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Efficient Road Traffic Policing With Coordinators and Routers Using Radio Frequency

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ABSTRACT

Effective reduction of the road traffic in the real time phase is very essential. The present infrastructure available for the road traffic is not adequate, due to steady increase in the number of vehicles per day. The automated signals need more dynamism. This paper endeavors to provide solution to such a situation. The methodologies and technologies vary from inductive loop detection, video data analysis, passive infrared sensors and wireless sensor network. These available technologies are costly and complex. Radio frequency identification (RFID) is an easier, efficient and inexpensive technology which can be deployed for such heavy traffic situation. RFID tags, routers and coordinators could be used with the CRTO (Coordinated Router Traffic Optimization) algorithm. These RFID tags fixed in the vehicles could be read by the routers and coordinators fixed on the road sides. Regular distance could be maintained between one set of coordinators and the routers. The vehicles which are plying on such roads will be sensed by the signal and read by the routers and then by the coordinators. The speed of the vehicle is calculated by the time taken to reach the coordinator after crossing the router. Based on the number of vehicles nearing the signal and the speed of the vehicles, the coordinators are allowed to communicate and the signals are controlled by the coordinators. Traffic is controlled taking these parameters into consideration.

Keywords: RFID, Router, Coordinator, Inductive loop detection, Infrared sensors.

1.0 INTRODUCTION

Radio frequency identification (RFID) is an emerging technology with applications in several areas, from logistics to security. Usually, RFID cards have been used for people access control in office buildings, for public transportation billing, and even to store digital information in passports. Using the RFID tags, receiver and coordinator we can also reduce the traffic congestion in the real time.

The ministry of heavy industries is considering a proposal to make it mandatory to fit RFID-enabled devices in the vehicles manufactured in India. It is believed that RFID tags would help in traffic management as traffic violations by motorists could be tracked and all violations identified. Also, motorists would get charged automatically as soon as they enter a toll area.

1.1 PRELIMINARIES

1.1.1 Intelligent Highway By Fuzzy Logic

Krause et al proposed a fuzzy logic system [1], [5] to control traffic involves analysis of both detected traffic flow and environmental conditions. Due to individual behaviour of traffic participants, and the inherent uncertainty of weather condition interpretations, a mathematical model cannot fully describe traffic control problems.

There are two aspects of a traffic management system for multi-lane highways with variable road signs. First, fuzzy logic is used to take into account the uncertainties of traffic data, and to detect traffic congestion in isolated road sections. Second, a traffic control approach using a fuzzy model based on experience.

1.1.2 Remote Automatic Incident Detection Using Inductive Loops

Cherrett et al proposed the remote automatic incident detection [2] algorithm designed to detect abnormal periods of traffic congestion existing over single inductive loop detectors. This algorithm identifies those detectors which show a critical increase in average loop-occupancy time per vehicle coinciding with a critical decrease in average time-gap between vehicles according to a set of rules previously defined by the operator.

The rules define the maximum and minimum values of loop occupancy and time gap respectively for each detector, which when exceeded for a given duration, trigger a report of a potential traffic flow ‘abnormality’ for that time of day at that particular location on the network.

1.1.3 Detection Of Traffic Congestion In Optical Remote Sensing Imagery

Palubinskas et al proposed a new approach for the traffic congestion detection in time series of optical digital camera images [3], [4] is proposed. It is well suited to derive various traffic parameters such as vehicle density, average vehicle velocity, beginning and end of congestion, length of congestion or for other traffic monitoring applications. The method is based on the vehicle detection on the road segment by change detection between two images with a short time lag, the usage of a priori information such as road data base, vehicle sizes and road parameters and a simple linear traffic model based on the spacing between vehicles.

1.2 ACTIVE RFID

Active RFID has onboard battery to power up Tag circuitry. It also contains More Memory and Better Read Range. Using Active RFID the Tag-to-Tag communications and Ad hoc networking are possible.

1.3 WHY ACTIVE RFID?

An active tag does not depend on Readers to initiate a communication. It can send unique beacons to inform its presence periodically. Active RFID devices can act as tags or Readers or Routers. Active tags can even be integrated with sensors to form a standard wireless sensor node.

1.4 ADVANTAGE OF ACTIVE RFID

- No direct Line of Sight required for identification & tracking.
- Enables very specific detection of vehicles.
- Simultaneous multiple detection of vehicles are possible using RFID.
- No performance degradation during harsh weather.

1.5 SCOPE OF ACTIVE RFID BASED SYSTEM

Using Active RFID and Wireless Networking Technology for Automatic Vehicle Identification with the following objectives:

- Automatic Congestion Detection in Real-Time.
- Automatic Detection of Vehicles approaching towards congested area and automatic messaging for redirecting the (selected) Vehicles for Congestion Avoidance: Priority-based Congestion Management
- A high vehicle density in a particular lane causes a traffic
- signal in that particular direction to remain open for larger duration thus adaptively controlling the signal
- Automatic Billing of Core Area Charges / Toll Charges by identifying vehicles within Core Area / Toll Area
- Automatic Billing of Penalty Charges for selected Traffic Rule violation (speed limit violation, entry into congested area in spite of re-routing messaging)

2.0 EXISTING SYSTEM

2.1 VIDEO DATA ANALYSIS

Video feeds from the cameras are taken and fed to the built-in system. The built-in software harvests information from that video and the Information (vehicle volume, average velocity, etc.) then fed into the fuzzy system [1]. This system manipulates the data based on predefined conditions and produces the output. That outputs the level of traffic congestion [5].

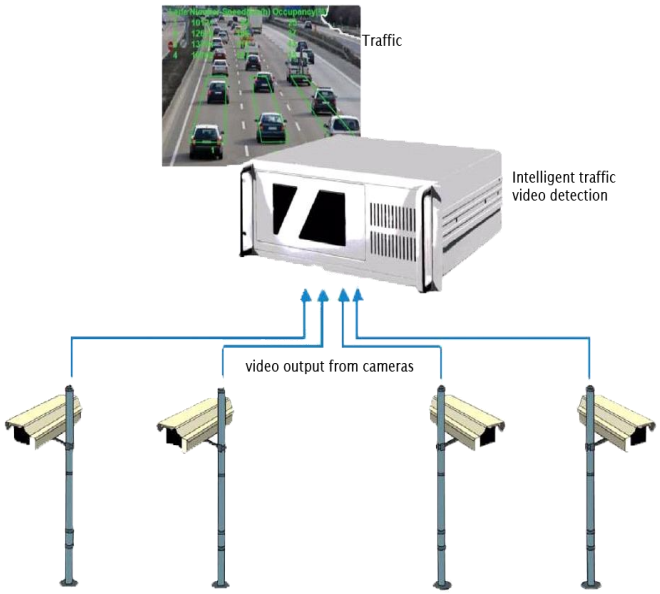

Fig.1: Video Data Analysis

2.1.0 DRAWBACKS

1. The overall system is quite expensive.
2. The fuzzy algorithm is not very accurate.

2.2 INDUCTIVE LOOP DETECTION

This method of detection is used to detect the vehicles at a certain point such as traffic signal, gate entry, etc. This works on the magnetic field induced by the fleets [2]. This system transmits frequencies between 10 kHz to 200 kHz based on the model.

It can be placed in a roadbed to detect vehicles by measuring the vehicle's magnetic field. The simplest detectors simply count the number of vehicles during a unit of time. Loops can be placed in a single lane or across multiple lanes.

2.2.0 DRAWBACKS

1. The error rate is quite high.
2. Maintenance is very tedious.
3. Traffic cannot be managed locally.

2.3 PASSIVE INFRARED SENSORS

Passive sensors detect energy emitted from vehicles, road surfaces and other objects in their field of view and by the atmosphere. The captured energy is focused by an optical system onto an infrared-sensitive material which converts the reflected energy into electrical signals. Real-time signal processor analyzes the signals to detect presence of a vehicle [3].

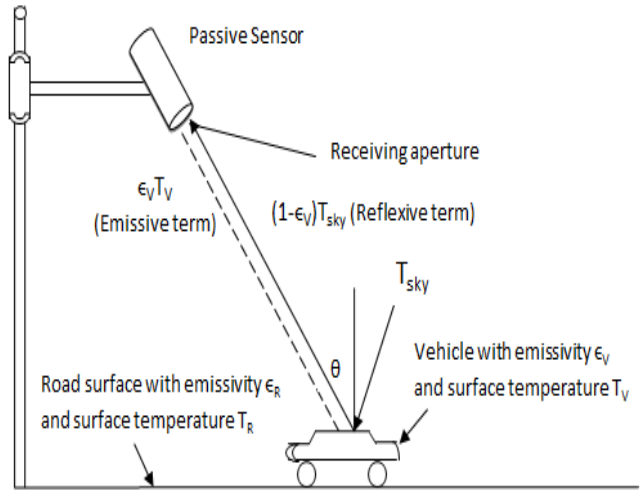

Fig .2: Passive Infrared Sensors

2.4 WIRELESS SENSOR NETWORK

Magnetic sensors are deployed by the road intersection to detect vehicles. The sensors send the collected data to the Intersection Control Agent (ICA). ICA processes the data and dynamically controlled the traffic light. A high vehicle density in a particular lane causes traffic signal in that particular direction to remain open for larger duration thus adaptively controlling the signal [4].

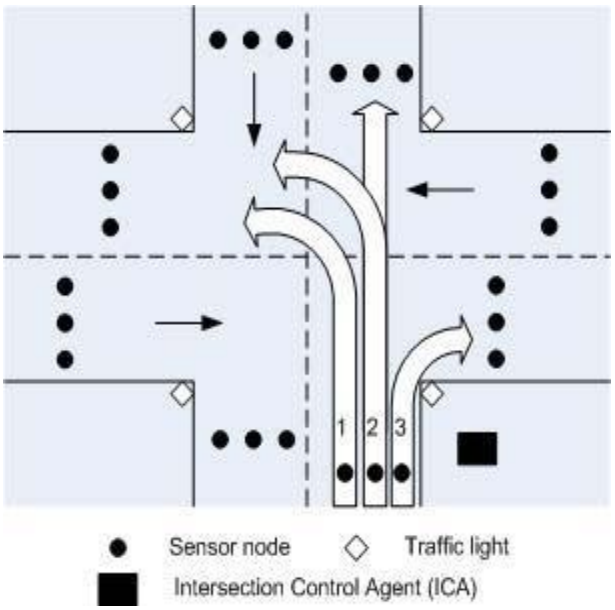

Fig .3: Wireless Sensor Network

3.0 PROPOSED FRAMEWORK

The framework consisting of the following components:

Vehicle unit with Active RFID tag (optional) display & audio interface. Roadside Active RFID Reader / Router units that would capture beacons from cars and forward them to control station, either in multi-hop through other roadside routers or using GSM/GPRS network services.

Control Station(s) for accepting vehicle data, doing necessary computations based on pre-defined traffic-rules, issuing traffic-management messages and emergency service information to the relevant vehicles and computing necessary billing for individual vehicles

3.1 DETECTION AND MANAGEMENT OF TRAFFIC CONGESTION

The system will use roadside RFID readers to collect signals from active RFID attached to the vehicle units already installed in the customer vehicles. The RFID tags installed in the vehicles will be sending the signals continuously which are received by the receivers located at the roadside.

The goal is to implement a system that would trace the travel time of individual cars as they pass the roadside readers, compute an average trip time and then use a rule-based system to decide whether the area is congested.

If congestion is detected, the system would control traffic signals/ generate automatic re-routing messages to the nearby coordinators that are used to change the traffic signals accordingly.

3.2 AUTOMATIC DETECTION OF SPEED LIMIT VIOLATION

The above technique is used to calculate the speed of a motorist. The speed will be calculated by calculating the difference in time of arrival between two readers and the distance between them.

On detection of such violation, a warning message will be sent to the audio and display interface of the motorist and penalty will be calculated in the server and will be billed monthly to the vehicle owner.

3.3 AUTOMATIC BILLING OF CORE AREA / TOLL CHARGES

Automatic toll collection and automatic “core area charge” collections are also done using the same framework.

Reader unit will be placed at toll-booth and along the roads around the core area which will detect each individual vehicle uniquely within its zone by capturing their device ids

and will keep records of the time during which the vehicle was seen by those readers within its reading zone.

This information will be sent to a central server. Accordingly the central server will calculate the charges and raise bills against the vehicle ids.

3.4 CONGESTION DETECTION & MANAGEMENT SCHEME

Our scheme basically consists of two parts:

First part is the Detection of congestion at any road leading to a junction and the second part is that the Effective management to control that congestion ensuring smooth traffic flow.

4.0 SYSTEM DESIGN

Let the 4 stretches leading to a four point crossing as A, B, C and D. The left, straight and right turn be denoted by 1, 2 and 3 (in subscript). Ca, Cb, Cc and Cd are coordinators and R1 to R8 are routers that are capable of reading active RFID tags. Routers and coordinators are placed 300m apart on each stretch of road leading to crossing. All the four coordinators placed are not in each other's range. R2 and R3 are in the range of Cb, R4 and R5 are in range of Cc and so on.

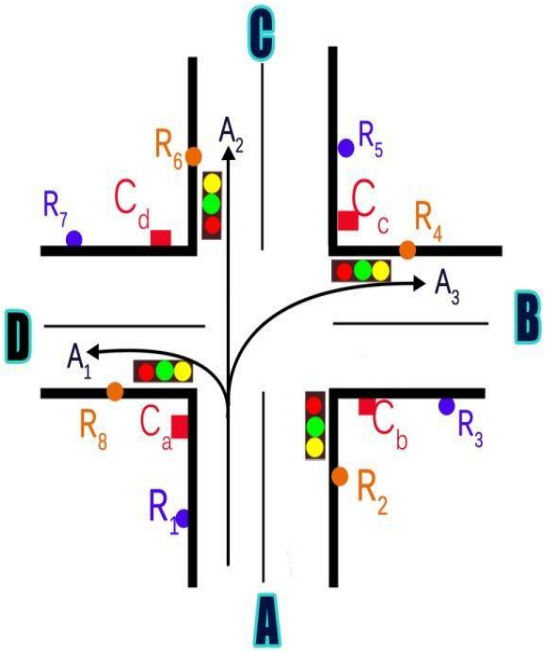

FIG .4: PROPOSED SYSTEM DESIGN

ASSUME THAT ALL THE VEHICLES HAVE A UNIQUE ACTIVE RFID TAG ATTACHED TO THEM.

All the coordinators are connected to GSM modems, and are capable of receiving and sending SMS texts to coordinators in other neighboring junctions, and also to the local traffic kiosk and central control room.

Traffic lights at the junction are controlled by the coordinators nearest to them. All coordinators have a clock integrated with them, and they are capable to recording timestamps (the absolute time of occurrence) of events.

4.1 CONGESTION DETECTION PHASE

When a vehicle passes the router, the active RFID tag of that vehicle sends a beacon to the nearest router. Router then forwards it to the coordinator.

As soon as the coordinator gets the routers message, immediately it saves the message and waits for getting another message from the same tag when it passes by the coordinator.
When that tag passes by that coordinator it sends another beacon to the coordinator.
After receiving the beacon, from its timestamp, the coordinator calculates the speed of the vehicle and sends it to the control station using GSM network.

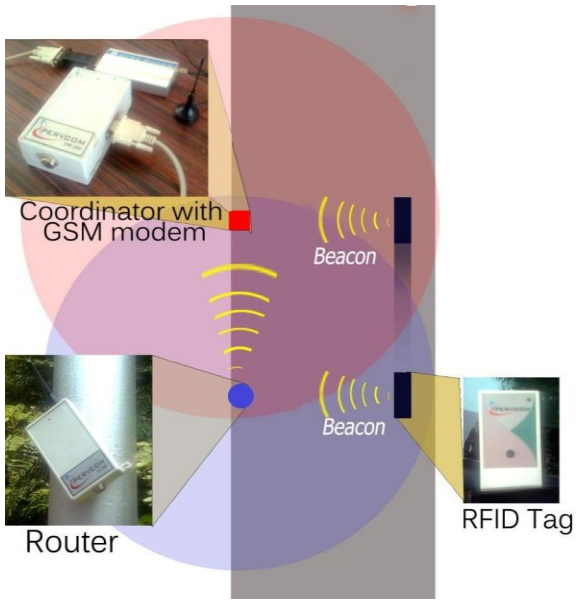

Fig.5: Working of Coordinator and Router

All the stretches leading to the junction get the green signal in a cycle, for a time duration that is proportional to the population of vehicles.
This population is calculated from the number of tags that are in the range of each coordinator.
After obtaining the count and the average speed of all vehicles, the coordinator determines the level of congestion depending on some predefined condition.

4.2 CONGESTION MANAGEMENT PHASE

When a coordinator detects a high level of congestion, it cannot take further load It sends a SMS to coordinators in its preceding junction notifying them to temporarily stop traffic along that stretch.

After receiving the SMS from its successor crossing point the coordinator will put the red signal on for that stretch towards that congested crossing point for a set period of time.

As soon as the congestion is released at the crossing, the corresponding coordinator will send another SMS to its earlier coordinator indicating to resume the traffic flow again in that direction.

Accepting this message the coordinator of the preceding junctions put the red light off and green signal on and restart the signal cycle as before.

Algorithm 1 Pseudo code of CRTO Algorithm

1. Init();
2. senseRF(R/ϵ =1);
3. senseRF(C);
4. While R/ϵ =1() do
5. CRTO(R,C);
6. Exit(0);

CRTO(R,C)

1. calcSpeed(R,C);
2. retrieveFleetdetails();
3. calclength();
4. checkPriority();
5. setSignal();

5.0 SIMULATION MODEL

Simulation software was developed using Java applet.

Each junction is controlled by 4 traffic signals, each controlling the traffic from a particular direction (as shown in figure).

Each traffic signal consists of 3-light for controlling the left, straight, right turn.

The vehicles approach the junction from all the 4 directions and can choose to move in any direction (left, straight or right) maintaining a minimum space between each other to avoid collision.

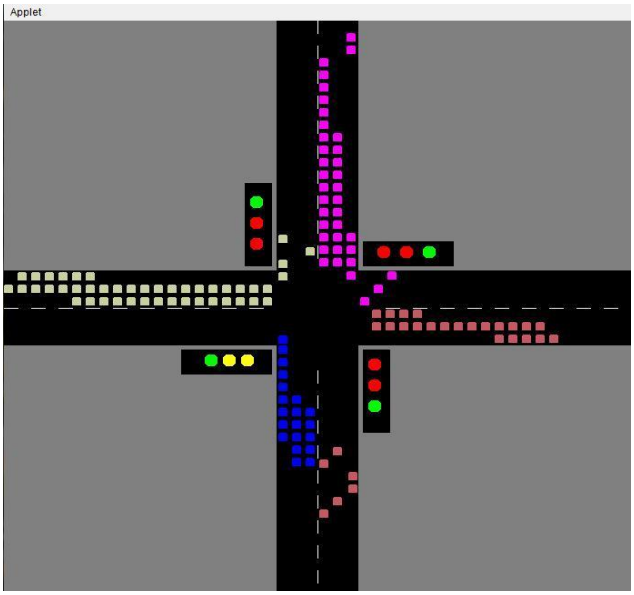

Fig.6: proposed traffic signal flow

5.1 IMPACT OF THE RFID SYSTEM

- The congestion management system is used to reduce the waiting time of the vehicles in the traffic.

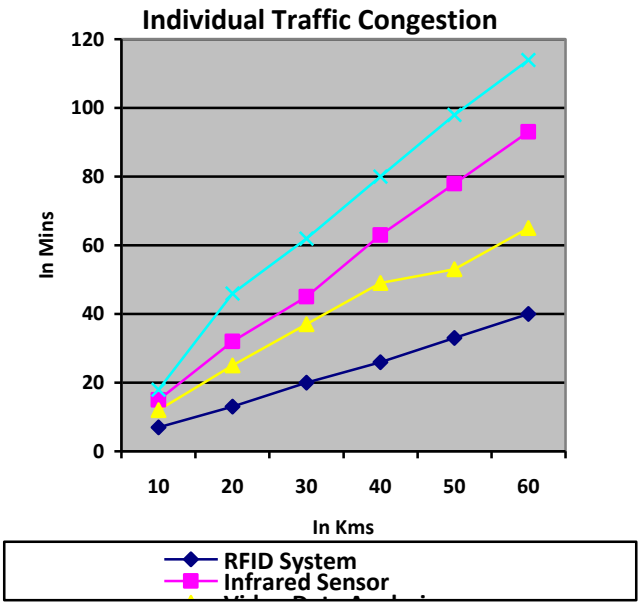

Fig.7: Comparison of traffic control methods

- After installing this system the average waiting time of the vehicles at the road signals are reduced.
- This system also controls the traffic flow and road accidents.
- This system ensures the traffic is maintained and also used to maintain the traffic rules.

6.0 FURTHER RESEARCH

1. The GSM network is used to exchange SMS among the coordinators, which is not fully reliable.

2. Loss of message or delay may hamper the correct detection of congestion and real time delivery of message.

3. The main consideration was only the velocity of the vehicles to determine the degree of congestion.

4. Other criteria, such as, average waiting time, average queue length, and some special cases might be taken to consideration to measure congestion more accurately.

5. This can be extended to dynamically control the signal timing of the traffic light depending on the degree of congestion at a particular lane.

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