Traffic Light Monitoring System based on NodeMCU using Internet of Things

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Abstract. The increasing numbers of the private car cause the road traffic congestion. That is becoming important problems in the big cities. Another solution to reduce the traffic jam is developing intelligent transportation system such as intelligent traffic light system. However, the solution of such problems is one of the mandatory concern. In recent years, a smart city is the hottest topic for the efficiency of traffic light using the Internet of Things. Based on that issue, this research proposed traffic light monitoring system that can monitor and display a real-time traffic congestion through smartphones. The system utilized NodeMCU (ESP 8266 12E) equipped by IR obstacle sensor to indicate the road traffic congestion. To connect the internet, the system uses ESP8266 12E wifi in the chip of NodeMCU. It will send a notification to smartphones user. With this research, it is expected to improve road traffic tremendously such as to predict traffic congestion and the system can give some efficient routes for a user.

1. Introduction
Nowadays, Indonesia become urban country because every year the number of private vehicles always increases about six million units per year, 10-15 % comes from the cars. But the infrastructure to support that so bad. That is becoming important problems, because according from TomTom navigation devices Indonesia has the fourth worst evening rush hour traffic in the world cited by CNN.

Some countries in the world have the same problem [1], such as Japan, USA, and Europe countries. To reduce that problem their reformed the road system and improved the traffic management method using intelligent transportation system [2, 3]. The development of ITS has been a popular research for the traffic monitoring using The Internet of Things [1, 3]. IoT concept constructs some object around us become smarter for connection to each other such as roadside sensor systems for supporting road infrastructure systems[4], so that can communicate with each other for gather everyday information about the traffic environment with the minimum human intervention[4]. From that issues, this research was design an intelligent transportation system using internet of Things platform. The system can monitor a real-time condition the traffic congestion on road [5, 6], use some roadside sensor system for dynamic management of traffic signals. And to avoid the traffic jam, the user can able to find out optional routes to go to destination.
2. Methods

![Figure 1](image1.png)

**Figure 1.** Architecture of the system.

The figure 1 approximately overall architecture of the traffic light monitoring system. The system divided into two module such as hardware module and software module. In hardware module, utilized the Android Phone/Device, NodeMCU (ESP8266 12E), IR obstacle Sensors (FC-51), Resistors, LED, etc. And in software used the MIT App Inventor for an android application, a web server for saving the database [7, 8].

In this system, sensors will send information to a NodeMCU [9]. Then NodeMCU will receive that information and transfers to the android device via the internet. Android device will send all the collected information to the server over the web server and store it in the database [8].

According to the traffic signals from the sensors will be managed dynamically to avoid a traffic jam. When a user needs a real-time traffic data or condition the routes, the user can log in to the Android application, the application will request to the web server for the user requirement [7] and the server will get results from requirement and user will see the traffic data and traffic condition.

![Figure 2](image2.png)

**Figure 2.** Design of the system.
Figure 2 is a miniature of 2 crossroads and 1 T junction in an urban area with the maximum speed of the vehicle is 50 km/h with a road width of 7 meters and 3 meters, with a road length of 25 kilometers. Which equipped 3 sensors at a certain distance to the traffic signals. The first sensor indicates the route is normal, the second sensor indicates the route is jammed, and the third sensor indicates total traffic jam.

2.1. Hardware
The hardware for this system using some components includes: Phone/Device, NodeMCU (ESP8266 12E), IR obstacle Sensors, Resistors, LED etc.

2.1.1. NodeMCU (ESP8266 12E). ESP8266 is a microcontroller designed for Expressive Systems. ESP8266 is a solution for Wi-Fi networks from existing Micro Controllers to Wi-Fi and is also capable of running standalone applications. Connection with PC using the micro USB cable and there are 17 GPIO, with a consumed current of 10uA ~ 170mA and RAM of 32K + 80K [10]. It is designed for wireless location-aware devices, wireless positioning system signals, industrial wireless control, etc. ESP8266 is used to process and transfer information to the web server so that the smartphone can access the information.

2.1.2. IR obstacle sensors. It detected object range of 10-30 cm. This sensor can be used for most indoor applications where no important ambient light is present [11]. The IR sensor will used to sense the road traffic congestion.

2.1.3. Step down module (MB-V2-102). It is a voltage-reducing module and current stabilizer, the input voltage for the module is 6.5V-9.0V DC from datasheet [12]. While the output voltage of 3.3V Dc and 5 V Dc with current 700mA. The module can use a USB or jack from the adapter.

2.1.4. LED. A light-emitting diode (LED) is a semiconductor device that emits visible light when an electric current passes through it. In this system, LED is a miniature of traffic light system in the real life.

2.1.5. Resistors. It is a passive two-terminal electrical component. It implements electrical resistance as a circuit element and acts to reduce current flow. Also, act to lower voltage levels within circuits, at the same time.

2.2. Software
Software module for developing a system using various software tools which includes: Arduino IDE, MIT App Inventor, and Firebase.

2.2.1. Arduino IDE. Arduino is programmed with a C/C++. Then Arduino IDE software is written in Java based on the processing project from writing and uploading the code to the Atmega chip in Arduino. It is compatible software to program with some module such as ESP.

2.2.2. Firebase. It is middleware between the hardware module and the end user. Firebase is platform for internet of things for web server with open big data from sensors. Which is MQTT platform (Message Queuing Telemetry Transport), it is a protocol that runs on top of the TCP/IP stack and has a small data packet size with a low overhead (minimum 2 bytes) so that it affects the consumption of the power supply is also quite small.

2.2.3. MIT app inventor. The first one the application will receive all the sensor values and transmit/upload that sensor values to the server another app will use to monitor the traffic condition. The software is interfacing from android smartphone user with a web server, so user able to see the condition of the road from a smartphone.
3. Results and discussion
In this section discussion about the design overall of the system. This screenshots of the Android application are as follows:

![Android application](image1)

**Figure 3.** Android application.

![Arduino IDE program](image2)

**Figure 4.** Arduino IDE program.
The system was adapted from the Android application as shown in figure 3 was developed using App inventor software to connect with Wifi module, web server and display given sensor values which are collected from the hardware module and finally upload this values on the web server. This developed android app will active on any android device and it will always connect to the hardware module. Figure 4 showed the program from Arduino IDE to write in the microcontroller NodeMCU, it is important to program for this research because of all program from the system in here.

In the Android application showed some button for user requirement, the application provided some option for monitoring traffic light in the first crossroads or second crossroads or T junction in some condition, also user can select another button for monitoring traffic density. The application can show the condition of the route, the user chooses the location and destination in this system then application show how condition in the route. If the route is jam the system will give some optional routes.

In figure 5 showing the hardware system for monitoring traffic light. This prototype has several that is the mismatch between the goals with the results achieved. These constraints include:

- In the planning of the prototype using NodeMCU ESP8266 but I/O from the microcontroller is less than other microcontroller but NodeMCU stabil on connectivity.
- The output voltage from NodeMCU is 3V then the sensors need 5 volts to work and has a large current consumption, which that requires a separate adapter. Then NodeMCU did not have a voltage stabilizer so ESP always does the reset, to reduce it needed a voltage stabilizer using a step down the module.
- NodeMCU support with another web server, so that can be modified the web server or MQTT broker. And NodeMCU can programme with LUA. And for the Android application can use AndroidApp, its support for NodeMCU.
- The sensor can not implement in the real life because of many disadvantages, readability of the sensor so small from 0-30 cm. The sensor can not detect glass objects.

4. Conclusions
The design of monitoring traffic light system on this research is not too much developing as a whole. Need future research about ITS. The monitoring traffic congestion system was presented traffic connection routes with IoT to develop a real-time software for managing traffic conditions. This system used a web server and an Android client application for reporting and displaying traffic condition. The system for administrators includes a web application, and for the interface of the client application, it is easy and safe to use while driving. The focus on this research about efficiency and traffic density using ITS and IoT technologies.
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