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"Traffic Congestion Detection in Vehicular Adhoc Networks using GPS"

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Abstract: *In today's world traffic congestion is the critical issue. Huge amount of time, fuel and money is wasted due to traffic jams all around the world. Drivers select the path that they consider will be the fastest; however the inability of drivers to know the road situation ahead creates severe congestion. The competency of a driver to know the traffic situation on roads will make the driver capable of saving time and fuel by taking alternative routes. In this work we have proposed a traffic congestion detection system using Vehicular adhoc networks (VANETs), which will provide efficient communication between cars and infrastructure and propagate real time information about traffic congestion to the drivers. We also uses the GPS device to detect the congested areas and defines various works.*

Keywords: *Vehicular Ad-hoc networks, Mobile Ad-hoc networks,ITC, v2v and v2i*

I. Introduction

Traffic on road is a major problem today. Millions of hours and gallons of fuel are wasted everyday by vehicles jammed in traffic. This is fact that wasted billion gallons of fuel today due to increase of traffic intensity [1].

Technology is at a point today in which vehicles themselves could be used to compile and analyze traffic data and relay it to the drivers in a format that will allow them to make smart decisions to avoid congested areas. Communications between vehicles can be achieved either through vehicle-to-vehicle (V2V) communications and/or vehicle-to-infrastructure (V2I). Vehicular ad-hoc networks (VANET) [2] are a form of mobile ad-hoc networks (MANET) that provide communications between nearby vehicles and nearby fixed equipment.

Congestion detection algorithms are designed to detect areas of high traffic density and low speeds. Each vehicle captures and disseminates information such as location and speed and process the information received from other vehicles in the network. Congestion detection is

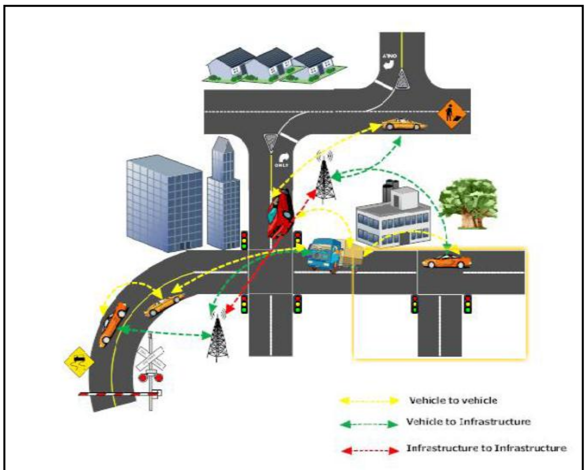

Figure 1: Vehicular Ad Hoc Network overview

only one of many applications of VANETs and it is not designed to be used as means for automated driving but rather as a tool to deliver information to the driver that will help him/her make decisions to avoid heavy traffic [5]. Developing a traffic congestion detection system will have great impact on the economy, the environment and society in general allowing us to spend less time stuck in traffic and more time doing more productive.

his work focuses on GPS for traffic congestion detection: Vehicular Over-the-air Traffic Information Gathering GPS Navigation System, that is capable of detecting traffic congestion areas in real-time with data collected and disseminated by vehicles using V2V communications, with the need of external infrastructure (such as antennas, GPS satellites, etc.), and developing the tools for interactively simulating and visualizing the behavior of this and future congestion detection systems on a myriad of scenarios.

The Vehicular Ad-hoc Network (VANET) has been studied in many fields [Figure 1] since it has the ability to provide a variety of services, such as detecting oncoming collisions and providing warning signals to alert the driver. The services provided by VANET are often based on collaboration among vehicles that are equipped with relatively simple motion sensors and GPS units [3][8][9]. Awareness of its precise location is vital to every vehicle in VANET so that it can provide accurate data to its peers. Currently, typical localization techniques integrate GPS receiver data and measurements of the vehicle's motion. However, when the vehicle passes through an environment that creates a multipath effect, these techniques fail to produce the high localization accuracy that they attain in open environments. Unfortunately, vehicles often travel in environments that cause a multipath effect, such as areas with high buildings, trees, or tunnels [4]. The goal of this research is to minimize the multipath effect with respect to the localization accuracy of vehicles in VANET. The proposed technique first detects whether there is a noise in the vehicle location estimate that is caused by the multipath effect using neural network technique. It next takes advantage of the communications among the VANET vehicles in order to obtain more information from the vehicle's neighbours, such as distances from target vehicle and their location estimates. The proposed technique integrates all these pieces of information with the vehicle's own data and applies optimization techniques in order to minimize the location estimate error.

II. Literature Survey

Traffic congestions are formed by many factors; some are (somehow) predictable like road construction, rush hour or bottle-necks and some are unpredictable like accidents, weather and human behavior. Drivers, unaware of congestion ahead eventually join it and increase the severity of it. The more severe the congestion is, the more time it will take to clear once the cause of it is eliminated [7]. The ability for a driver to know the traffic conditions on the road ahead will enable him/her to seek alternate routes saving time and fuel. When many drivers have this ability, traffic congestions, specifically those related to localized incidents such as accidents or temporary disruptions will be less severe and only the vehicle in the immediate vicinity of the incident, at the time of the incident, will be affected. This would lead to a much more efficient use of our road infrastructure.

Traffic congestions result from driver behavior and the lack of wide distance information. Current systems, such as helicopter traffic reports are effective because from the air we can get a good picture of a congestion area, where it starts, where it ends and how slow or fast is moving, however these reports require enormous resources and are therefore limited to major metropolitan areas[11][12]. In order to provide drivers with useful information about traffic ahead a system must:

GPS is a positioning system that has been developed by U.S. Department of Defence. It is implemented in all over world. A GPS system is formed from a network of satellites that transmit Continuous coded information, which makes it possible to identify locations on Earth by measuring distances from the satellites; moreover, the receiver also has the ability to obtain information about its velocity and direction. A GPS network consists of 24 satellites arranged in six orbital planes, as depicted in [Figure 2], so that at any given time a minimum of five satellites can be observed by GPS receivers at any location in the world. Different types of GPS receivers have been developed for many applications according to the accuracy required.

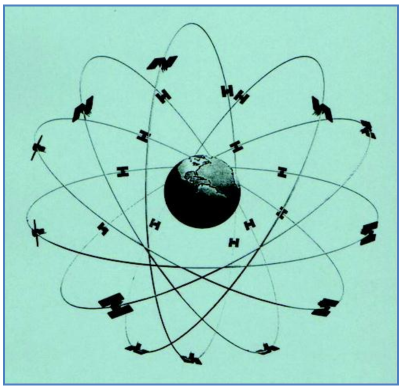

Figure 2

In fact, basic GPS receivers often have four radio channels so that the receiver can observe four GPS satellites at once and obtain a pseudo-range measurement from each satellite signal. Leva in [13] and Hoshen in [14] show two different techniques by which a GPS receiver can compute its location from four pseudo-range measurements, minimum required for localization in three dimensions. However, if one of the GPS satellites' signals does not appear,it is hard to identify the location of the GPS receiver from only three measurements. Therefore, the more advanced receivers have been developed to have six or more radio channels. The extra channels keep observing other GPS satellites and put their information in reserve, to use in case one or more of the four signals is missing.

Various techniques are being used to overcome the traffic congestion issues. There are certain advantages and disadvantages of each proposed technique.

A. Vehicle-to-Vehicle Communication (V2V)Cooperative Traffic Congestion Detection (CoTEC):

Cooperative Traffic Congestion detection architecture is based on vehicle-to-vehicle (V2V) communication and fuzzy logic to monitor and detect traffic congestion on road without using any infrastructure . In this idea the vehicles which are at the front end of a traffic jam are responsible for the periodic production of congestion messages, which are then transmitted to rear end of congestion. In this technique a threshold level is maintained to detect the traffic situation example if the speed of car is less than the predefined threshold level, it's mean that there is a congestion then CAM (congestion alert messages) are started broadcasting after given amount of time.

B. Self-Organizing Traffic Information System (SOTIS):

In this architecture only vehicles are responsible to transmit and receive data without using any central unit, infrastructure and large no of sensors along the highway. The SOTIS system is mainly based on a simple wireless interface, which is installed in each vehicle to establish a self-organizing radio network link between vehicles. All SOTIS vehicles are equipped with GPS receiver, a digital street map, a simple digital radio and small data processing unit. The SOTIS architecture is based upon distributed receive-analyze-send algorithm. The received information is firstly analyzed by the vehicle and after that only results of analysis are transmitted to other vehicles. In this architecture each vehicle store road information in its local database called knowledgebase.

C. Traffic View system:

In Traffic view system, only speed and position related information is gathered and distributed between vehicles. In this system vehicle is only limited to the send information to the vehicle which is in front of it. Vehicles periodically broadcast reports (which consists of single data packet) to inform other vehicles about their current status. Whenever vehicle received the report, it stores the updated information and sends it to other vehicles. The main drawback of V2V based techniques is that, at nighttime in some rural areas the lowest density of vehicles is very high so there is the probability of loss of data packet (i.e. detection of an accident) due to lack of presence of vehicles to receive and broadcast it to other vehicles.

D. Proposed Algorithm: Vehicular Over-the- Air information gathering (voting):

One of the work focuses on the development of a system for traffic congestion detection: Vehicular Over-the-air Traffic Information Gathering (VOTING), that is capable of detecting traffic congestion areas in real-time with data collected and disseminated by vehicles using V2V communications, without the need for any external infrastructure (such as antennas, satellites, etc.), and developing the tools for interactively simulating and visualizing the behavior of this and future congestion detection systems on a myriad of scenarios.

E. Vehicle-to-Infrastructure communication (V2I):

V2I communication can be implemented by using several technologies such as

- Digital broadcasting
- Cellular networks
- Dedicated short range Communication (DSRC) systems

The concept of single frequency network (SFN) has been used. Digital audio broadcasting, digital multimedia broadcasting (DMB), DVB-H, or digital video broadcasting–terrestrial (DVB-T) are based on (SFN). In these networks the transmitter broadcast the same signal on same frequency band, where each receiver receives multiple copies of same signal which creates a large no of self- interference. For the purpose of V2I communication the one DVB-T transmitters can cover distance from tens to hundreds kilometers. The SFN can increase the coverage area by the adding large no of transmitters, but it can't increase the data rate.

Cellular networks usually used General Packet Radio Service(GPRS) and Universal mobile Telecommunications Services (UMTS) for V2I communication. CN has higher latency with increased access and have bandwidth constraint. In cellular network 3G technologies uses a licensed band spectrum, so the data transfer is normally charged per byte, thereby making internet accesses more expensive. Cellular networks can't use large no of users simultaneously for a long period of time. Cellular networks are not used for broadcast purpose since cellular networks used point-to-point communication.

To improve the efficiency of V2I architecture, Dedicated short range communication (DSRC) based systems are being developed to improve the traffic flow and road safety. The road side unit (RSU) provides the Travel time (TT) and start of congestion location (SoC) to the drivers. On board units (OBU) uses GPS interface, are placed inside the vehicles to communicate with RSU. The (RSU) using the DSRC technology engages the OBUs of moving vehicles and gathered the necessary information about data, speed and location. From the received data the RSU unit periodically approximates the TT and SoC location, which are then broadcasted to all the vehicles within the coverage area.

F. Vehicle-to-vehicle to Infrastructure Communication (V2V2I):

In this architecture the communication network is divided into small clusters, each cluster has a head vehicle which is usually called as super vehicle of the cluster. In a cluster only super vehicle is capable of collecting data from all other vehicles then sum it up and forward it to central infrastructure. The size of the cluster must be small. Cluster-to-Cluster communication has three modes of operations: Normal mode, Emergency mode and night mode. The speed of vehicles is calculated by using different sensors and by comparing it with threshold level.

III. Problem Formulation

Much of the research in VANET focuses on simulating vehicular traffic and multi-hop routing. A few researches have studied the problem of using VANETs to discover and disseminate traffic congestion information. Using vehicle based GPS systems we can create an ad-hoc wireless network that can find and disseminate traffic congestion information. We proposed a system that uses vehicle based GPS systems to discover and disseminate traffic congestion information, the system is called COC for VANET. This system maintains and disseminates three types of information: Raw Information (level 1), density information (level 2) and congestion areas information (level 3). Higher levels contain aggregated information.

With COC, each vehicle collects original information that each vehicle has by communicating each other, and creates contents which may be useful for drivers, by analyzing original information. COC deliver the analyzed contents to other vehicles. The simulation results show that COC provide timely information of vehicular accidents and congestion to drivers.In COC for VANET, vehicles exchange the information like GPS (Global Positioning System). Moreover, vehicles distribute and share the analyzed traffic information. For example, the analyzed traffic information is the information of the vehicular accidents and congestions, or the information on emergency vehicle under approach.

If we face to some congestion, we don't know why the congestion occurs and how long the congestion is. If we use COC in this case, vehicles exchange the information of their own status from GPS at first. The status consists of the location, time, speed, direction, etc. Second, each vehicle analyzes a surrounding traffic situation from exchanged information. Finally, we can avert the vehicular accidents and congestions by using the analyzed information.

IV. Objectives And Scope

Our research is directed to the application layer of a VANET network. In this work we are not concerned on low-level protocols for radio communications or routing, many such protocols have been developed, some commercially available like IEEE 802.11 (Wi-Fi) that can be adapted to V2V communications. This work is focused on congestion detection for a simplified model of traffic using GPS Transceiver, node(s) of VANET will communicate with Satellite, maximum number of vehicles unit communicate with GPS means congestion in a particular region. In particular, highway traffic on a straight highway segment with only one entry and exit points. More complex road layouts and traffic scenarios are a subject for future work, however the general ideas presented in this work for congestion detection and propagation, as well as the simulation and visualization tools developed can be extended to more complex traffic models.

In this work, it is assumed that VANET is an ad-hoc wireless network that is comprised of vehicles equipped with a GPS receiver, an Inertial Navigation System (INS), and a radio transceiver. The vehicles resemble mobile nodes in an ad hoc wireless network. In this work, the target vehicle in the network is marked as Vo, and the other nodes are marked as Vi, where i=1,2,3....n. n represents the number of the immediate neighbours [Figure 3]. Every node can communicate directly with other nodes within a radius R that depends mainly on the type of transceiver installed in the vehicles. Since the nodes are mobile, they have speeds and directions, marked $S_{t,i}$ and $\theta_{t,i}$ respectively, where i signifies the index of a specific node and ***t*** indicates the time; the presumption is that the speed and direction may change over time. Moreover, it is assumed that all measurements are taken in discrete intervals indexed by it.

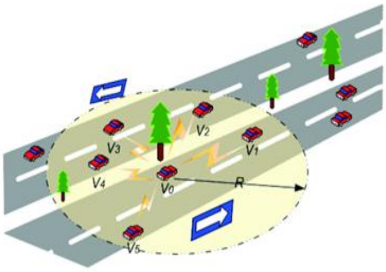

Figure 3

V. Research Methodology

A. Simulation Environment

In order to do research in traffic congestion we need to have a reliable simulation environment that allows us to simulate traffic patterns as well as wireless communications. Testing with real-life vehicles in real-life traffic situations should be done only after the algorithms have proven to work well in the simulated environment. A good simulation environment allows the researcher to test congestion detection algorithms in $NCTU_{NS}$ of real-life situations.

The NCTUns network simulator and emulator (NCTUns), is a high fidelity and extensible network simulator capable of simulating various devices and protocols used in both wired and wireless networks. The predecessor of NCTUns is the Harvard network simulator, which Wang authored in 1999.To overcome drawbacks of this simulator, after joining National Chiao Tung University (NCTU), Taiwan in February 2000, Prof. S.Y. Wang lead his students to develop NCTUns since then. It supports remote simulations and concurrent simulations.

It uses an open-system architecture to enable protocol modules to be easily added to the simulator. In addition, it has a highly-integrated GUI environment for editing a network topology, specifying network traffic, plotting performance curves, configuring the protocol stack used inside a network node, and playing back animations of logged packet transfers. NCTUns can generate high-fidelity simulation results at high speeds when the network traffic load is not heavy.

VI. Proposed Work:

Today's vehicles are complex systems with networks of computers controlling their most important functions. In the last years, control systems of cars have moved from the analog to the digital domain and emerging vehicular networks in the forms of in- Car, C2C and C2I communications, are fast becoming a reality. In a future scenario, real-time information could be provided to vehicles through heterogeneous wireless networks in order to obtain a smarter navigation and improve traffic efficiency. While the original motivation for vehicular communications was to promote road safety, recently it has become increasingly obvious that this technology opens new opportunities for traffic efficiency and infotainment applications. A reference architecture for vehicular networks is proposed within the C2C-CC, which serve as a building block for many European R&D research projects.

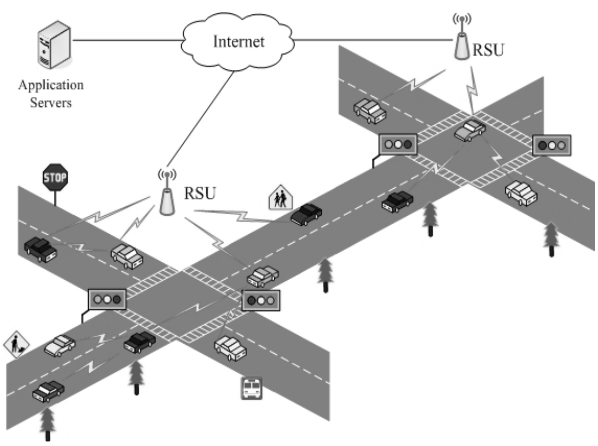

Figure 4: Reference Architecture

- The In-Vehicle Domain refers to the vehicle internal network. Each vehicle is equipped with an On-Board Unit (OBU) that implements the communication protocol stack and offers an interface to driver and passenger devices, called Application Units (AUs).
- The Ad-hoc Domain is composed of vehicles equipped with OBUs and fixed network nodes installed along roads, Road-Side Units (RSUs). OBUs and RSUs form a VANET, which allows communications in a fully distributed and self organized manner, without the need of centralized coordination. OBUs directly communicate if wireless connectivity exists among them, or perform multi-hop communications through the use of a dedicated routing protocol.
- Finally, in the Infrastructure Domain, the RSU can simply extend the VANET coverage by acting as forwarding entity, or be attached to an infrastructure network, which in turn can be connected to the internet. The RSUs may allow OBUs to access such infrastructure, and hence, the vehicle AUs can communicate with any host on the internet.

It assumes that vehicles have knowledge of its current position via Global Positioning System (GPS) or other positioning system. Furthermore, every vehicle periodically advertises this positioning information to the vehicles in its vicinity, and hence, vehicles are informed about the location of all vehicles within their direct communication range.

Here the communication is done between vehicle and RSU . In our work the GPS device informs the nearby RSU about the vehicle position and speed. Similarly all the vehicle does and now these RSU share the information with their nearby RSUs and then with other vehicles. So in this form it there is congestion then its information flows in wide range and can be controlled and managed by the vehicles which are far from the congested area.

The communication between the RSU and the vehicle is done by the OBU which are installed in the vehicles as we can see in the figure above.

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