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SMART TRAFFIC CONGESTION CONTROL USING WIRELESS COMMUNICATION

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Abstract: Recently, various driver assistance systems have been actively developed that use both state-of-the-art information communication technology and on-board sensors. This paper describes a method to solve the problem of 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. This system comprising of a microcontroller with a RF module is to be installed at major traffic junctions and toll gates and is programmed to connect to each automobile passing by. Each automobile would be installed with a system comprising of microcontroller and transceiver RF module so that it can receive signals from the signal posts and display 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. An electronic database is maintained for each automobile so that electronic payment for the vehicles can be done at toll gates.

Keywords*:* RF module, traffic signal invisibility, warning systems, electronic payment services, AVI systems.

1. INTRODUCTION

With globalization and the need for mobility fueling traffic growth all over the world, the problem of congestion on highways and in cities is becoming more and more acute. Intelligent traffic management systems are helping people reach their destinations quickly and safely while at the same keeping traffic's environmental impacts in check. The goal of intelligent traffic management systems is to achieve improvements in mobility, safety and productivity of the transport system through integrated application of advanced monitoring, communication, display and control process technologies both in the vehicle and on the road.
The paper presents a method to

- Solve the problem of Invisibility of the traffic signal due to huge vehicles blocking the view.
- Prevent congestion caused at toll gates
- Give Collision Warning to the vehicles.

A system comprising of a microcontroller, RF module and a traffic signal status display system is installed in every automobiles. The RF module installed in the vehicle is capable of transmitting and receiving appropriate data which is controlled by the backend software algorithm in the microcontroller. The system is capable of communicating with similar systems installed in other automobiles in order to update the signal status or to provide advanced collision warnings to the automobiles travelling on the same road. The vehicle identification data such as registration number etc is stored in order to facilitate the electronic payment services at the toll gates. Vehicles at the toll gates are not required to stop thus avoiding congestion.

Each road would be given a unique 5 bit address. Considering the range of the RF modules to be about 30 meters, the 5 bit unique address for the road can be repeated such that any two roads having the same road ID are not within 30 meters distance from each other. This gives the system a capability to address a region of any size. An alternative to this would be to increase the number of bytes to be wirelessly exchanged instead of a single byte.

2. IMPLEMENTATION

The traffic signal status is made available to the vehicles in the traffic junction by using RF communication. The address of the traffic pole for a particular road is given by the road identifier which is placed approximately 100 feet away from the junction for each traffic pole. When these vehicles reach the traffic junction, the traffic signal from the particular pole is transmitted using RF transmitter and the vehicles waiting receive these signals and pass it on to the vehicles behind it. This process continues till the vehicle on the road is waiting at the junction. One important feature of this design is that the RF modules do not require any hardware configuration of address. The address is configured in software in a way such that first 5 bits of data transmitted by the road identifier pole uniquely defines that road and all subsequent information received by the vehicles relevant to the traffic signal status should have the same first 5 bits.

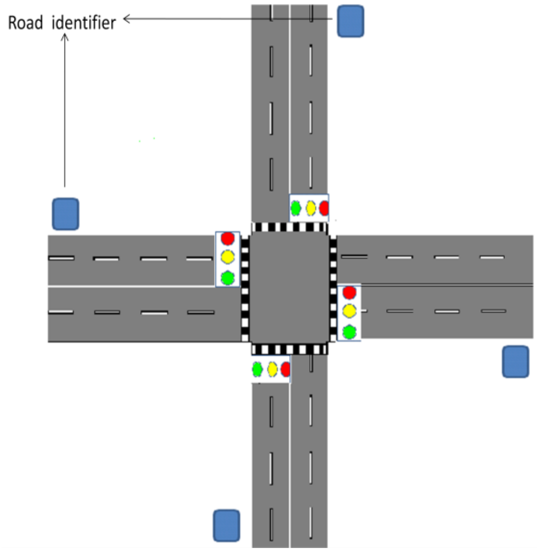

Fig 1: Diagram showing the location of road identifiers

The vehicles receive data in the following format:

I5	I4	I3	I2	I1	S3	S2	S1

Road id

The algorithm implemented inside the automobile for updating the traffic light signal status is as follows.

1.

t about 100m before the traffic pole, a road identifier module is placed whose primary function is to continuously transmit the road ID. The road identifier module will be put in the broadcast mode so that all the automobiles passing by can receive the bit pattern. The byte format transmitted will be as shown in figure below.

I5	I4	I3	I2	I1	0	0	0

Road id

2.

he vehicles passing by capture this byte of data and store it in a memory location. This makes them eligible to receive any subsequent information about the traffic signal status or collision warnings.

3.

s the vehicles reach the traffic pole it receives the data from the traffic pole's electronic unit. On receiving the data it compares the first 5 bits of the data received and the Road ID that it received earlier. If they match then it updates the traffic signal status display installed in the vehicles. Different combinations of the last 3 bits are present for 3 different traffic signal statuses and it updates the status display in the vehicle accordingly.

4.

fter updating the traffic signal status it transmits the byte received from the traffic pole to the vehicles behind it. This enables vehicles which are out of range of the traffic pole's RF module to receive and update their signal status.

The last 3 bits can take the following form as shown in table 1 depending on the type of data being transmitted:

Table 1: code format for various signals

S3S2S1	**Assigned functionality**
000	Road ID to vehicles
001	Red
010	Yellow
011	Green
100	Warning Signal
101	Acknowledgement for Receiving data at toll gate
110	Start and End of vehicle identification data
111	Toll gate entry probe

If a vehicle stops in the middle of a highway due to mechanical failure, it remains hazardous to any approaching vehicles. Human drivers suffer from perception limitations on roadway emergency events, resulting in large delay in propagating emergency warnings, as the following example illustrates. Three vehicles, namely A, B and C are travelling in the same lane. When A suddenly applies brake, both vehicles B and C are endangered, and being further away from A does not make vehicle C any safer than B due to the following two reasons:

- Line-of-sight limitation of brake light: Typically, a driver can only see the brake light from the vehicle directly in front. Thus, very likely vehicle C will not know the emergency at A until B brakes.

- Large processing/forwarding delay for emergency events: Driver reaction time, i.e., from seeing the brake light of A to stepping on the brake for the driver of vehicle B, typically ranges from 0.7 seconds to 1.5 seconds, which results in large delay in propagating the emergency warning.

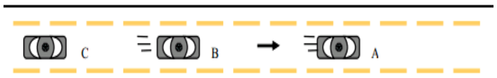

Fig 2: Vehicle to Vehicle communication helps to improve road safety

Using Vehicle to vehicle communication, when a vehicle on the road either applies brakes suddenly or there is a major mechanical failure in the vehicle and the vehicle stops, an warning signal is sent with the first 5 bits same as the Road ID and the last 3 bits as 100. A vehicle that receives the warning signal can verify the relevancy to the warning based on first 5 bits and further processing can be done with the help of the integrated GPS unit. The GPS data can be used to determine whether the vehicle is moving in front of it and if found to be so it can give audio/visual warnings to the driver. The emergency signal is given higher priority than the traffic signal data which ensures immediate response to the warning signals.

Automatic vehicle identification systems (AVI) identify vehicles as they pass through a detection area. AVI consists of a roadside communication device that broadcasts a predefined bit pattern. Vehicles are installed with radio frequency (RF) transponders that communicate with the toll collection system. At the entrance of the toll gate the AVI sends a predefined bit pattern to the vehicles passing by .On receiving this bit pattern the vehicle to vehicle communication gets disabled. The transponder which is installed in the vehicle sends vehicle identification number which is captured in a memory device to the AVI device at the exit. This information will be sent to the central computer system for further processing. Vehicles passing through the toll facility entrance and exit are not required to stop. The amount corresponding to the toll fee can be automatically deducted from the vehicle owner's credit card details/through any other means, depending on the information in the electronic database. Eliminating traffic jams at toll gates brings many benefits in addition to relieving driver's stress. Fuel consumption can be improved since vehicles do not have to repeatedly stop and go at toll road entrances and exits, ultimately contributing to the reduction of noise around toll gates and the emission of exhaust gases.

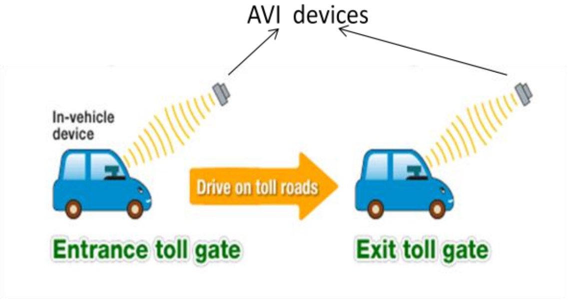

Fig 3: Diagram showing the communication of vehicles with AVI devices

The algorithm for the Automatic vehicle identification systems at the toll gate is as follows

1. The RF module at the toll gate entry probes the vehicles passing by for the identity information. RF module at the toll gate is in the transmitting mode and sends the following bit pattern.

I5	I4	I3	I2	I1	1	1	1

Road id

2. The vehicle in response to the data sent by the module at the toll gate entry sends the following bit pattern to the RF module at the exit indicating the start of vehicle identification data.

I5	I4	I3	I2	I1	1	1	0

Road id

3. Once the RF module at the exit gets connected with the vehicle's RF module it sends the following bit pattern to the vehicle's RF module to which it is connected.

I5	I4	I3	I2	I1	1	0	1

Road id

4. Once the connected vehicle's RF module receives the above bit pattern, it sends predefined number of bytes of vehicle identity information to the RF module at the toll gate exit.
5. After sending the vehicle identity information, the vehicle's RF module sends the following bit pattern.

I5	I4	I3	I2	I1	1	1	0

← Road id →

6. On receiving the above bit pattern for the second time, the RF module at the toll gate exit understands that it is the end of vehicle identity data transmission.
7. The module at the Toll gate exit confirms the receipt of the identity information by sending the following bit pattern.

I5	I4	I3	I2	I1	1	0	1

← Road id →

8. On receiving the confirmation byte, the vehicle stops transmission. Otherwise the vehicle resends the identity information by repeating the procedure from step 2.

3. CONCLUSION

An intelligent communication network is created in an effort to help traffic flow and alleviate traffic problems in large cities. The equipment is cost-effective and can be ported on automobiles for receiving the signal status and collision warning. The electronic units can be deployed at traffic junctions and toll gates for enforcing traffic regulation across cities.

The advantages of the proposed system are:

- License-free 2.4 GHz frequency band is used for communication thus making the equipment cost-effective.
- The equipment can be easily installed on traffic poles, toll gates and in all vehicles.
- The system provides a mechanism to prevent collision by giving advanced collision warning to the vehicles.
- Vehicles passing through the toll facility entrance and exit are not required to stop. The payments are done electronically using the details of the vehicle owner stored in the database.

The disadvantages of the proposed system:

- There might be situations where a vehicle may be receiving the Road ID from 2 different road identifiers simultaneously. The only way to overcome this problem is to place road identifiers at an appropriate distance from each other (>30 meters) so that this situation never occurs.
- There might be excessive traffic on the RF module installed at the toll gate exit as it has to receive identity information from many vehicles passing by.

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