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Traffic Congestion Control

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Abstract—The paper investigates a prototype which makes use of RFID technology for traffic management. This system can figure out the congestion intensity at any junction of the road by using RFID readers and tags as sensors. The idea behind this paper is to make the fixed and preset traffic signal timing dynamic and adaptive. The paper presents a novel approach for making green signal timing proportional and adaptive to the congestion on the road at any time instant. This system also provides a real time(IOT) level of congestion to the internet; this data can be accessed by the users. It may also suggest shortest and time efficient path based on traffic as well as distance.

Keywords*-RFID; IOT; Traffic congestion; Traffic control.*

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I. Introduction

Road traffic management is one of the leading problems in urban areas. With the ever expanding boundaries of cities, the number of vehicles as well as the average travel time for office goers is rapidly increasing. A lot of travel time is wasted in traffic jams. One of the major causes of traffic congestion is that the signal timings are fixed. Some lanes with sparse amount of traffic end up having more green time assigned to their signal than what is required whereas some lanes with heavy traffic do not get enough green time to reduce the traffic they hold. Lanes with not enough green time and constant inflow of heavy traffic end up getting more and more congested as time passes by. Traffic on the road changes according to time of the day and also is a subject to special occasions wherein a particular road may experience heavy traffic for a short interval. The optimal solution would be to use a mechanism to sense traffic on the lane and assign a green signal time which is proportional to it. In order to deal with such problem, in this paper a system has been proposed which can calculate the congestion at any part or junction of the road.

This smart system can be implemented by RFID technology. RFID stands for Radio Frequency Identification System[1].It consists of two parts: a passive tag which is attached to the vehicle which is to be identified and the RFID reader which is used to read the tag attached to the vehicle without any physical contact. RFID Readers can be integrated within street lights and can be powered using solar energy which is already to power street lights in many areas. RFID passive tags require no energy for their operation. They are small in size, portable and inexpensive. They can be installed either by the car manufacturer or the government agency which issues number plate to the cars can incorporate the RFID tag with the number plate[2].

The real time data of the congestion level at any particular road can be obtained by the user on the internet.This facility is provided by the IOT. The Internet of things (IOT) is the inter-networking of physical devices, vehicles, buildings, and other items—embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data[3].

Section II of the paper talks about related work whereas Section III describes the proposed method. Results are discussed in Section IV and Section V concludes the work.

II. RELATED WORK

The first requirement for designing a traffic congestion controller which is dynamic is to put a sensing mechanism in place. The aspects of this sensing mechanism must be robust, must be easy to install, inexpensive, robust and must be able to operate for years without any maintenance. Various traffic management schemes have been proposed which make use of image processing, Google maps, radar etc. for sensing traffic. All of these schemes have their own set of disadvantages like high complexity of software, difficulty in detection due to diverse factors such as lightness, weather conditions or velocity of the vehicle [4]. Installing video cameras requires a huge amount of capital. The images captured may require some further modifications, enhancements and editing which increases the processing time. Inductive loops are effective and work at all traffic speeds. But their cost of installation and maintenance at large scale is higher and there is a significant error margin in their use.

Google map is the latest addition to traffic sensing mechanisms[5]. It uses crowd sourced anonymized location data from android devices to calculate the speed at which the devices are moving[6]. This data is then used to simulate and estimate traffic conditions in real time. Considering that the number of android devices is already large and increasing, Google maps gives a very accurate representation of live traffic. But Google Maps only monitors traffic, and a system wherein traffic is controlled using data from Google Maps is not available. Also Google maps estimates traffic on major roads where buses ply but it has been observed that smaller roads are also prone to traffic congestion. Their smaller width is one of the leading causes for congestion.

RFID technology has been proposed for traffic monitoring and control before. The implementation is as follows: When a vehicle equipped with an RFID tag passes an RFID reader say R1, its tag number and time stamp is sent to another reader say R2. When the same vehicle passes through R2, it's time stamp is recorded and compared with the time stamp received from R1. In this way, velocity of the vehicle is estimated and congestion is detected. In this scheme, the RFID tag number as well as time stamp of every vehicle needs to be transmitted wirelessly. This would create a large overhead for the wireless transmitter and receiver. Also the processor has to compare the time stamps of each and every vehicle, which calls for the need of a powerful processor [7]. In this paper, an alternate scheme has been proposedusing RFID where wireless overhead as well as processor overhead will be much lesser than previous methods.There is a similar approach presented in [8], where the blend of RFID devices and IoT connectivity is used for traffic optimization, where congestion information from all neighboring road intersections are collected to give insight for the traffic police. In this paper, it has been proposed an automated real time congestion calculation method, which also drives dynamic signal timing and also the congestion information is available to the user requesting it.

III. PROPOSED SCHEME FOR CONGESTION MONITORING AND CONTROL

A. Designing an adaptive traffic controller

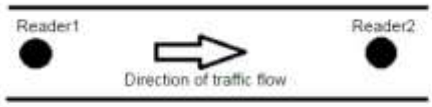

Figure.1 Sensing mechanism

Every vehicle must be equipped with a passive RFID tag. These passive tags are inexpensive and do not require any external power supply for their working. They extract power along with data from the reader used for sensing them. When a vehicle passes the RFID reader 1, its tag is read and a count value say c1 is incremented by one. Similarly, when a vehicle passes reader 2, another count value c2 is decremented. The difference of the two count values: c1 - c2 gives the total number of vehicles in the road stretch betweenreader 1 and reader 2. It is important to note that, there is no break-in or break-away paths between the two RFID readers. Hence a vehicle which has passed through reader 1 has to compulsorily pass through reader 2. Once we have calculated the number of vehicles on a road stretch, we can estimate the time required for them to clear out and accordingly we can assign this time as the green signal time.

B. Generation of green signal time t

The green signal time't' is ideally the time required for all the vehicles to clear out before the signal turns red again. Hence time t is directly proportional to the number of vehicles on the road[9].

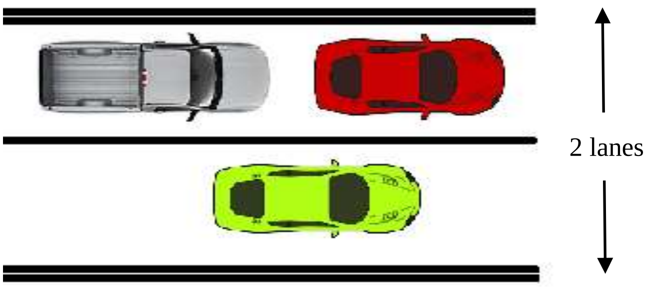

Figure.2Traffic on a multilane road

t∝number of vehicles(1)
Also the number of lanes of the road has to be considered. A 4-lane road would require one fourth of the green time of a single lane road for the same number of vehicles.
t∝1/(number of lanes)(2)
Therefore,
t∝(number of vehicles)/(width of road)(3)
There are some additional constraints on green signal time[10] which are important:
t must be less than a maximum time t_{max}so as to not cause an indefinite wait for a vehicle.
t must be greater than a minimum time t_{min}so that the signals don't change frequently causing confusion and more traffic jams.

C. Design of wireless network

The two readers as shown in Figure.1 are connected wirelessly. In a practical scenario a road stretch may extend for kilometers without any breakaway roads. Hence connecting the readers using wires is not practically feasible[11]. ESP8266 module is used to connect to the server and send the sensor values in real time.These values are displayed on the web page to be available to the users in real time.

D. Block Diagram

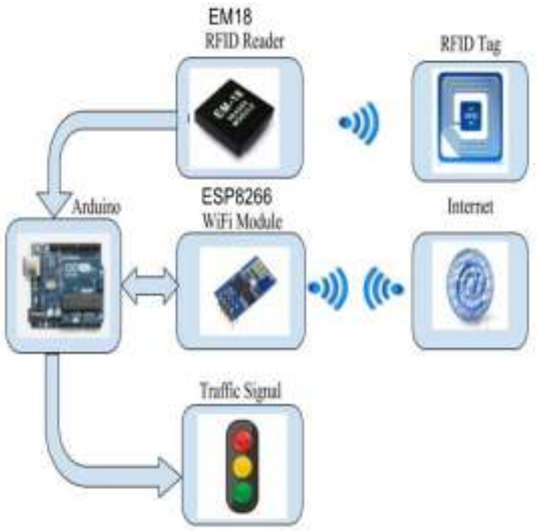

Figure.3Block diagram of proposed system

Here, the RFID reader will count the number of vehicles by reading the tags on the vehicles.This count will be synchronized and processed with the count values from other RFID reader setup node on the same road.Their counts will be subtracted which will give the effective count of cars between those two nodes, and the congestion percentage will be calculated.This value will also be posted to the webpage through the ESP8266 module.

E. Method of working

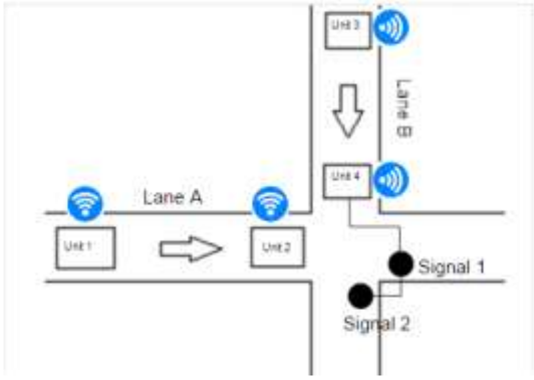

Figure.4 Illustration of traffic congestion control at a junction

In Figure.4, the arrows indicate the direction of traffic flow. Lane A and Lane B intersect at a junction. A signal is placed at the junction so as to alternate traffic low between lane A and lane B. The time duration for which the signal will remain green will be proportional to the traffic on the lane at that time instant. Each unit consists of a RFID reader, processor and a Wi-Fi module. The unit connected to the signal is the central controller which assigns green signal to the lanes. All of the units are wirelessly connected to the internet.
Let us suppose lane A has a green signal. As lane B has a red signal, vehicles begin to accumulate at lane B. For every vehicle passing through unit 3, a count value C3 is incremented. This value is then stored in a database on the internet. Similarly count values C4, C2 and C1 are stored in the database. When the green signal at lane A is about to turn red, C3 is pulled from the database. C4 is already available to unit 4. Then green signal time for lane B say 'tb' is calculated and green signal is assigned to lane B for that time. 'tb' is proportional to the number of vehicles at lane B which is given by C4-C3. Again when the green signal for lane B is about to turn red, C2 and C1 are pulled from the database and next green signal time for lane A 'ta' is calculated similarly.
The values C1, C2, C3 and C4 are constantly updated in the database and can be used to display real time traffic data to any user using a computer or smartphone.

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IV. RESULTS

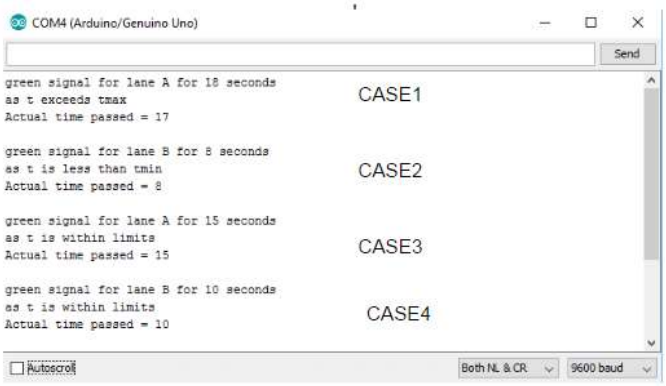

Figure.5 Implementation on Arduino IDE

Figure.5 shows the results for various cases of inputs. The minimum time t_{min} has been set to 8 seconds and the maximum time t_{max} has been set to 18 seconds. The green time has been calculated as per the method described before. Output pins of the Arduino have been made high/low for the calculated time. Also the duration for which the pins were high/low is measured independently for verification purposes. It has been assumed that all roads consist of single lanes and each vehicle takes 5 seconds to clear out.
In Case 1, RFID tags were read such that there were 4 vehicles on lane A. So ideally signal should be green for 4*5= 20 seconds. But this exceeds t_{max}=18 seconds. Hence signal will be green for 18 seconds only.In Case 2, tags were read such that there was just 1 vehicle on lane B. So ideally should have been green for 5 seconds. But instead it was green for t_{min}=8 seconds.In Case 3 and Case 4, 3 and 2 vehicles were simulated on lane A and lane B respectively. In these cases, the green signal time was within the limits of t_{min} and t_{max} and hence proportionate green signal time was assigned.

V. CONCLUSION

In the implemented system, the signal state is dynamically changing in accordance with and as an adaptive response to the congestion on the road in real time. Parameters like capacity of the road, a maximum waiting time for any car, minimum time for which the signal stays in same state are considered.
To achieve this, capacity of the road, maximum waiting time for any car and the minimum time for which the signal stays in same state are considered as parameters. If the width of the road is more and multiple cars are passing at a time in that case RF antenna can be used instead of reader to improve the coverage area

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