A Comparative Study on Sensor based Intelligent Rush-Hour Traffic Mechanism

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Abstract—An intelligent Wireless Sensor Network consists of a number of sensor nodes that spread across a geographical area; where each sensor has got the processing power, communication capability and transmission of data to other sensors. In this paper, we report recent trends in wireless sensor network research including a survey of WSN technologies and a discussion of existing research areas and traffic management applications. This study highlights that it is needed to provide a common interface for various functional components of WSN: detection and data collection, signal processing, data aggregation, and notification. Thus the conducted survey covers major intelligent traffic management systems in wireless sensor network that present the obstacles and the requirements in the traffic data collection.

Keywords: **GREEN Light, ITMS,*JMLS*,TMS,*WSN***

I. INTRODUCTION

Wireless sensor network (WSN) is one of the major technologies so far developed for large-scale monitoring application. It mainly consists of a set of nodes deployed on a particular region for sensing some phenomena. The ease of deployment, low cost and scalability makes it popular to apply in different fields. Recent advancement in sensor device technology helped WSN as a solution to wide variety of applications like environmental monitoring, health care monitoring, structural analysis and traffic monitoring.

Research on efficient and effective Traffic Management System (TMS) aims to monitor, analyze and manage traffic flow. Traffic management becomes quite difficult in medium and large sized cities due to rapid development of urbanization. It faces certain challenges like traffic rule violation, traffic congestion etc. The methods which are currently adopted are GPS, radars and digital cameras. They can estimate number of vehicles passing over a particular time interval, their velocity and type of vehicle. But cost for installation, operation and maintenance s very high and it sometimes affects the normal traffic flow. Thus it is necessary to develop an Intelligent Traffic Management System (ITMS) which is efficient, effective and cheap. The solution to such a system is to design a sensor network for traffic monitoring as it is easy to deploy, manage and use.

The major objective of ITMS is to make road less congested and safe to drive and walk. For this, set of sensor nodes are deployed on roadside bed, on vehicle and on highways. The node placed on vehicles forms a mobile sensor network which is difficult to manage than static network which is formed by nodes on roadside bed. The placement of nodes is too important as it affects the quality of data obtained.

II. REVIEW OF PAPERS

Intelligent Traffic Management with Wireless Sensor Networks

The presently using technologies like wired sensors, surveillance camera for vehicular monitoring are expensive and their maintenance cost is very high. Also the accuracy of these devices mainly depends on environmental conditions. Traffic is mainly an adaptation problem rather than optimization problem. So here we need a system that can adapt to changing traffic flows and densities regularly. Wireless Sensor Network is the most suitable solution to meet the traffic issues as they provide highly flexible and healthy system that work well for almost all applications with low power, low cost and low maintenance. This paper aims at developing an intelligent system that reduces the average waiting time of vehicles at a junction. The proposed system [1] also optimizes the traffic flow by utilizing the free roads. Here two algorithms are

Proposed which are capable of reducing average waiting time of all vehicles at the junction.

They are:

1. Maximum Intersection Utilization
2. Empty lane with Green Light.

Three performance requirements are considered while measuring the average waiting time:

1. The average waiting time for a vehicle at a junction should be minimized while keeping the policy fair.
2. The number of vehicles at a junction should be minimized when a road has green light but there are no
3. vehicles, then the vehicles on other junctions should be minimized or allowed to move by following a fair traffic policy.
4. There should not be any delay between the TLC (Traffic Light Controller) and traffic light. When the TLC gives instructions i.e., the light (red, green) then it should be displayed without any delay.

The proposed system model uses magnetometer sensor nodes for vehicular detection, which detects distortion of earth's field caused by large objects like vehicles. In order to conserve the energy, these sensors turn off between samples and active only for 0.9msec to receive one sample. The communication protocol adopted here is PEDAMACS. Road intersection represents the meeting point of 3 to 4 roads and each road consists of 3 lanes. Lane represents the direction in which vehicles should move. The traffic signal light consists of two states: GREEN and RED. The traffic at the intersection are programmed and controlled by Intersection Control Agent (ICA). In order to measure the vehicle count and to communicate wirelessly with the ICA, sensors are placed on each lane of each road at a fair distance from the intersection.

Maximum Intersection Utilization Algorithm:

1. Identify the number of roads at the intersection and numbered it sequentially from 0 to 3 clockwise.
2. Set all the roads initially to red state.
3. Randomly choose one road as the start point and continue the cycle after every 4th stage.
4. During each stage 2 roads that are opposite to each other are regulated.
5. Vehicles should wait for 3 cycles for their turn and those want to take a left turn, should wait for 2 cycles.
6. Free left turn is allowed for all the stages.
7. Equal time slots are given for each road which is followed in a round robin schedule.
8. This operation will get stopped only by issuing a stop or pause command by the user.

Empty lane with Green Light:

1. Identify the number of roads at the intersection and numbered it sequentially from 0 to 3 clockwise.
2. Set all the roads initially to red state.
3. Time slots of 20 seconds are given to each road by scheduling round robin algorithm.
4. If a green signal is given and there is no vehicle on that road;
   - 4.1 All the lanes of that road are assigned with RED light.
   - 4.2 Choose the road with MAX traffic and assign GREEN signal for that road. Check whether vehicles arrived at the road that is assigned previously with RED light. Assign GREEN light to that road, else assign GREEN light to the next road with maximum vehicle count.
5. Repeat the above steps for that particular until the timeslot for that particular road is over.
6. The turn is shifted to the next maximum vehicle count road and repeats the steps 3 and 4 for same.
7. This operation will get stopped only by issuing a stop or pause command by the user.

WARIM: Wireless sensor network Architecture for a Reliable Intersection Monitoring

This paper [2] proposes energy efficient, low cost and light weight multihop wireless sensor network architecture for monitoring and measuring the vehicle queue length on roads, in order to find traffic at the intersection. The Intelligent Transportation System here mainly focuses on vehicle traffic monitoring and measuring vehicle queue length on each lane of an intersection. Due to the low equipment, installation and maintenance costs, WSN based architecture have proposed for road and intersection monitoring. For intersection monitoring, here propose a lightweight WSN architecture known as WARIM (Wireless sensor network Architecture for a Reliable Intersection Monitoring). Open communication protocol like IEEE 802.15.4 is used to reduce the financial burden. For reducing the deployment and maintenance cost, self configuration and organization protocol is developed. Battery-equipped wireless sensor nodes are used to increase the lifetime of WARIM architecture. Surface -mounted sensors are used here to reduce the deployment time and road deterioration.

The proposed architecture consists of sensors which are deployed on the road surface and these sensors are capable of communicating with the controller for reporting vehicle detection through multi-hop WSN. Each lane of the intersection is deployed with several numbers of sensors and the distance between two sensors should be in the order of 5-10m. Communication between the nodes will be reliable due to this short range distance deployment even in presence of traffic. Better connectivity is also provided by the short distance deployment of sensors, even if the road links are asymmetric, unstable and dynamic. WARIM architecture provides an accurate measurement of vehicle queue length at each lane-level by using small distance between sensors. Based on desired accuracy and node communication capabilities, number of sensors is deployed on each lane. Higher accuracy is achieved by using higher number of sensors. Only surface-mounted sensors are used without any extra infrastructure, which help to reduce the deployment and maintenance costs. Energy Harvesting capabilities are equipped in sensors, which helps to reduce the maintenance time. In order to recharge the sensors, small size panels are used to harvest solar energy.

Architecture for smart highway real time monitoring

The most important issues faced by cities today are the smart management of traffic and transport infrastructure. This paper [3] proposes an architecture which is based on wireless sensor network, used to monitor highways in smart cites.Additional parameters that are monitored are: velocity of traffic in highways, type of traffic occurred and number of traffic, temperature and humidity of the environment, State of perimeter fence, noise analysis, and monitoring pollution. For security reasons, highways are provided with security fence on either side of the road. The security fence should be monitored in every 24 hours in order to ensure security. For this purpose, the WSN nodes are attached to the fence's posts and equipped with accelerometers. Singular events are detected using sensors which are deployed in every 85-120 meters in the security fence. The accelerometers mounted in the WSN nodes, deployed in the security fence monitor the state of the fence as well as the frequency disturbances associated with wind, fence fall and impacts.The wireless interface of the node goes to sleep state and periodically wakeup and send the gathered data to gateway. The gateway collects information from all sensors to disseminate information about the highway. Gateway nodes are attached with inexhaustible source of energy. The entire WSN architecture is divided into three layers: Event layer, Management layer and Presentation layer. Environmental sensors and Multimedia sensors are used by event layers. The event layer is responsible for guiding events from sensors to the management layer. The management layer process the raw data from sensors and make information based on client defined algorithms. The information's are collected from accelerometers periodically. The presentation layer is responsible for providing information to the users based on their needs. MQTT-S module for Tiny OS is implemented in sensor layer to collect all information from sensors to gateways.

Real Time Optimized Traffic Management Algorithm for Intelligent Transportation Systems

This paper [4] proposes an intelligent transportation and traffic Management system that mainly focuses on dynamically determining the duration of green light and efficient management of emergency vehicles on the heavy traffic conditions. The method used here also deals with the deadlock and starvation condition that occurs during the arrival of emergency vehicle in traffic intersection at repeated interval of time.

Due to the large number of vehicles at the intersection and the vehicles number varies from time to time, the traffic signal project is implemented dynamically rather than in static way. The proposed method uses wireless sensor network placed along the road that collects the real time input.

Steps for Dynamic Traffic Signal

1. Find the volume or queue length of traffic
2. Check any emergency vehicle on the traffic
   2.1. Perform the best case or worst case scenario
3. Find the most suitable phase and assign GREEN LIGHT
4. Calculate GREEN LIGHT duration.

Stages for managing worst case or deadlock condition

Stage 1: Categorizes the Emergency vehicle based on the standard policies of the country.
Stage 2: Find the distance between the Emergency vehicle and Intersection point.

Improving Emergency Messages Transmission Delay in Road Monitoring based WSNs

This paper [5] proposes a method to reduce the transmission delay from the detector sensor node to the

gateways. To enhance the faster transmission of detected data towards TMS, it suggests an improved back off selection method for IEEE 802.15.4 protocol. The CSMA/CA used in this protocol works as follows: it draws random back off time from Congestion Window (CW) interval when a device want to send data, after back off time expires, Clear Channel Assessment (CCA) task is performed and check whether the channel is free. If it is free, then data is sent otherwise wait for another back off time.
The main objective of this paper is to decrease the waiting time of critical message without affecting the rest of process. The architecture mainly consists of a set of sensor nodes and a gateway. These sensor nodes are deployed in two ways:

1. Set of static sensor nodes deployed on roadside parallelly.
2. Other sensors are deployed one per lane across the road.

The gateway is placed in one corner of the intersection which plays an important role in synchronization and priority management. It manages priority by using three types of queues with different priority levels. A Wireless Mesh Network (WMN) consisting of Wireless Mesh Routers connects this gateway to the local Traffic Management Controller (TMC). The sensors used in this architecture is capable to capture three types of messages namely weather condition, traffic condition and incident report. But the paper mainly focuses on reporting incident data.

Based on the class of each message CW is adapted in CSMA/CA. The main idea is that collaborate back off selection interval with the class of message which is being transmitted using Normal distribution. As a result, messages related to incidents or dangerous situation can be reported with less back off with respect to that of periodic traffic flow.

HaTTC: An Urban Traffic Sensing Method Based on Tensor Completion Technique

Data reconstruction is a big problem due to missing of data captured by both road monitoring devices and vehicles. As a solution to this, a tensor-completion-based algorithm [6] is proposed which is referred as the extension of matrix completion. To replace the rank of tensor, a non-convex function named tensor rank minimization is used which is very complex and contains many objective function. To solve this problem, this paper proposes local estimation techniques like temporal periodicity and continuity etc. to increase quality and accuracy. The following are the major contributions of this paper:

1. Revealed the hidden structure of traffic data by finding correlation between traffic data collected on consecutive days and done principle component analysis. Based on this, they proposed tensor-completion-based approach to find out missed traffic information.
2. Tensor completion algorithm based on Alternating Direction Method of Multipliers (ADMM) called Half Thresholding Tensor Completion (HaTTC) adopts local estimation methodologies.
3. A full-time traffic sensing is conducted by using VSN-based traffic monitoring system.

The VSN based traffic sensing system mainly consists of Traffic Management System (TMC), Base Station (BS), and cloud server for processing data and probe vehicles. Vehicles are equipped with GPS to collect data. BS relay sensed data to TMS via cellular networks. A cloud server which is used in this architecture can locate the vehicles through map matching and connect it to road segment.

This method integrates tensor completion with local interpolation method which can tie together both global low-rank structure and local data structure. The convergence can be made fast by adopting L1/2-norm.

Cooperative Bayesian Estimation of Vehicular Traffic in Large-Scale Networks

This paper [7] proposes stochastic method for traffic estimation which guarantees low computational cost and high accuracy. It reduces message complexity by eliminating the need of exchanging highly sensitive information. To enable the recovery of traffic data, a Bayesian approach that exploits live sensor data and analytical traffic model is used. Network architecture used in this paper consists of different sub networks (blocks), whose size may vary depending upon the type of application.

The defined Cooperative Bayesian estimation can be applicable in heterogeneous sources or sub networks operated by different operators. Aggregating the data from different sources will improve quality and coverage. This concept can be used in different areas like traffic light management, traffic forecast and for traffic monitoring. The objective of this paper is to provides a transition from centralized traffic estimation to corporate approach. The method uses graph theory to describe statistical relations that exist in collected traffic data. The main features pointed out in this paper are as follows:

1. Applying Bayesian traffic estimation to corporate data from different sub networks and sharing statistical information
2. Defining new traffic model that extends existing jump Markov linear system (JMLS)
3. Developing an efficient procedure for implementing co-operative approach.

To implement this paper, at first each sub network estimates traffic individually and then updates the information by gathering the sensed data from neighboring sub networks. An iterative message-passing procedure is used for data sharing between each sub network.

This procedure allows mutual sharing of traffic data as for a global estimation, but with a much lower computational cost, which is proportional to the dimension of the sub network and to the number of neighboring sub networks. We used a macroscopic approach to traffic modeling, which is based on the Cell Transmission Model (CTM) extended with a stochastic component to account for the randomness of traffic. For the estimation, we used in each sub network a JMLS based on a linearized version of the CTM and a Particle Filter (PF) approach to track the traffic phase sequence. For making the sub networks share information on their estimates, we proposed an iteratively message-passing procedure based on BP.

III. Comparison

Sl. No	Title	Author	Technology/Architecture	Results
1	Intelligent Traffic Management with Wireless Sensor Networks,2013	Juhi R Srivastava et.al	• Two algorithms are proposed. *Maximum Intersection Utilization *Empty lane with Green Light algorithm.	• Average waiting time of the vehicles at the junction can be reduced considerably.
2	WARIM: Wireless sensor Network Architecture for a Reliable Intersection Monitoring,2014	Rodrigue Domga Komguem et.al	• Proposes an architecture named WARIM	• Reduce the traffic jam • Calculate the vehicle queue length
3	Architecture for smart highway real time monitoring,2013	Felix Jesus Villanueva et.al	• The proposed architecture is based in an object-oriented distributed middleware and it uses MQTT to collect information from sensors	• Monitoring *Vehicle velocity *Type of traffic occurred *Number of traffic *Temperature and humidity ofthe environment *Pollution • Noise Analysis
4	Real Time Optimized Traffic Management Algorithm for Intelligent Transportation Systems,2015	Partha Sarathi Chakraborty et.al	• Two algorithms are used * Dynamically determining the duration of green light * Deals with the deadlock and starvation condition that occurs during the arrival of emergency vehicle in traffic intersection	• Minimizing the average waiting time. • Prioritization of emergency vehicles • Effectively handles the deadlock and starvation condition.
5	Improving Emergency Messages Transmission Delay in Road Monitoring based WSNs,2013	Horiya Imane Brahmi	• A new adaptive backoff scheme for IEEE802.15.4 protocol is used in order to ensure faster transmission of emergency messages in road environment.	• Ensure fast transmission of the detected events on the road • Shorter waiting time for messages carrying critical information without changing the basic principle of the backoff mechanism.

6	HaTTC: An Urban Traffic Sensing Method Based on Tensor Completion Technique,2014	Qianli Zhao et.al	• Based on tensor completion to estimate missing traffic data. • Integrate local interpolation methods with tensor completion method to seize both local data structures and global low rank structure.	• Full time traffic sensing on all road segments
7	Cooperative Bayesian Estimation of Vehicular Traffic in Large-Scale Networks,2014	Alessandra Pascale et.al	• Uses cooperative method for large-scale traffic estimation based on the splitting of the road network into small sub networks. • A macroscopic approach is used to traffic modeling, which is based on the CTM extended with a stochastic component to account for the randomness of traffic. • JMLS based on a linearized version of the CTM and a PF approach is used to track the traffic phase sequence.	• Guarantees high accuracy • Moderate computational • Sub networks do not need to exchange sensitive information but simply traffic beliefs

IV. CONCLUSION

WSN is a technology with promising future and it is presently used in a wide range of applications including traffic monitoring. WSN offers significant advantages over wired system. In this paper we have conducted a survey based on intelligent traffic management system in WSN. They have the common objective of reducing the traffic congestion at the intersection points by the proper assigning of traffic signals and the fast transmission of the detected events in case of emergency. Through the Intelligent Traffic Management System, many areas take advantages. The beneficiaries areas are freeway, transit, incident, emergency, data collection, toll collection, environmental issue, traffic information and archived information management. The results of this literature review have shown that Intelligent Traffic Management System is a broad field which covers many technologies and they play a significant role in the technology era. Intelligent Traffic Management System deployments offer the following benefits: improved safety, efficiency, mobility, accessibility, intermodal connections. We finally analyzed each topic by a comparative survey of the approaches available in the literature. Our analysis also provides hints for open research problems. As a general remark, there are only a few implementations on real scenarios .An experimental evaluation on test beds and real deployments is an aspect that requires more in-depth investigation. In addition, comprehensive solutions which can be applied out-of-the box to specific application scenarios have yet to be proposed. Although many of the traffic management systems look promising, still many challenges are present here that need to be solved using wireless sensor networks.

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