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IMPROVING TRAFFIC FLOW AT INTERSECTION USING INTELLIGENT TRAFFIC MANAGEMENT SYSTEM

Daniel Shunu[1]
[1]College of Information and Communication Technologies,
University of Dar es Salaam, Tanzania

*Corresponding Author: Daniel Shunu
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ABSTRACT

In this study, a proposed intelligent traffic management system is presented making use of the wireless sensor network for improving traffic flow. By making use of the clustering algorithm, VANET environment is utilized for the proposed system. The components of the proposed system include sensor node hardware, vehicle detection system through magnetometer, and UDP protocol for communication between the nodes. The intersection control agent receives the information about the vehicles and by making use of its algorithm, it dynamically changes the traffic light timings. By making use of the greedy algorithm, the system can be enhanced to a wider area by connecting multiple intersections.

Keywords: Wireless Sensor, Network, Traffic Intersections, Traffic Lights, Intelligent Traffic Management.

INTRODUCTION

The wireless sensor networks are important technology attracting greater interest because of remarkable growth in electromechanical systems and microelectronics. Recent development in this field have enabled development of low-cost and efficient solutions for different fields. These efficient and low-cost sensors networks using the wireless links and can be deployed in larger number providing solutions in many fields such as homes, cities, traffic, and so on. In current study, we use the wireless sensor network for solving the traffic congestion issues. In traffic

management field, the wireless sensor networks collect traffic information and control the traffic flow based on incoming traffic data.

The background of the problem is that in developing countries, the higher increase in population is resulting in higher traffic congestions leading to traffic jams. Traffic congestion is becoming a global problem especially in major urban cities. There are different methods proposed for overcoming the traffic congestion issue. For example, for monitoring the traffic congestion and early warning systems, city governments have installed radars and video surveillance cameras. Often these solutions cost a lot of money and their effectiveness depends on the public willingness to follow such system requirements. Mostly, these methods are not considered very efficient due to the different problems. In this study, an intelligent system is designed which is based on minimizing the total vehicle travelling time based on wireless sensors. The system can be developed at large scale and promise low cost feature. the system is based on wireless sensor networks and the interaction control agents. The difference between this system and the traditional system is that in traditional system, each intersection is managed in isolation but the proposed system works on the basis of collective functioning using the wireless network. The system work by calculating vehicle passing through one interaction to another by means of transmitting the data through wireless network nodes. Thus, wireless sensor network nodes collect such information and take action to optimize the traffic flow.

The idea behind the intelligent traffic management system is that at each traffic light, monitoring nodes sense the traffic and send this signal to control system which utilize this to manage the timings of the traffic lights. This way it reduces the time of waiting at traffic light and improve the traffic flows.

LITERATURE REVIEW

A traffic management system is proposed based on radio propagation model in VANET 3 which is used for decreasing the intersection congestion and reducing the traffic jams (Dorle & Patel, 2018). The system utilizes the vehicular ad hoc network and is part of the intelligent transport system.

A traffic management system using the wireless network was proposed by Tubaishat, Shang, and Shi 1. The wireless networks nodes consist of processors which collect information about car speeds, car numbers, length and feed this information to its algorithm for improving the traffic flow at traffic lights. The system work on the basis of power efficient and delay aware medium access protocol for sensor networks.

Gradinescu, Gorgorin, Diaconescu, & Cristea (2015) propose a system for managing the traffic flow using the adaptive traffic lights by means of vehicle-to-vehicle communication. The proposed system works on the basis of information received from vehicles itself which are managed by including short-range wireless communication capabilities to vehicles where vehicles forms a network and communicate about traffic jams.

The intelligent traffic system can work in synchronize manner means the wireless sensor network sare placed in the traffic direction on a road which monitor the car stoppage, and start and stop behavior which is managed to reduce the traffic ques and waiting time. For instance, at

three intersections, if green signal is managed synchronously, it will reduce the queue length and improve the total travel time at minimum.

Some relevant concepts are the nature of intersections. Some are discussed below;

Isolated intersection control

It is that intersection where traffic is controlled without taking into account the adjacent signalized intersections.

Interchange and closely Spaced Intersection Control

It is that intersection where progressively traffic flow is managed using the two closely spaced intersections. A single traffic controller can manage the flow on both intersections.

Arterial Intersection Control

It is used for managing the traffic flow along the arterial by coordinating with the traffic signals.

Areawide System Control

It monitors the most portion of signals in a city as a total system.

Signal-related special control concepts include:

- High occupancy vehicle (HOV) priority systems.
- Preemption - Signal preemption for emergency vehicles, railroads, and drawbridges.
- Priority Systems - Traffic signal control strategies that assign priority for the movement of transit vehicles.
- Directional controls - Special controls designed to permit unbalanced lane flow on surface streets and changeable lane controls.
- Television monitoring.

In current study, the VANET environment is used for managing the traffic flow dynamically using the radio model of propagation. At intersection, the proposed system utilizes the clustering algorithm. The proposed system utilizes the wireless sensor network (NS2) for possible large-scale implementation.

Sensor Node Hardware

Atmel ATmega128L is used as a microprocessor in this proposed network based on 512 KB of flash data memory and 128 KB of programmable memory. It can be placed anywhere on a pavement using the ordinary glue (Tubaishat, et al., 2007).

Vehicle Detection

For vehicle detection, magnetometer is used. The function of the magnetometer is to detect the distortion caused by vehicles. The detection is based on distortion which is happened on the ground due to the ferrous material and the orientation leading to development of a signature induced magnetically based on vehicle shape.

Communication Protocol

Loss Monitor UDP protocol is adapted in this proposed system. The benefit of using this protocol in this system is that it is fast, reliable, efficient, and minimizes the data loss and delays. Periodical updates are taken from the sensor nodes at the WSN and fed into the ICA.

Road Intersection Configuration

The systems are workable with intersections controllable by traffic lights. Mostly at intersections, traffic lights manage the flow of traffic. Sensor nodes are deployed at each lane of a selected road. The sensor is placed in such a manner that they can monitor the vehicles entry and exit of a particular intersection.

Intersection Control Agent (ICA)

Intersection control agent will be utilized for the controlling and monitoring the activities of traffic light for the intersections managed by the system. The system goal is to replace the vehicle detection system with the wireless sensor detection-based system which will inform the intersection control agent about the traffic on separate road lanes. The intersection control agent will manage the traffic in all lanes in particular junction or intersection. The system will work based on four messages types.

Sensor Nodes to Intersection Control Agent

The first type of message is about number of vehicles approaching an intersection. The sensor node will communicate to the intersection control agent the information about vehicles such as number of lanes occupied, number of vehicles, and type of vehicles.

Intersection Control Agent to Sensor Nodes

The intersection control agent will monitor all of the information received from all nodes and based on the analysis; it will use its algorithm to make decision about the best flow model for the optimum vehicle flow over the intersection.

Greedy Intersection Control Agent to Intersection Control Agent

At wider area, the intersection control agent can communicate information to other intersection control agents for improving the traffic flow at wider level. The more information is available to an intersection control agent, the better decision regarding traffic flow can be made. This is based on greedy algorithm where intersection control agent uses information at each intersection to optimize the flow at its own intersection.

Traffic Direction

In most of the traffic intersection, the traffic can be of only four directions including north, south, east and west, denoted by N, S, E, and W respectively. The other possible ques are north west (NW), south east (SE), and west north (WN). At any one intersection, two directions can be open at the same time such as N and S at the same time and W and E at the same time. When taken into account the other turning scenarios such as NW or SE, so algorithm becomes more complicated and requires greater sensing.

SIMULATION DETAILS

The network simulation tool version 2 or NS2 was used for simulation testing of the proposed model. The NS2 can be used to simulate concepts in wired as well as wireless network. The similar is popular tool and can be used for showing the road and traffic virtually. The NS2 contains most of the internet protocols (IP) for simulation purpose.

Algorithm

In proposed system for managing the traffic flow at intersection, following is the input for the algorithm

Let input be N, λ, μ and Qi, i =1, N

Output is measured by communication between the traffic control system in order to get the best traffic flow.

The intersection control agent refers to Traffic Base station

The algorithm is referred as traffic signal time manipulation algorithm

Lighting period is denoted by L

The communication node is used for sending 'operating message' from intersection control agent.

At each network TSN, random time slot within L is selected for communicating the traffic status information ((λ , μ and Qi) to intersection control agent.

The intersection control agent utilizes the algorithm labelled as 'traffic signal time manipulation algorithm' to manage the traffic signals at different lanes and directions. Typically, an intersection consist of four roads with 8 possible ques which assumes that all right side movements are free and function signals free. Assume that

Movement is denoted by i

Time by t seconds

Time is indexed with integer k

And express by the current queue $q_i(k)$, then

$qi(k+1)=qi(k)+qini(k)-qouti(k)+jini(k)-jouti(k),i=1,2,\cdot.8$qik+1=qik+qiink-qioutk+jiink-jioutk,i=1,2,·.8

The general discrete LTI state space representation is the following:

$x(k + 1) = A\ x(k) + B\ u(k) + F\ d(k)$

$y(k) = C\ x(k)$

The traffic control box is used for managing the dynamic duration of traffic signals by the traffic intersection control agent.

Single Intersection Base Model Formulation

For modelling the lanes in multiple intersections based on random arrival times, mathematical que model is used. The mathematical que model length can be calculated as follows;

$QL(j) = QL(j-1) + \lambda(G) - \mu(G) + \lambda(R)$

Terminologies:

λ = Rate with which the arrivals follow Poisson distribution with constant average

P0 = ideal proportion of the time the traffic signal (server)

P = busy proportion of time the system

QL(j-1) = Remaining from the previous cycle.

λ(G) = Vehicles arrive in green time.

μ(G) = Vehicles departure in green time.

λ(R) = Vehicles arrive in red time.

j = the traffic cycle number,
QL (j) = the expected queue length of one lane for the next cycle j,
Hence, the queue length equation is given by: $QL = \rho 2/(1 - \rho)$
And using Little's Law, the AQL is given by: $QL = \lambda W$ (where 'W' is the average time spent in the system)
The simulation result shows that average junction time is reduced compare to the traditional method which helps in improving the traffic flow. This method can be applied in large scale and can be used for improving the intersection traffic flow.
In this paper, a proposed intelligent traffic control system is proposed by using the wireless sensor networks. The proposed system is based on adaptive traffic signal scheduling algorithm. Currently, it is proposed for the single intersection but with some improvements, it can be utilized to connect multiple road intersection at wider level possibly by using the greedy algorithm. The proposed system is promising because it shows good results in simulation in terms of efficiency and resource cost. The system is easier to install with minimum capital requirements.

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