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An Intelligent Traffic and Vehicle Monitoring System using Internet of Things Architecture

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Abstract: ***Traffic in modern cities and urban area is creating huge menace and is a major concern for the public and administration system. Incidents such as jams, accidents have become quite common because of exponential growth in vehicles on road. While human errors are one of the major reasons for these problems, the lack of proper measures and adaptive traffic control system is another reason. Security for the vehicles is also important. Even in this latest technological world, hackers are still managing to break the security aspects incorporated in modern vehicles. Many technologies such as RFID, Bluetooth, Zigbee, GSM-GPS based systems were developed but they have limitations in terms of operation and usage. Internet of Things (IoT), a technology that connects various objects, is growing at a rapid pace. This paper presents traffic and vehicle monitoring system based on IoT. This system is capable of addressing problems such as traffic congestion, early warnings regarding jams, vehicle spotting, VIP and emergency vehicle clearance. The system is built using ATMEGA 2560 microcontroller board, and AMICA NodeMCU IoT board, and UBLOX NEO 6N GPS module. The compact design makes the system more reliable and accurate.***

Keywords: ATMEGA, GPS, IoT, Traffic Management, Ublox-Neo 6M

1. Introduction

One of the major sources of revenue for many countries is transportation. Human transportation, logistics, private traffic forms part of transportation. The developing and developed countries are striving to improve the standard and efficiency of transportation system. Because of the traffic jams, and lack of proper traffic management system, time and money of the public is being wasted. Goods transportation, machinery and human transportation are the key factors which influence the development of industries. The development of traffic monitoring and controlling system is a very important requirement in all the countries. Figure 1 shows the blue print of Intelligent Traffic System. As there is a rapid growth in the traffic these days, the authorities have to find different ways to avoid these problems [1-4]. Measures such as developing new roads, over bridges, under bridges, fly-overs, tunnel roads etc. are some alternatives. Apart from this, use of trains such as Light Rapid Transit [LRT] trains is handy. Construction of inner ring roads will divert the traffic and provides easy monitoring of traffic during peak hours.

2. Literature Survey

In this section we discuss about different methods of monitoring and control. Related to the traffic monitoring and vehicle monitoring, many approaches and methods have been proposed [5]. It includes rule based learning to the modern fuzzy and neural network approaches.

Findler and Stapp described an expert system based on connected roads and traffic lighting system. These expert systems use a set of rules and based on those rules, the next action will be decided. As mentioned in [6], the rules are analyzed by optimizing set of rules that apply to them and based on the frequency at which these rules fire. Authors show that the system developed by then can perform better

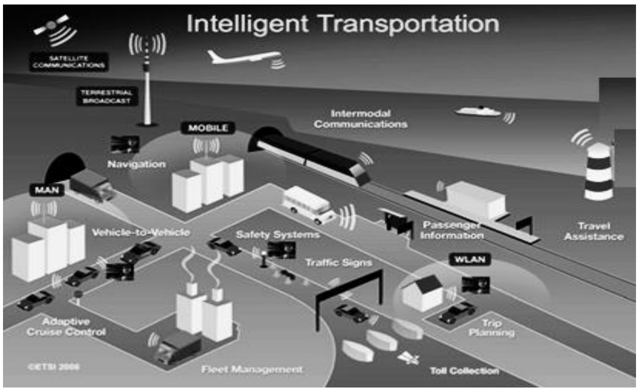

Figure 1: Intelligent Transportation System

provided they make slight modifications and simplified assumptions. In [7], a traffic light system using a simple predictor was developed by Tavladakis and Voulgaris. It takes measurements during current cycle and uses these measurements to test several possible settings for the next cycle. This system proves to be highly adaptive but could not handle high traffic fluctuations.

In [8], Liu has demonstrated some methods to overcome the fluctuations by incorporating traffic detectors at both sides of a junction and vehicle identification were used to measure the average delay at a junction. Tan describe a fuzzy logic controller for a single junction that should mimic human intelligence [9]. Traffic is quantized as many, medium and none. This system uses a predetermined order of states and

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the states can be skipped if there is no traffic volume in that particular state.

In [10], Lee et al. used fuzzy logic to control traffic at multiple junctions. In [11], Choi et al. used fuzzy logic controllers and is used to adapt them to the congested traffic flow. A better strategy compared to the fixed fuzzy logic traffic light controller is shown in [12]. This system will work perfectly even in larger traffic flow under very crowded traffic conditions. In [13], fuzzy method augmented with the hierarchy and interpolation are applied to the large number of lanes and more road intersections to decrease the complexity. Taale et al. compare using evolutionary algorithms evolution strategy to evolve a traffic light controller for a single simulated intersection to using the common traffic light controller in the Netherlands (the RWS C-controller). There are many other methods and approaches in many different programs, each have their own pros and cons.

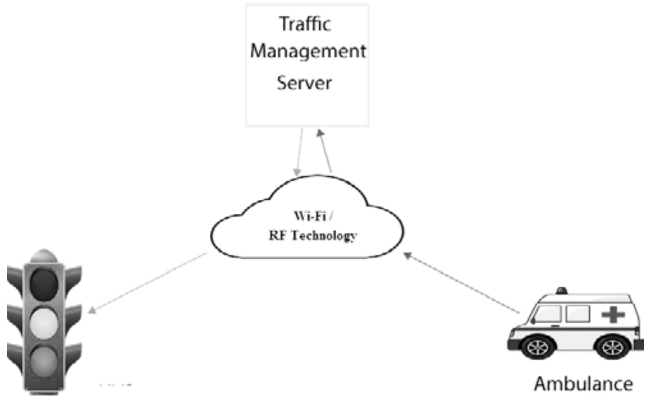

Figure 1 ITVMS running in Priority Mode

In this paper, we present a novel method to control and monitor the traffic. This system uses Internet of Things architecture. The system block diagram is shown in Figure 2.

The system contains two parts. The first part is used to track the car and the second part contains logic to monitor and control the traffic. Each of these sections is elaborated in the following sections.

3. System Design

As we already mentioned, the entire system is divided into two parts. Now let us look into the details of each of these parts in detail.

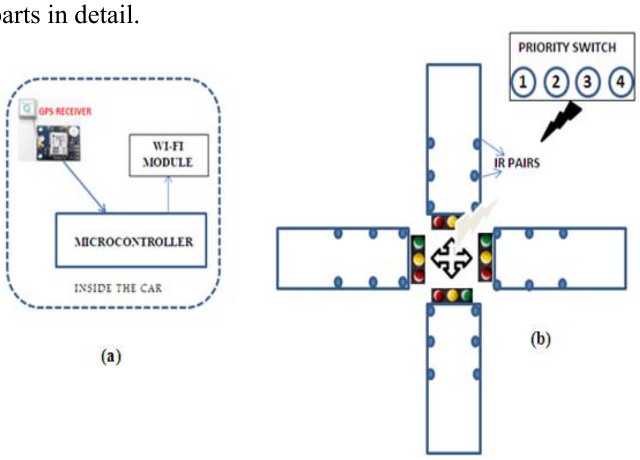

Figure 2: (a) Tracking Module (b) Monitoring Module

3.1 Tracking Module

The tracking part is placed inside the car. This module is designed to read the latitude and longitude of the locations through which the car is traversed. Ublox NEO-6M GPS module is used for reading latitude and longitude. This module is updated to use with latest microcontrollers and the position information given by this module is very accurate. This module is configured to 115200 bps to communicate with the microcontroller. It is a standalone GPS receiver and takes 1 Second time to first fix for hot and aided starts. The tracking sensitivity of the module is -162 dBm and also has anti-jamming technology incorporated. The position update rate is 5Hz. Operating in a temperature range of -40 to 85^0 C, the module has UART TTL socket and EEPROM to store settings of the receiver. This avoids configuring the module on each restart. The device RoHS compliant and has rechargeable battery for backup.

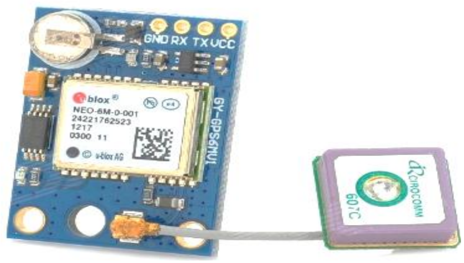

Figure 3: Ublox Neo – 6M GPS Module

The National Marine Electronics Association (NMEA) is the standard body for providing specifications and defining interfaces between marine equipment. Using this standard, marine equipment can communicate with the other equipment. GPS communication uses this NMEA standard for its communication. All the programs and systems expect the data in this format for processing. The data contains position, velocity and time information computed by the GPS receiver.

NodeMCU is the microcontroller used for this purpose. The NodeMCU microcontroller contains nine digital I/O pins and one analog I/O pin with built-in ADC. It support UART, I2C, and SPI communication protocols and requires 600 mA of current for its full load operation. The device operates at 3.3V power supply. The microcontroller is equipped with an ESP8266 Wi-Fi module.

The ESP8266 Wi-Fi module contains an in built Tensilicon 80 MHz 32-bit RISC processor. It has 4 MB of flash memory thereby allowing the program to be stored on chip and hence reduces the development cost. The Wi-Fi module supports both Access Point (AP) mode and Station Mode. In our context, we have configured the module in station mode, where the module connects to the server using TCP/IP protocol using HTTP at port 80 using an access point and streams the data.

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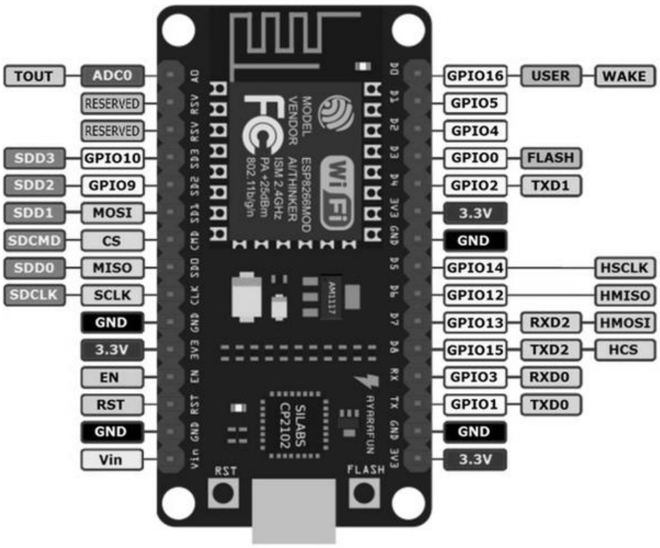

Figure 4: NODEMCU 32-bit Microcontroller

The data received from the GPS receiver is given to a microcontroller. This data contains many sentences and the microcontroller gathers the latitude and longitude from the $GPSRMC (Recommended Minimum Data from GPS) sentence. This latitude and longitude information is then packed into a prescribed format and using a data stream posted into the cloud server. The http://data.sparkfun.com is a free cloud service provider. A user can create his data stream in this cloud and can store data upto 50MB.

3.2 Monitoring Module

In this mode, the module will keep track of the traffic. We assumed a 4 way junction in our implementation. This module operates in three modes namely Normal, Congestion-based and Priority modes.

a) Normal Mode

In this mode, the traffic lights will change their states based on pre-determined interval. This mode is useful when the traffic on all the lanes is uniform and traffic is moderate. This mode is similar to the normal traffic lights operation we see in most of the areas in the city. The problem with this mode is that even when there is no traffic in a particular lane, still the other lanes with traffic has to wait. This will waste the time of the people.

b) Congestion-based mode

In this mode, we can overcome the problem in the conventional traffic systems where people wait in the traffic even when there is no much traffic. IR Sensors are installed on all sides of the lanes. The density can be identified by checking the number of connection breaks in the IR sensor pairs. The IR sensors are positioned in Line-of-Sight configuration. In general, they are conducting. When any obstacle enters in between, the connection breaks and more breaks in a line compared to the other lanes implies that the traffic is more in that lane and hence passage is given to this line while the remaining lanes are blocked.

c) Priority Mode

This mode is most useful in cities which are also administration headquarters and in general useful to give way to the emergency vehicles such as ambulances. This mode is implemented using RF technology. The logic is simple and comfortable. We have four switches corresponding to the four lanes. When corresponding switch is pressed, then the lane will get passage and all the remaining lanes are blocked. We can set the time interval for this operation. After the prescribed duration elapsed, the system goes back to previous mode (Normal or Congestion based).

4. Results

The system is implemented using ATMEGA series microcontroller for monitoring module and NodeMCU for tracking module.

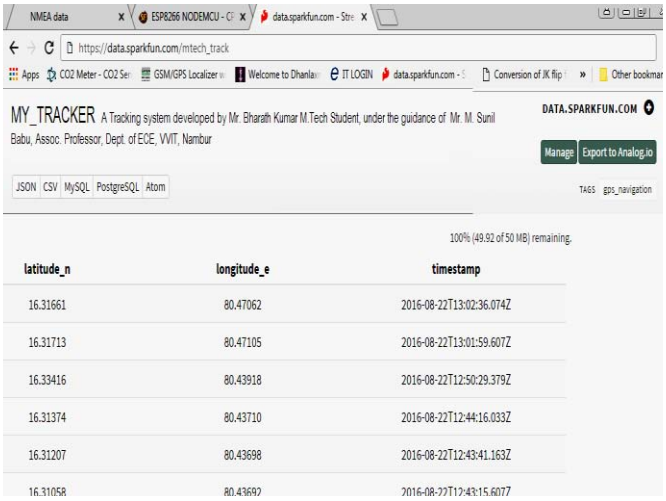

Figure 5: Screenshot of data posted in cloud server at data.sparkfun.com/mtech_track

The code is written using C programming language on Arduino IDE and the system is then tested for its accuracy. tests proves that the system is doing well in all aspects and tracking data is successfully being posted into the cloud server. Figure 6 shows the screen shot of the data posted in the cloud. We have created a data stream for the cloud with alias name "mtech_track" and used this stream to post the data.

5. Conclusion

In this paper, we have developed and implemented a novel traffic system that is capable of monitoring and managing urban traffic. This system is tested with various conditions and is proved to be scalable. The additional vehicle spotting feature makes this system different from the other implementation. The incorporation of IoT into the system makes this as a blend of standard and advanced technologies. Vehicle owners can track their vehicle from anywhere in the world. The system developed in this paper proves to be reliable and cost-effective.

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whom proofs of the paper will be sent. Proofs are sent to the corresponding author only [2].

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