AN APPLICATION OF INTERNET OF THINGS: MEASURING TRAFFIC FLOW

Ivan Jezdović*, Aleksandar Ivković, Sanja Matejić
Faculty of Organizational Sciences
*Corresponding author, e-mail: ivan@elab.rs

***Abstract**: This paper shows an example of an application of IoT for measuring traffic flow. A model of measuring traffic flow based on IoT was shown. An application of IoT is developed in aim to measure traffic flow in real time. A web application for tracking statistical data is shown. The device that follows the sound and registers the number of vehicles that passed is shown. This web application should enable detection of traffic jam and sending notification about alternative routes to drivers. It can be used as a mobile application also. It is also possible to develop system that will send SMS messages and report all users where is traffic jam and ensure them that they will not be part of that jam. The example of implementation is shown by using sensor which measures traffic flow in real time. After the processing, all statistical data can be seen through developed web application.*

***Key words:** internet of things, smart traffic, traffic security, traffic flow, traffic management, web application*

1. INTRODUCTION

With every day number of people living in a city is increasing. Current estimations say that 50% of world's population lives in cities. Today's cities are not projected for these huge amounts of people. Streets are narrow, infrastructure is old, and systems for managing almost do not exist. With the advent of Internet, microcomputers, sensors and actuators it came to accomplishing all necessary conditions for building smart cities (SAS, 2016).

Smart cities are cities which have their own information systems. These systems do different things, from managing traffics to managing hospitals and schools. These systems are connected with each other and it is possible to control all of them from one place. Elements of smart cities are: smart lightning, smart system for trash removal, system for air analysis, smart traffic and many others. It is possible to implement street lightning which turns on only when somebody passes by and in this way saving a lot of energy. Instead of management vehicles (trash removal vehicles) which pass by buildings every day to remove trash randomly and emptying trash cans that are not really full it is possible to develop system that informs workers when trash cans are full. System for air analysis can track air quality and inform people who need these information which parts of the city they should avoid. Important part of smart cities is efficient traffic management (IBM, 2016).

Traffic management is a problem that lots of cities have deal with. Many cities are trying to find a solution to improve public transportation and provide better services inside the cities with smart traffic signs. Responsible for highways also are trying to find new ways how to ensure efficiency to the passengers on long journeys as well as efficient transportation of goods. They are also trying to reduce traffic jam with new parking system. Smart traffic increases capacity, pleasure of travellers and ensures transportation from one to another place as safe as possible. Local police, emergency services and other government organizations can use these networks of sensors to get a quick look about situation in the city, so they could help and milder crowding on the roads, but also quickly react to the accidents.

The model of measuring traffic flow is developed that should enable collecting traffic data in real time. A web app should enable improving traffic flow, reducing delays, increasing security and improving ecological situation. Collected data are shown in real time, so that each change on the road is spotted immediately. With good analysis of these data it is possible to improve traffic flow, reduce delays, increase security and ecological situation.

2. LITERATURE OWERVIEW

Smart traffic includes data processing that sensors collected in the streets and inside the vehicles (Galán-García, Aguilera-Venegas and Rodríguez-Cielos, 2014). Some cities already use different analysis for prevision and traffic reduction. This kind of system helps drivers and authorised personnel. Drivers use different mobile and web applications to detect and avoid traffic jams. Authorised personnel for traffic use collected data to determine where it is needed to include new bus lines or change the traffic lights working order.

One of the cities that invests in smart traffic implementation is Singapore. Singapore adopted intelligent transport strategy. It is one of the cities in which the least traffic congestion occur, with an average speed on main roads of 27km/h, compared to an average speed in London which is 16km/h and Tokyo where is that speed only 11km/h (Batty *et.al.*, 2012). City uses electronic pay toll system where price varies in relation to the traffic flow. Each taxi vehicle has a GPS system which sends data about traffic conditions in the city. Information from all these systems are sent to the main control centre which merges data and provides information about traffic flow in real time.

Intensity of traffic represents interaction between vehicles, drivers, pedestrians, cyclists and other participants and infrastructure including roads, signs and devices for traffic control (Caragliu, Del Bo and Nijkamp, 2009). Purpose of measurement of traffic flow is understanding and development of optimal traffic flow with minimal congestions. For traffic flow measurement as a main information is used average annual daily traffic (AADT) and it is obtained by total number of vehicles for a year on a specific section divided by number of days in a year (Galán-García, Aguilera-Venegas and Rodríguez-Cielos, 2014).

Basic parameters of traffic flow are (Lécué *et al.,* 2014):

- Vehicle flow. Flow is the rate at which vehicles pass a given point on the roadway, and is normally given in terms of vehicles per hour.
- Density of traffic flow. Density refers to the number of vehicles present on a given length of roadway. It is reported in terms of vehicles per mile or vehicles per kilometre.
- Speed of traffic flow. The speed of a vehicle is defined as the distance it travels per unit of time.
- Peak Hour Factor (PHF). The ratio of the hourly flow rate (q60) divided by the peak 15 minute rate of flow expressed as an hourly flow (q15). PHF= q60/ q15.
- Vehicle volume. Volume is simply the number of vehicles that pass a given point on the roadway in a specified period of time.
- Time interval between vehicles. Gap is very similar to headway, except that it is a measure of the time that elapses between the departure of the first vehicle and the arrival of the second at the designated test point.
- Distance between vehicles (Clearance). Clearance is similar to spacing, except that the clearance is the distance between the rear bumper of the leading vehicle and the front bumper of the following vehicle.
- Total distance (Spacing). Spacing is the physical distance, usually reported in feet or meters, between the front bumper of the leading vehicle and the front bumper of the following vehicle.

There are two types of counting traffic flow and they are static and dynamic. Static – vehicles which pass in certain period of time through the certain section of the road are counted. Dynamic – it is counting of traffic flows. Actually it is used to determine intensity, direction and path of traffic flows.

Not only that information are collected from the traffic, one of the great ways to stop traffic jams is improvement of parking systems. It is considered that 30% of city traffic jams are caused by drivers who are looking for a parking spot. In a study 15 city blocks are observed in Los Angeles for a time duration of a year. Researchers have found out that drivers have driven more than 1.500.000 km, produced 730 tons of carbon dioxide and used around 200.000 l of fuel to find a parking spot. Smart parking has a job to find quickly and efficiently parking spot for each user. Some of analysed examples allow users to reserve parking spots directly from mobile application (Wang and Wenbo, 2011).

Smart wireless sensors build in the parking spots can collect data in real time about certain parking spot. Sensors will follow if the parking spot is occupied, empty or expired. Device sends information to competent centre which is connected with mobile application for drivers. Using the application user can find a free parking spot, and the city can thoroughly change traffic patterns and driver’s habits.

3. MODEL OF MEASURING TRAFFIC BASED ON IOT

In this work is shown model of measuring traffic flow based on IoT. System allows monitoring of number of vehicles which in certain point of time drive through certain section of the street. Basic component of the system is laser for distance detection. On the basis of work of laser it can be measured how many vehicles have passed. In case of cutting the laser beam, the noise level will be checked with the sound sensor LM393 and it will be determined if the car has passed or some other object. In addition to laser and sound sensor, Raspberry Pi microcomputer and Arduino microcontroller will be used.

In case number of detected vehicles passes the certain point, it is possible to conclude that on a monitored road traffic jam has developed. Another parameter to detect traffic jam is constant cutting of laser beam. In these situations, vehicles are moving slowly which leads to long-term cutting of laser beam.

Using this kind of model it is very easy to determine critical spots of traffic jams in the city. This information is of a great importance for drivers and authorized personnel. It is possible to inform drivers about traffic jams and offer them an alternative route, and authorized personnel can analyse traffic and implement changes that will decrease traffic jams.

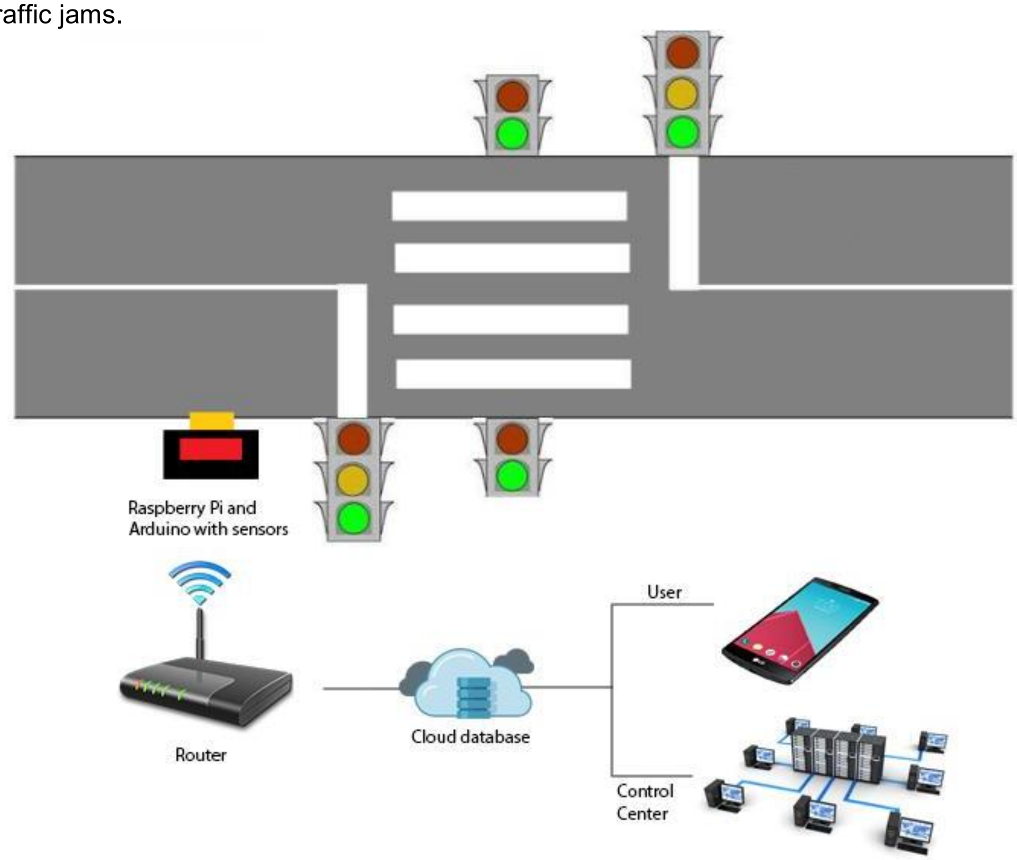

Figure 1: Model of measuring traffic flow based on IoT

Sensibility of the sound sensor is set to minimal, so it would avoid detecting any other sounds other than the sound of vehicles. The device follows the sound and registers the number of vehicles that passed. Remote following of the counter is also possible through web application.

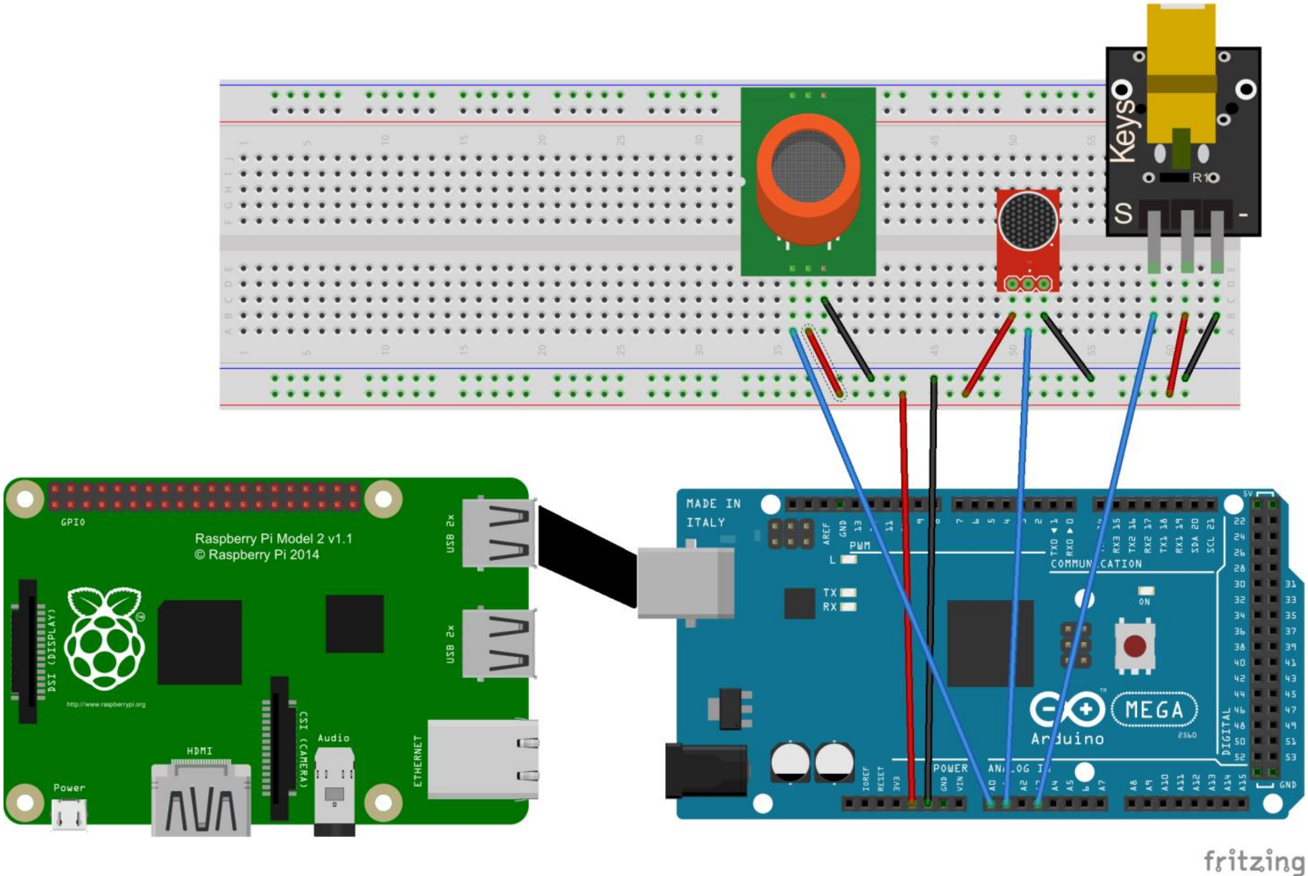

Figure 2: Physical connection of devices

On the picture are shown Raspberry Pi microcomputer and Arduino microcontroller connected with sensors and actuators. Black lines represent cables that are connected to the ground (negative pole) on Raspberry Pi. Red lines represent cables that are connected to power source of 3.3v or 5v on Raspberry Pi. Blue lines represent cables that transfer data between devices.

Raspberry Pi has a web server running. Arduino is connected to Raspberry Pi and sends data read from sensors. Laser sensor, sound sensor, CO_2 air pollution sensor are connected to Arduino. Raspberry Pi is running on Linux distribution called “Raspbian”. Web server is developed using “web.py” framework and has a task to send information to service that saves them in database. Because of big amount of data the non-relational database is used (MongoDB) and it is located on the cloud.

4. DEVELOPMENT OF WEB APPLICATION FOR TRAFFIC FLOW MEASUREMENT

This paper shows a web application that allows monitoring the number of vehicles in real time. Based on collected data it’s needed to do analysis and represent results to user in graphical view. The web application is developed by using Bootstrap framework. For graphical view of data is used Chart.js library. Application logic on server side is developed in PHP programming language. Parts of the application logic that are being executed on client’s side are developed using JavaScript. For data insight in real time is used AJAX. All communication with web server takes place through sending and receiving HTTP requests that carry data in JSON format.

Alongside with the insight of traffic flow in real time, it is also possible to filter the data and get more information for previous period of time. Actually it is possible to choose previous day, week, month, year or any other time period. This information can help people who are responsible for highways to make some revolutional changes and make much better traffic system. Also, it is possible to get information about air pollution for certain sections of the road.

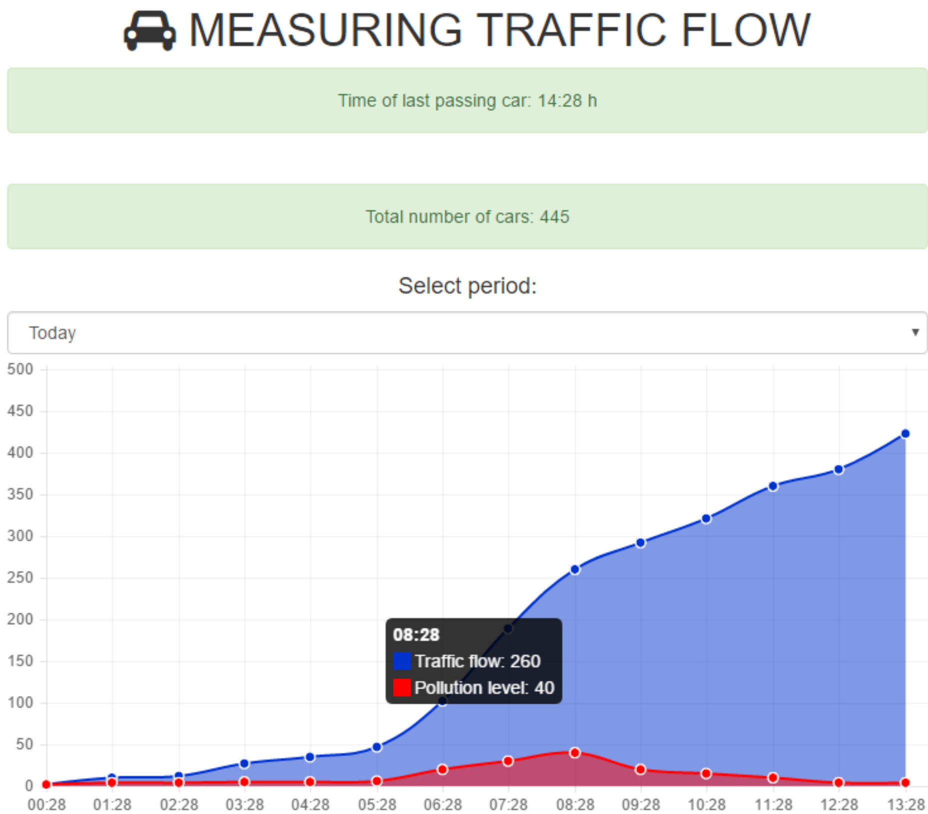

Figure 3: Web application

As an alternative to web application it is possible to develop mobile application. Within mobile application user would have an insight to the same data like in a web application, with some additional functions like push notifications. System would follow current location of the user and in case of noticing that user is moving through route where is traffic jam it would pop up notification with a new route. During suggestion of a new route it should do the selection of users so it doesn't happen that all users get rerouted to the same route. In case of traffic accident in certain street, operator can easily send notification to all users. It is also possible to develop system that will send SMS messages. User can send a message to the certain phone number to get some information about traffic flow and as a replay he/she will get list of the streets where is traffic jam.

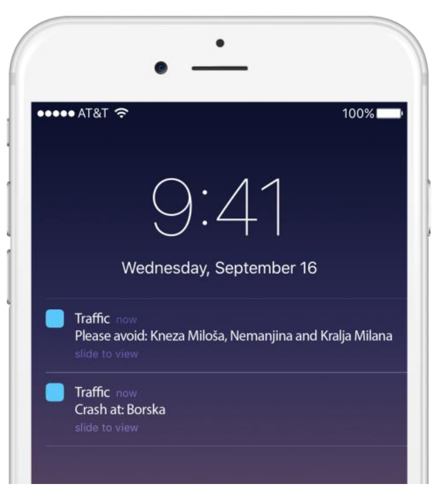

Figure 4: Proposal of system with push notifications

5. CONCLUSION

In this work is shown model of measuring traffic flow based on IoT which was developed on Department of e-business at Faculty of Organizational Sciences, University of Belgrade. Architecture of the proposed model is defined. Furthermore, implementation for model for traffic flow measurement and level of air pollution on the roads was shown.

Main advantages of this solution are simplicity, low cost of equipment and possibility of implementation in other smart environments like smart parking. Important advantage of this solution compared to other solutions is collecting information in real time which offers possibilities with smart traffic signs, traffic can be rerouted to less crowded roads and avoid congestions in this way. Model can be improved with additional sensors. Expanding the sensor network will increase data collection which will lead to improvement of system precision and it will allow recognition of driving patterns.

While other solutions relay on data from cameras (Calderoni, Maio and Rovis, 2014) and information from mobile phones (Khoo and Asitha, 2016), this solution is completely relayed to sensor information which is it's advantage. Cameras are more expensive, it is harder to estimate number of vehicles, and applications can undermine user's privacy.

Real-time and historical data collected from network of sensors are used for prediction of travel times. Travel times are usually posted on the web and on signs both on the side of highway and on overhead signs (Bickel, 2007).

All analysed systems are facing the same problem – rejecting users to use alternative routes (Khoo and Ong, 2011). In Malaysia the survey was conducted about using applications to avoid traffic jams. Only 26% of drivers was ready to change their route and use the one that application has suggested. This number is not big enough to make significant difference. Although this percent will grow, it is needed to increase conscience of the drivers about those applications and their advantages.

Today`s main focus is on technologies that are measuring traffic flow of vehicles, but in the future we might see new hybrid systems that are using similar technology to measure flow of pedestrians along sidewalks as well for counting bicycles on the roads.

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