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Review Article

A Smart Traffic Management System for Congestion Control and Warnings Using Internet of Things (IoT)

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Abstract: Over the years, there has been a sudden increase in the number of vehicles on road. Traffic congestion, is a growing problem everyone faces in their daily life. Manual control of traffic by policeman has not proved to be efficient. Also the predefined set time for the signal at all circumstances (low and high traffic density) has not solved this problem. Mechanisms to use IR sensors to detect traffic density is not very effective as even a single vehicle detected at the last sensor can imply high traffic density even when there is free space in front of it. A model to effectively solve the above mentioned problems by using Internet of things for traffic controlling systems which also gives priority to emergency vehicles is proposed. We use cloud for internet based computing, where different services such as server, storage and application are delivered to an organization. Cloud computing store data on the internet which must give continuous update so that it can handle traffic smoothly. We then use load cell to approximately calculate the amount of time required to clear the traffic on a particular road based on the density of traffic. RF transmitters are used in emergency vehicles to transmit signal to RF receiver mounted on traffic signal. This makes sure the signal is turned green to let the emergency vehicle pass by. A real-time traffic information collection and monitoring system to solve the problem of real-time monitoring and controlling road vehicles is proposed. This system employs key technologies: Internet of Things, Load Cells and RF Transmitters and Receivers to collect, Store, Manage and Supervise traffic information. Multiple advantages of the work are: Cost effectiveness, reduction in waiting/ travelling times with cost and fuel efficiency, traffic surveillance using URL available for smart decision making is of major concern.

Keywords: Load Cells, Internet of Things (IoT), RF Module, PIC Microcontrollers, LCD Display.

INTRODUCTION

The term the Internet of Things (IoT) was coined by Kevin Ashton of Procter & Gamble in 1999. Internet of Things is an environment of smart devices which are always, anywhere and anytime connected with each other while sending and receiving some data or information which can further be processed to generate meaningful analytic results. IoT has two main parts; Internet being the backbone of connectivity, and Things meaning objects or devices. With the increasing number of vehicles owned by individuals, Traffic Congestion is an ever rising problem.

Out of many various reasons for traffic congestion, vehicles waiting for a longer time at a signal lights also contribute significantly for the same. Emergency vehicles blocked by such huge traffic can put one's life in danger. There is currently no mechanism available for the clearance of traffic in case of an emergency. The existing systems of manual control of traffic or predefined time for change of traffic lights are inefficient. The goal of traffic congestion control and management system is to clear the accumulating traffic as soon as possible and also to pave way for the emergency vehicles. It is a known fact that even when there are less vehicles on one lane and more on another, the green signal is turned on for the same time thus wasting precious time on green signal for empty roads. This paper proposes a solution to solve this and also aims at providing priority to emergency vehicles stuck in the traffic.

The proposed model uses load cell which generates an electric signal based on the weight placed

on it. This helps us in approximately and calculating the number of vehicles on the particular road and thus calculate an approximate amount of time that the signal must be turned green in order to clear the traffic on that road. This eliminates the convenient process of keeping the signal light green for a fixed amount of time. The signal is, time based on the density of the traffic, is dynamically calculated using the proposed approach.

We aim at giving priority to emergency vehicles which provides a smart solution to traffic congestion problems with emphasis to emergency vehicles. The emergency vehicles are provided with RF transmitters and the RF receivers are mounted on the signal lights. An emergency vehicle stuck in traffic can then signal through the RF transmitter. The road on which the emergency vehicle is located is then traced and that corresponding signal is turned green. In case of multiple emergency vehicles, they are served based on First Come First Serve (FCFS) priority.

RELATED WORK

In the field of IoT, many systems are proposed in order to control, manage the traffic system effectively. Each of the systems use different types of technologies, components for managing Traffic congestion like IR Sensors, RFID's, Zigbee, Traffic warning systems, Big Data, Bluetooth etc. The following are some the works that are related to our project. In the past ten years, the Internet of Things evolution has been unprecedented.

Recently, various driver assistance systems have been actively developed that use both information communication technology and on-board sensors. Invisibility of traffic signal caused by huge vehicles blocking the view, prevent traffic congestion at toll gates and give advanced collision warning to the drivers. A microcontroller with a RF module will be installed and is programmed to connect to each automobile passing by. Later it displays signal status on the traffic signal status display system installed inside the automobile. This system installed in the vehicle is also capable of giving collision warnings to the driver [1].

IoT links the objects of the real world to the virtual world. It constitutes to a world where physical objects and living beings, as well as virtual data and environments, interact with each other. Urban IoT system that is used to build intelligent transportation system (ITS) has been developed. IoT based intelligent transportation systems are designed to support the Smart City vision, which aims at employing the advanced and powerful communication technologies for the administration of the city and the citizens. ITS uses technologies like Near field communication (NFC) and wireless sensor network (WSN) [2].

Automation combined with the increasing market penetration of on-line communication, navigation, and advanced driver assistance systems will ultimately result in intelligent vehicle highway systems (IVHS) that distribute intelligence between roadside infrastructure and vehicles and in particular on the longer term, are one of the most promising solutions to the traffic congestion problem [3].

The simulation and evaluation of a traffic congestion detection system which combines inter-vehicular communications, fixed roadside infrastructure and infrastructure-to-infrastructure connectivity and big data. To simulate and evaluate, a big data cluster was developed based on Cassandra. Big data cluster is coupled with discreet event network simulator with the SUMO (Simulation of Urban Mobility) traffic simulator and the Veins vehicular network framework. The results validate the efficiency of the traffic detection system and its positive impact in detecting, reporting and rerouting traffic when traffic events occur [4]. In order to avoid incidents like jams, accidents and to reduce huge menace concepts like Zigbee, RFID, Bluetooth, GSM-GPS technologies were developed [5].

The most frequently used component for traffic congestion control is IR sensors. The objective of IR sensors is that, using the IR transmitter and receiver decreases delay, fuel wastage, wear and tear of vehicles, collisions, traffic jams, frustration of passengers and drivers. An IR sensor is placed at the traffic lights. This IR sensor will detect the traffic on the road and will then label that traffic as light, normal or heavy traffic. The assumption of the traffic by the IR sensor will be taken by the microcontroller and that will be sent to the webpage through the GPRS module installed. To measure the traffic density, other than IR sensors Inductive looping as an instrument, concept was developed. A microcontroller was programmed to receive information about traffic density on different lanes, as measured by the inductive loops [7]. An Automated Highway System (AHS) represents the evolution of the current interstate highway system making use of both intelligent vehicles and smart highways. The latter would include roadside monitors that will measure traffic flow, patterns of vehicular traffic volume, vehicle speed, vehicular routes, heavily trafficked intersections, and ways to prevent gridlock in vehicle-intense urban centers. The traffic flow is evaluated at one-way, perpendicular intersections by use of paired infrared (IR) sensors, an IR LED and an IR photo detector [6].

There are many approaches that are followed by different countries. Each adopted Traffic management techniques have some loopholes. In the countries like USA, San Jose, California, Portland etc follow Adaptive Traffic Control System. This system creates more traffic towards residential streets. This system partially reduces the congestion on US arterial roadways. More initial cost for both field equipment and traffic management center management. Higher maintenance cost for the field components. More difficultly initial system setup and tuning process. In Sydney, Oakland County, Michigan, Sydney Coordinated Adaptive Traffic System is followed. SCATS sometimes fail to manage dynamic timing of signal phases at traffic signals, meaning that it fails in finding the best phasing for the current traffic situation, if traffic is hectic. There is only average of 7.8 % reduction in delay. Active Traffic Management system is followed in Washington state and Minnesota. It includes multiples strategies to smoothen the high traffic and leads to confusion. This technique is time consuming. It disturbs the network by injecting artificial probe traffic into the network. Hence create traffic congestion. Split Cycle Offset Optimization Technique is followed in Dubai. The technique used requires high operational cost and mainly concerned on highways. Only delay reduction of up to 19% during special events, 8% decrease in travel time, 17% decrease in delay 7% travel time. Optimized Policies for Adaptive Control is followed in Northern Virginia. Only 5-6% improvement in delays is obtained. Performance measure like logged measures of effectiveness, including average cycle lengths, vehicle counts by phase, and average phase green times and estimated speeds is not completely achieved.

The proposed methodology uses which load cells reduces the wastage of time, fuel consumption, traffic congestion. It also provides special clearance of traffic for emergency vehicles that are deployed with RF transmitters in it. When an emergency vehicle, pass the RF signal, it is received by RF receiver that is placed at about 10-15 meters from emergency vehicle. Hence incidents like traffic congestion or disturbance in traffic system is completely avoided. During orange signal, complete details of vehicles in the specified road will be uploaded to the cloud. Information about the required time will be displayed, depending on the density of the traffic during green signal.

Evolution of algorithm

Consider four roads like R1, R2, R3 and R4. In each road load cells are deployed at an appropriate distance. When it is R1, each and every vehicle passes the load cell. The load cell is programmed in such a way that, it calculates the weight of each vehicle's specified weight even if it is moving simultaneously depending on the position of the vehicle and its pressure towards the load cell. If ten vehicles pass the load cell, each type of vehicle's count will be incremented. For example, two wheelers, three wheelers and four wheelers are the type of vehicles. Later total count of all vehicles is calculated for the computation of time duration to be displayed. These processes are carried out when the signal is red. When the signal is yellow, the details about the density of traffic will be uploaded to cloud. Information about the density of traffic can be observed using the URL provided. During green signal, time duration for passing the vehicle will be displayed. If there are any emergency alert by emergency vehicles, RF receivers which are placed at traffic signal receives the signal from RF transmitter that are deployed at emergency vehicles. Consider if all four roads have the signal like 00, 01, 10 and 11. If road R2 is in green signal, that road will receive 00 signals. If emergency vehicle arrives, depending on the green signal, the driver needs to send specified signal (like 00, 01, 10, 11) through RF transmitter. Hence that road is been cleared.

Algorithm

```
1.)  // Description: Compute time_ duration
     // Input: vehicle's weight
     // Output: total time period will be computed
Step1: if ( signal == RED)
Step2: if (a>30 && a<=60)
          count ← count+1
        else if(a>60 && a<=90)
          count1← count1+1
        else
          count2 ←count2+1
       end if
Step3:c← count/2+ count1/2 + count2/2
Step4:TD= (count/2)*2+ (count1/2)*4+ (count2/2)*8
end if
End of algorithm
2.)  // Description: Uploading vehicle details
     // Input:
//   Output: Traffic density details will be displayed
Step1: if (signal == YELLOW)
Step2: Uploading density details to cloud
End of Algorithm
3.)  //Description:  Display time period
     //Input:
     //Output: Displaying the time duration
Step1: if (signal == GREEN)
Step2: green signal appears
Step3: display time_duration
step4: while (time_duration --)
        end while
End of Algorithm
4.) //Description: emergency_ veh (trans, receiver)
```

//Input: 00, 01, 10, 11 signals from Emergency vehicles

//Output: Clearance of road traffic for emergency vehicles

Step1: switch (signal)

case 00: clearing road R1

case 01: clearing road R2

case 10: clearing road R3

case 11: clearing road R4

End of algorithm.

PROPOSED WORK

This system is developed to overcome the drawbacks of the existing system and hence enhances the existing system for better traffic control and management. In this model the load cells are placed beneath the roads, and as the vehicles pass on the road, the load cells convert the load acting on them into electrical signals. The number of vehicles on the road are then approximated and depending on the density of the traffic, this model calculates the amount of time to be dedicated to clear the traffic on each side of the road.

The traffic density is further updated in the cloud where the end user can for see the traffic by logging into the URL which is dedicated for this purpose. The waiting time period is then displayed on the traffic signal. This process happened when the signal is red. When the signal is turned yellow only the time period is updated in the cloud for the users to have traffic density information. When the signal turns green, the reverse count of remaining time is displayed on the traffic signal board.

The distinguishable feature of proposed system is that it is feasible and preference is given to the emergency vehicle such as an ambulance. During an emergency, if an ambulance happens to get struck on a particular road due to high traffic, then the driver can raise a request by using the RF transmitter fixed in the ambulance. The signal is then passed to the RF receiver mounted on the traffic signal and the signal of that road is turned green.

CONCLUSIONS

Our work presents a real-time traffic information collection and monitoring system to solve the problem of real-time monitoring and controlling road vehicles. An intelligent communication network is created in an effort to help traffic flow and alleviate traffic problems in large cities. The proposed system employs key technologies: Internet of Things, Android application, Load Cells and RF Transmitters and Receivers to collect, Store, Manage and Supervise traffic information.

The advantages of the proposed system are:

- The equipment is cost-effective.
- The electronic units can be deployed at traffic junctions for enforcing traffic regulation across cities.
- It helps reduce waiting and travelling times hence save fuel and money.
- The end users can always have a foresight about the traffic through the android application and take smart actions.
- A provision for emergency vehicles to pass the signal is also a major cause of concern.

In general, the IoT plays an important role in the traffic management enhancing the efficiency of information transmission, improving traffic conditions and management efficiency, traffic safety, and reducing management costs. The future enhancements include:

i) The proposed traffic system based on the IoT consists of a large number of RFIDs and sensors that transmit data wirelessly. This calls for improved security to protect such massive amounts of data. It‘s a challenge for future research to ensure the security of smart objects in the traffic monitoring management system in case of a cyber attack or an intentional interest to a member of the IoT infrastructure.

ii) More advanced systems can be built which can help control traffic at the tolls too.

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