Improvement of Traffic Monitoring System by Density and Flow Control for Indian Road System using IoT

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Abstract— The growth and scale of vehicles today makes management of traffic a constant problem. The existing traffic control system works based on a timing mechanism, meaning an equal time slot is provided for each junction. This is inefficient for non-uniform flow of vehicles. Hence there is a need for a system which is adaptive in nature. Routes should have an option of being granted more time slots depending on the requirements for the given route. This paper proposes a traffic congestion control system which would be adaptive in nature and provide time slot to each route based on traffic density.

Key words: Wireless Sensor Network, Traffic Congestion, traffic lights, road traffic

I. Introduction

Many technical communities are vigorously pursuing research topics that contribute to the Internet of Things (IoT). Nowadays, as sensing, actuation, communication, and control become even more sophisticated and ubiquitous, there is a significant overlap in these communities, sometimes from slightly different perspectives. More cooperation between communities is encouraged[8].

The Internet of Things (IoT), also called Internet of Everything is the network of physical objects or "things" embedded with electronics, software, sensors, and connectivity to enable objects to exchange data with the production, operator and/or other connected devices[8]. The Internet of Things allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration between the physical world and computer-based systems, and resulting in improved efficiency, accuracy and economic benefit[8].

Each thing is uniquely identifiable through its embedded computing system but is able to interoperate within the existing Internet infrastructure. Experts estimate that the IoT will consist of almost 50 billion objects by 2020[8].

There are several applications of IoT. For example, nowadays, many buildings already have sensors for attempting to save energy; home automation is occurring; cars, taxis, and traffic lights have devices to try and improve safety and transportation; people have smart phones with sensors for running many useful apps; industrial plants are connecting to the Internet; and healthcare services are relying on increased home sensing to support remote medicine and wellness.

From all these applications we are focusing on smart city concept. In smart city we are focusing on smart traffic. The basic architecture of smart traffic system is as shown below:

Fig.1: System Architecture

II. Literature Survey

A. *Adaptive Traffic Signal Flow Control using Wireless Sensor Network [3]*

The objective of this paper is to reduce the waiting time and traffic flow volume using Wireless Sensor Network (WSN). Wireless sensor networks are composed of hundreds of inexpensive, low-powered sensing devices with limited memory, computational, and communication resources. The existing traffic control system works based on a timing mechanism, meaning an equal time slot is provided for each junction. This is inefficient for non-uniform flow of vehicles [3] [6]. Hence there is a need for a system which is adaptive in nature. Routes should have an option of being granted more time slots depending on the requirements for the given route. This paper proposes a traffic congestion control system which would be adaptive in nature and provide time slot to each route based on traffic density.

The existing fixed time approach and the proposed approach ATSWSN have been simulated in LabView. The proposed adaptive approach has been developed on a hardware board using ATMEL microcontroller AT89C51. The inputs to the microcontroller are provided by the sensor nodes. The microcontroller executes an internal scheduling algorithm and controls the traffic signals. The direction to be cleared is decided by the algorithm based on a number of parameters. The parameters like speed factor and emergency factor are significantly needed to reduce the waiting time of the traffic and to devise a system with acceptable QoS. The basic system model is as shown below:

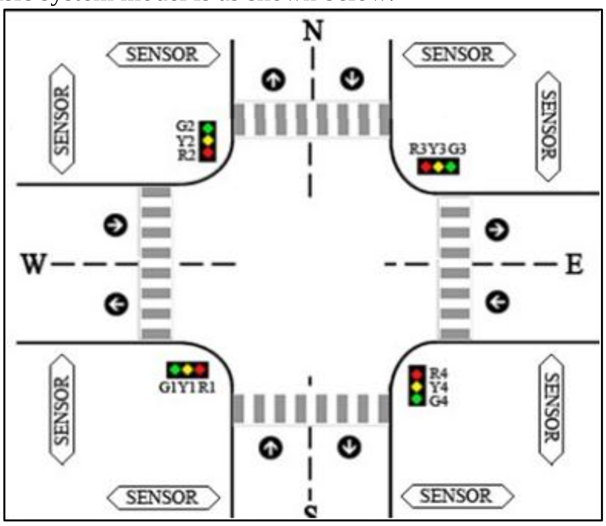

Fig. 2: System Model

III. Smart Traffic Congestion Control Using Wireless Communication [4]

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. 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.

IV. TECHNIQUES FOR SMART TRAFFIC CONTROL: AN IN-DEPTH REVIEW [5]

Almost all urban cities in the world use traffic lights to control the traffic on the roads. The lights switch from red, which means stop, to green, which means move. Over time there has been developments of different types of traffic light control systems, the most commonly used being static traffic lights and vehicle actuated lights. Static traffic lights' timing and switching patterns are predetermined despite prevailing traffic conditions for the different lanes. They do not operate with real time data.

Smart traffic light controls are dynamic. This means that they use real time data to make priority based decisions. They use advanced communication systems based on sensors and/or RFID tags to collect data and provide the system with information on the current situation on the roads (such as number of vehicles on individual roads or how long vehicles have been waiting for green light). The smart system then processes this information and makes decisions; that is, it automatically determines the duration of each traffic light signal based on prevailing traffic situation on the roads. Commonly used systems include fuzzy expert systems (FES), artificial neural networks (ANN) and wireless sensor networks (WSN).

A. *Fuzzy Expert Systems (FES)*

FES is a suitable approach to dynamic traffic signal control because of the nature of uncertainties on road traffic where the traffic distributions fluctuate non-uniformly. It is a superset of Boolean logic that has been extended to handle partial truths between completely false (0) and completely true (1). The sensors collect data from the environment which in turn is fed into the fuzzy logic controller (FLC) for processing. The FLC's objective is to control operations in systems by making decisions that utilize rules expressed with the uncertainty of human terms such as cool (slightly cold) or warm (slightly hot). Therefore FLCs are a suitable approach to traffic signal control because it assigns green or red light signal based on urgency or as traffic fluctuates; and selects the best decision that will minimize congestion at a particular interval. For instance, a lane could also have low or medium traffic as opposed to just no traffic (0) or high traffic (1).

B. *Artificial Neural Networks (ANN)*

The major difference between ANN (learning systems) and FES is that; while an FES uses present knowledge to make decisions, in a learning system, the decisions are computed using the accumulated experience or knowledge from successfully solved examples. Since ANNs try to mimic the human brain they possess an adaptive feature that allows each node within the network to modify its state in response to past and present knowledge.

C. *Wireless Sensor Networks (WSN)*

In the event WSN is used to not only collect traffic data but also actively control road traffic, additional functionalities are incorporated into the network's controller. An algorithm is embedded to control the traffic lights – it generates routing decisions based on sensor data aggregated. Unlike some A.I systems, WSN does not require vehicles to have additional systems such as RFID tags to control and manage traffic. As a result WSN are cost inexpensive and make it a more practical than ANN and FES approaches especially in emerging economies.

V. STUDY ON THE SCHEME OF TRAFFIC SIGNAL TIMING FOR PRIORITY VEHICLES BASED ON NAVIGATION SYSTEM [6]

With the development of urbanization and the increase of automobile ownership, the traffic becomes more and more congested. At the same time, the traffic accidents arise and the environment aggravates. These problems have happened not only in the developing countries but also in the developed ones. This paper presents a new signal timing method The purpose is to make priority vehicles reach their destinations without delay at signalized intersection. That is, whenever the vehicles reach a signalized intersection, the signal light is always green.

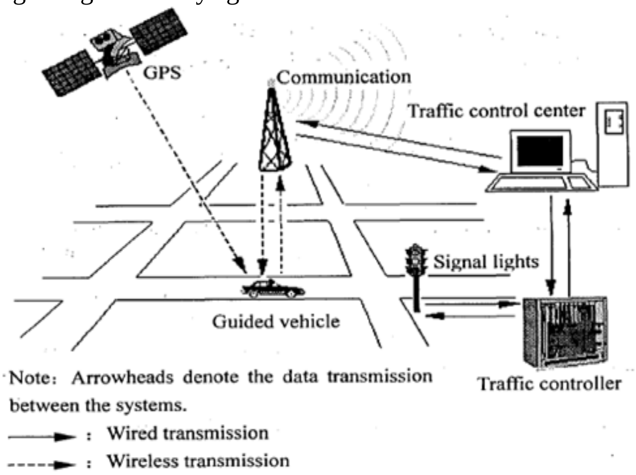

Fig. 3: Architecture of the system operation

In our scheme, signal parameters of intersections can be changed at any time if needed. The subject vehicle uses the Global Positioning System (GPS) to locate its position. According to these data, we can get the vehicle's position and speed, then calculate the accurate time when the vehicle reaches the next intersection. At that time, if the indication of signal light is not green, the timing plan must be changed so that the subject vehicle can be given the right of way to move into the intersection. The architecture of the system is simplified as Fig. 3:

When the vehicle determines its origin and destination, it can get the optimal path offered by the vehicle guidance system. During its course the vehicle can gain position, velocity and other useful information by the GPS receiver assembled on it. Based on this information the vehicle will calculate the time to arrive to the next intersection. If the time is greater than the cycle time (C) of the next intersection, the vehicle will keep going without submitting a request to the traffic control center. For the intersection timing plan can be adjusted in next cycle. If it is smaller than the cycle C, the vehicle will submit a request and send all the information to the traffic control center. These are done through communication system. The traffic control center will predict the accurate time when the vehicle arrives at the intersection according to its performing status. The control center also knows the timing plan at that time, and judges whether the traffic light is green or not. If green, there is no need to adjust the timing plan of that intersection. If not, the timing plan will be changed.

VI. City traffic congestion control in Indian Scenario using wireless sensor network [7]

Traffic management is becoming an increasingly serious concern due the rapid rate of increase of vehicles. The growth and scale of vehicles today makes management of traffic a recurring problem.

In this paper author has proposed a mechanism to increase the capacity using existing infrastructure like traffic lights while incorporating new infrastructure such as sensor motes on vehicles to study the traffic flow pattern. The algorithm for this system is as shown below:

A. Pseudo code for the Algorithm:

- Step 1: Synchronize all the routes; calculate 'mf' and 'k'.
- Step 2: Calculate CR for all the routes; sort them in descending order.
- Step 3: Choose the first route; calculate TClearance for it.
- Step 4: Find the set of possible routes.
- Step 5: Grant clearance to these routes for the time TClearance.
- Step 6: Repeat the steps 1 to 5.

The following parameters are critical for the algorithm:

- Waiting time is defined as the time a route has been waiting for after its last clearance.
- Clearance time is defined as the total time allotted to schedule one round for a given route, and is calculated on the basis of requirement.
- Rate of arrivals is the number of vehicles arriving at the junction, desiring a particular route of travel.
- Proportionality constant 'k' is an exponentially varying parameter which is activated when the wait time of a particular path crosses a given threshold. The threshold can be configured.
- CR (clear route) is a variable which will be calculated using the parameters, waiting time, number of vehicles, and the proportionality constant. The route having the highest CR will be cleared first.
- Multiplication factor 'mf' is a critical parameter to maintain fairness in the system and also helps to handle emergency situations.

VII. Conclusion

This paper proposes a traffic control system using the WSN technology. The advantages of the proposed system include: 1) accurate monitoring and measurement of the vehicle number and vehicle speeds in real time due to the introduction of the WSN technology; 2) it is easy to append more functions to this system since the system not only know the statistical information but also the information of a special vehicle as well; and the roadside system can communicate with the vehicles. This paper also proposes a traffic control algorithm for the signal control in an intersection. Since the vehicle state is monitored dynamically, the phase time is determined exactly instead of by forecasting. Compared with conventional algorithm, the advantages of the algorithm includes: 1) eliminate the phase time when no vehicle passing across; 2) Let all of the waiting vehicles pass if possible, which reduces the waiting time.

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