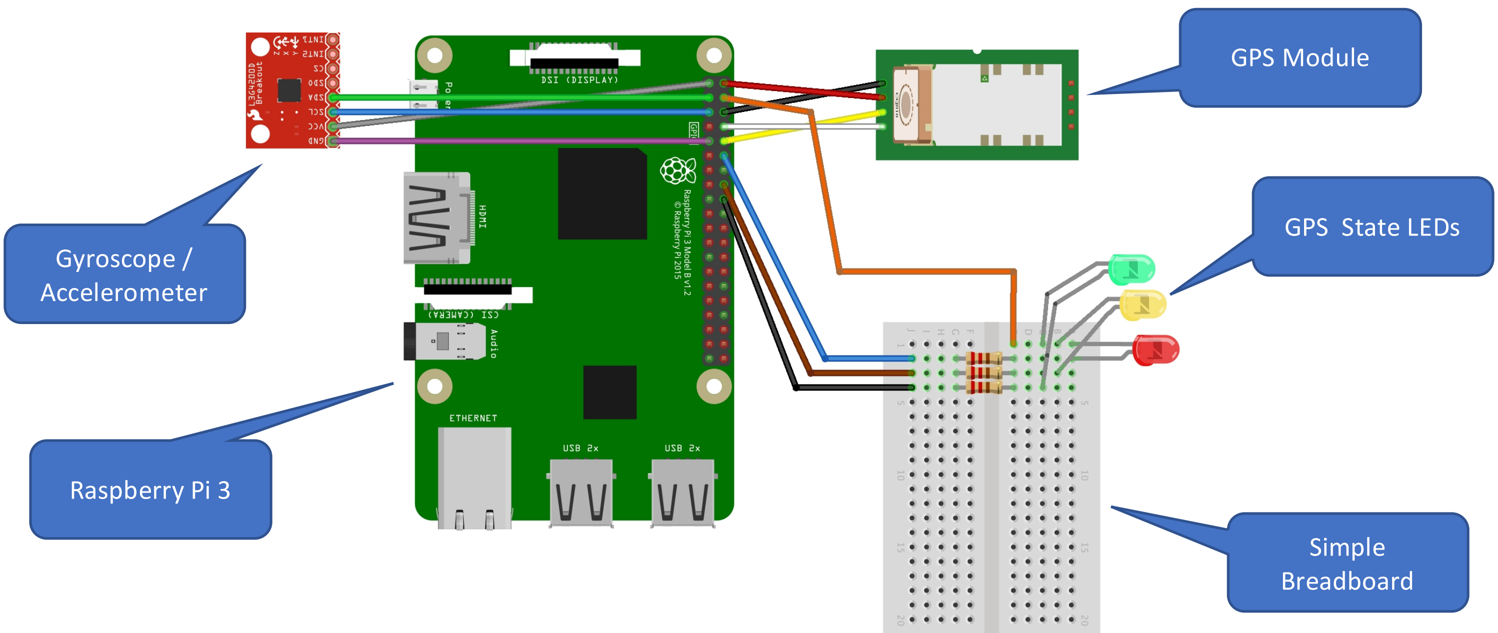


**Figure 3.** Circuit Diagram

## Problems Faced

- **Problem 1**: The GPS sensor was faulty and the replacement of the sensor required too much time. The sensor was correctly connected and configured, and also added to the Node-RED flow. Due to the lack of real-data transmission from the sensor, mocked data are used to display how the prototype will work.
- **Problem 2**: There was no Node-RED node available to connect the gyroscope /accelerometer. Thus, we used a python script to read the data and wrap it in a node.

## Work Items

- **Task 1**: No node was available to connect and read data from gyroscope/accelerometer, thus we had to write a python script and wrap it in a node.
- **Task 2**: Design and train a machine learning model to predict traffic situations, based on historic data. Used Azure ML Studio to achieve it.

# Work Split

In the following, a quick summary of the work done from the two project members is presented.

## Klaidi Gorishti

- **Task 1**: Hardware connections of the Raspberry Pi device with sensors.
- **Task 2**: Design and create Node-RED flow to connect the sensors with the device and read data from them.
- **Task 3**: Configure the GPS daemon and setup the GPS module.
- **Task 4**: Design and train a machine learning model, to predict possible traffic situations.
- **Task 5**: Configure the client-solution (map) to display the location of the device and possible travelling tracks.
- **Task 6**: Prototype testing.

## Newaz Md Bakee Billah

- **Task 1**: Setup of the Raspberry Pi and required configurations.
- **Task 2**: Installation of required Node-RED modules.
- **Task 3**: Write python script to connect and acquire data from gyroscope/accelerometer.
- **Task 4**: Generate mocked data to display the results of the prototype.
- **Task 5**: Design the architecture of the system and the information flow between the components.

# Concluding Remarks

The problem of traffic congestions is a concerning topic and different approaches to deal with it exist. The solution that is proposed with our system, can be integrated with existing approaches to have better results and improve the benefits. Some issues to be considered in the proposed solution are related to the scalability of the system, privacy issues, the need of a central authority and the accuracy of the retrieved data and made predictions.

To conclude, during this project we created a prototype which presents the core idea of the proposed approach to the traffic congestion problem. We think that with the help of IoT solutions it is possible to collect real-time data, which allows to monitor the traffic situations and possibly help on preventing them.

Future extends of this idea are possible and there is a lot of room to try new improvements and implement further functionalities of this system.

# References

[1] IELTS Mentor, URL: https://www.ielts-mentor.com/writing-sample/writing-task-2/2017-ielts-writing-task-2-sample-892-nowadays-traffic-is-a-serious-problem-in-big-cities, last accessed on 08.01.2018.

[2] Mobility, public transport and road safety, Government of the Netherlands, URL: https://www.government.nl/topics/mobility-public-transport-and-road-safety/mobility/traffic-management, last accessed on 03.01.2018.