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Efficient Distributed Computation At The Vehicles Re-Routing To Avoid Jamming

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Abstract--- Traffic congestion has become an ever-increasing problem worldwide. Congestion reduces efficiency of transportation infrastructure and increases travel time, air pollution, and fuel consumption. While congestion is largely thought of as a big city problem, delays are becoming increasingly common in small cities and some rural areas as well. Hence, finding effective solutions for congestion mitigation is becoming a stringent problem. This article proposes Efficient distributed computation at the vehicles re-routing to avoid jamming. Re-routing offloads a large part of the rerouting computation at the vehicles, and thus, the re-routing process becomes practical in real-time. To take collaborative rerouting decisions, the vehicles exchange messages over vehicular ad hoc networks. Re-routing is a hybrid system because it still uses a server and Internet communication to determine an accurate global view of the traffic. In addition, Re-routing balances the user privacy with the re-routing effectiveness. The simulation results demonstrate that, compared with a centralized system, the proposed hybrid system increases the user privacy by 92% on average.

***Index Terms*— Incompletely Predicable Networks, VANETs, Trustworthiness Evaluation, Routing Protocol, Self-Configured Networks.**

1. INTRODUCTION

Vehicular Ad-Hoc Networks, (VANET), are a particular kind of Mobile Ad Hoc Network, (MANET), in which vehicles act as nodes and each vehicle is equipped with transmission capabilities which are interconnected to form a network. The topology created by vehicles is usually very dynamic and significantly non-uniformly distributed. In order to transfer information about these kinds of networks, standard MANET routing algorithms are not appropriate (Lee *et al.*, 2010b).

The availability of navigation systems on each vehicle makes it aware of its geographic location as well as its neighbours. However, a particular kind of routing approach, called Geographic Routing, becomes possible where packets are forwarded to a destination simply by choosing a neighbour who is geographically closer to that destination. With the rapid growth of vehicles and roadside traffic monitors, the advancement of navigation systems, and the low cost of wireless network devices, promising peer-to-peer (P2P) applications and externally-driven services to vehicles became available. For this purpose, the Intelligent Transportation Systems (ITS) have proposed the Wireless Access in Vehicular Environments (WAVE) standards that define an architecture that collectively enables vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless communications (ITS, 2012). According to architectures of network, VANET can be divided into three categories, the first of which is the Wireless Wide Area Network (WWAN) in which the access points of the cellular gateways are fixed in order to allow direct communication between the vehicles and the access points. However, these access points require costly installation, which is not feasible. The second category is the Hybrid Wireless Architecture in which WWAN access points are used at certain points while an ad hoc communication provides access and communication in between those access points. The third and final category is the Ad Hoc V2V Communication which does not require any fixed access points in order for the vehicles to communicate. Vehicles are equipped with wireless network cards, and a spontaneous setting up of an ad hoc network can be done for each vehicle (Li and Wang, 2007). This study will focus on studying ad hoc V2V communication networks, which are also known as VANETs. The purpose of VANET is to allow wireless communication between vehicles on the road including the roadside wireless sensors, enabling the transfer of information to ensure driving safety and planning for dynamic routing, allowing mobile sensing as well as providing in-car entertainment. As VANETs have unique characteristics which include dynamic topology, frequent disconnection of the networks, and varying environments for communication, the routing protocols for traditional MANET such as Ad hoc On-demand Distance Vector (AODV) (Perkins and Royer, 1999) are not directly usable for VANETs. Researchers have developed a variety of efficient routing protocols for VANETs including Greedy Perimeter Stateless Routing (GPSR) (Karp and Kung, 2000); Greedy Perimeter Coordinator Routing (GPCR) (Lochert *et al.*, 2005); and GpsrJ+ (Lee *et al.*, 2007). The current issue, however, is that the range of the wireless sensors on vehicles is limited to a few hundred meters at most and the traffic conditions in a vehicular urban environment often change dynamically. Other than that, VANET routing protocols also face other problems including the issue of unstructured roads, the difference in the sizes of the intersections in a certain area, the sharp curves of the roads, uneven slopes, and other obstacles such as large buildings, traffic lights, trees, and sign boards. As it is impractical to spend excessively on rebuilding or restructuring the existing roads in urban environments, a routing protocol for the purpose of a larger distance of data communication in one-to-one and one-to-many transfers specifically for VANETs need to be developed.

RELATED WORK

Projects such as Mobile Millennium, CarTel , JamBayes, Nericell , and surface street estimation use vehicle probe data collected from on-board GPS devices to reconstruct the state of traffic and estimate shortest travel time. The proposed research moves beyond this idea: instead of investigating the feasibility and accuracy of using mobile phones as traffic sensors, this dissertation focuses on using that information to recommend routes more intelligently, thus, achieving better efficiency in terms of avoiding congestion and reducing travel time.

Services such as INRIX provide real-time traffic information at a certain temporal accuracy, which allows drivers to choose alternative routes if they are showing lower travel times. According to Wardrop's first traffic equilibrium principle [85], this could lead to a user-optimum traffic equilibrium. It is known, however, that no true equilibrium can be found under congestion. Several initiatives have been take in the directions of predicting long-term recurrent and short term non-recurrent congestions. However, the usefulness of these applications is also limited: (i) they have accurate information mostly about highways and thus are not very useful for city traffic, and (ii) they cannot avoid congestions and, at the same time, it is known that no true equilibrium can be found under congestion. Non-recurring congestions, which represent over 50% of all congestions, are especially problematic as drivers cannot use their experienced travel times to deal with them.

K Shortest Path Generation

A large body of existing route planning research focuses on fast generation of k-shortest paths in highly dynamic scenarios with frequent traffic information updates. In particular, presents transit-node routing and highway-node routing to reduce the average query time and memory requirements. The work in [53] proposes two new classes of approximation techniques (e.g., K-AS-Aggressive, K-AS-Variance,YModerate) that use pre-computation and avoidance of complete recalculations on every update to speed up the processing of continuous route planning queries. However, current instantaneous shortest paths are not necessarily equal to time-dependent shortest paths. These algorithms calculate shortest paths based only on the snapshot of current traffic conditions without considering the dynamic future conditions. One of the essential properties of the travel time on the road network is the time-dependency. Computing shortest paths in a time varying spatial network is challenging since the edge (i.e., road segment) travel times changes dynamically. In this case, the computation not only considers the instantaneous travel time in one single snapshot of the traffic graph but also the relationship among the consecutive snapshots across time. George et at. demonstrated a faster greedy time-dependent shortest path algorithm (SP-TAG) by using a Time Aggregated Graph (TAG) data structure instead of the time-expanded graph. SP-TAG saves storage and computation cost allowing the properties of edges and nodes to be modeled as a time series instead of replicating nodes and edges at each time unit. While algorithms such as SP-TAG provide insights into the dynamics of traffic network, two obstacles remain besides increased computational cost. Firstly, it is impractical to assume the system knows the exact travel time series of every single road segment given the traffic dynamics.

Secondly, these algorithms do not help with switching congestion from one spot to another if all the drivers are provided the same time-dependent shortest path.

Dynamic Traffic Assignment Model

An alternative to this work could be the research done on dynamic traffic assignment (DTA) which leads to either system-optimal or user-optimal route assignments. DTA research can be classified into two categories: analytical methods and simulation-based models. Analytical models such as formulate DTA as either nonlinear programming problems, optimal control problems, or variational inequalities. Although they provide theoretical insights, the computational intractability prevents their deployment in real systems. Simulation-based approaches have gained greater acceptability in recent years, in which the time-dependent user equilibrium is computed by iterative simulations. The simulations are used to model the theoretical insights that cannot be derived from analytical approaches. This process computes the assignment of traffic flows until the travel times of all drivers are stationary. Unfortunately, there are still a number of issues associated with these approaches that make their deployment difficult: tractability for large scale road networks given the computational burden associated with the simulator, capability of providing real-time guidance, effectiveness in the presence of congestion, and behavior of drivers who ignore the guidance. For example, they assume the set of Origin-Destination (OD) pairs and the traffic rate between every OD pair are known. This information is highly dynamic especially in city scenarios, leading to frequent iterations of computationally expensive

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algorithms even when not needed from a driver benefit point of view. Additionally, the OD set is large, and the DTA algorithms may not be able to compute the equilibrium fast enough to inform the vehicles about their new routes in time to avoid congestions.

The proposed system, on the other hand, is designed to be effective and fast, although not optimal, in deciding which vehicles should be re-routed when signs of congestion occur as well as computing alternative routes for these vehicles. The complexity of DTA systems has led scientists to look for inspiration in Biology and Internet protocols. In Wedde et al. developed a road traffic routing protocol, BeeJamA, based on honey bee behavior. Similarly, Tatomir et al. proposed a route guidance system based on trail-laying ability of ants. Inspired by the well-known Internet routing protocols, prothmann et al. proposed decentralized Organic Traffic Control. However, since they employ ad hoc networking, these approaches have only a partial view of the traffic conditions, which may lead to less accurate re-routing. Also, simply treating vehicles as packets which always listen to the guidance ignores the nature of human behavior. Furthermore, these systems react to real-time data without insight into future conditions, thus introducing greater vulnerability to switching congestion from one spot to another. There has been several other literatures that aim to provides near-optimal route to drivers but better scalability compared to DTA. The basic idea is divided into two steps: Calculated the possible first k shortest paths from source to destination, and then determine which path each vehicle should take by minimizing a Lyapunov-style cost function. Meanwhile, the work uses dynamic programming keep tracking traffic information in the network. Every time a car comes an intersection, it calculates the first-k shortest path candidates and proportionally chooses a candidate by using probability calculated from boltzmann distribution.

Vehicular Ad hoc Networks

There has been significant effort and progress on Vehicular Ad hoc Networks (VANETs) technology in recent years. VANETs are based on vehicle-to-vehicle and vehicle-to infrastructure wireless communication. IEEE 802.11p is an approved amendment to the IEEE 802.11 standard to add wireless access in vehicular environments (WAVE). It defines enhancements to 802.11 required to support Intelligent Transportation Systems (ITS) applications. Essentially, the VANETs research can be classified into three categories: routing, communication optimization, applications. These three categories tackle the VANETs key issues from the bottom to the top. Obviously, routing is the fundamental point providing the basis for communication of the platform. For example, one of the major works is presented by where RBVT-R and RBVT-P protocols are proposed. Both protocols leverage real-time vehicular traffic information to create road-based paths consisting of successions of road intersections that have, with high probability, network connectivity among them. Simulation results shows 40% increase in delivery ratio and 85% decrease in average delay. The second category involves applying optimization techniques to minimize the communication overhead. The work in described an effective safety alert broadcast algorithm for VANETs. Similarly, the technique in presented a domain specific data aggregation scheme and a genetic algorithm to minimize the overall bandwidth requirements and placement of the roadside units in the initial deployment. Since VANETs are used for collaboration and information sharing, one of the key challenges is to avoid broadcast storm". The work in firstly analyzed this issue in MANETs and proposed a probabilistic, counter-based and distance-based schema to reduce redundant messages. As an extension, investigated this problem in VANETs. Article described how to utilize 2-hop neighborhood information more effectively to reduce redundant transmission.

2. EXISTING SYSTEM

- The centralized system collects real-time traffic data from vehicles and potentially road-side sensors, and it implements several re-routing strategies to assign a new route to each re-routed vehicle based on actual travel time in the road network. Rather than using simple shortest path algorithms (e.g, Dijkstra), the re-routing strategies use load balancing heuristics to compute the new path for a given vehicle to mitigate the potential congestion and to lower the average travel time for all vehicles. This individualized path is pushed to a driver when signs of congestion are observed on his current path

Disadvantages:

- The central server has to perform intensive computation (to re-assign vehicles to new paths) and communication with the vehicles (to send the paths and to receive location updates) in realtime. This can make centralized solutions infeasible for large regions with many vehicles.

- Second, in a centralized architecture, the server requires the real-time locations as well as the origins and destinations of the vehicles to estimate the traffic conditions and provide effective individual re-routing guidance. This leads to major privacy concerns for the drivers and may prevent the adoption of such solutions due to "big brother" fears

3. PROPOSED SYSTEM

- This paper proposes DIVERT, a distributed vehicular re-routing system for congestion avoidance, which leverages both cellular Internet and VANET communication. DIVERT is a hybrid system because it still uses a server, reachable over the Internet, to determine an accurate global view of the traffic.

- The centralized server acts as a coordinator that collects location reports, detects traffic congestion and distributes re-routing notifications (i.e., updated travel times in the road network) to the vehicles. However, the system offloads a large part of the re-routing computation at the vehicles and thus the re-routing process becomes practical in real-time.

- To take collaborative re-routing decisions, the vehicles situated in the same region exchange messages over VANETs. Also, DIVERT implements a privacy enhancement protocol to protect the users' privacy, where each vehicle detects the road density locally using VANET and anonymously reports data with a certain probability only from high traffic density roads.

- When signs of congestion are detected, the server sends the traffic map only to the vehicles that sent the latest updates. Subsequently, these vehicles disseminate the traffic data received from the server in their region. User privacy is greatly improved since this protocol reduces dramatically the number of vehicle location updates to the server and, thus, the driver exposure and identification risks. Moreover, in this hybrid architecture, the server does not know the OD pairs of the users.

ADVANTAGES OF PROPOSED SYSTEM:

- A scalable system architecture for distributed rerouting

- Distributed re-routing algorithms that use VANETs to cooperatively compute an individual alternative path for each vehicle that takes into account the surrounding vehicles' future paths.

- Privacy-aware re-routing that significantly decreases sensitive location data exposure of the vehicles

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- Optimizations to reduce the VANET overhead and thus improve vehicle-to-vehicle communication latency.
- The experimental results show that, in comparison with the centralized system, DIVERT can decrease the privacy exposure by 92% in addition to not revealing the OD pairs of the user trips.
- DIVERT is more scalable since it offloads most of the computation burden to the vehicles and reduces the network load on the server by 95%.

SYSTEM ARCHITECHTURE

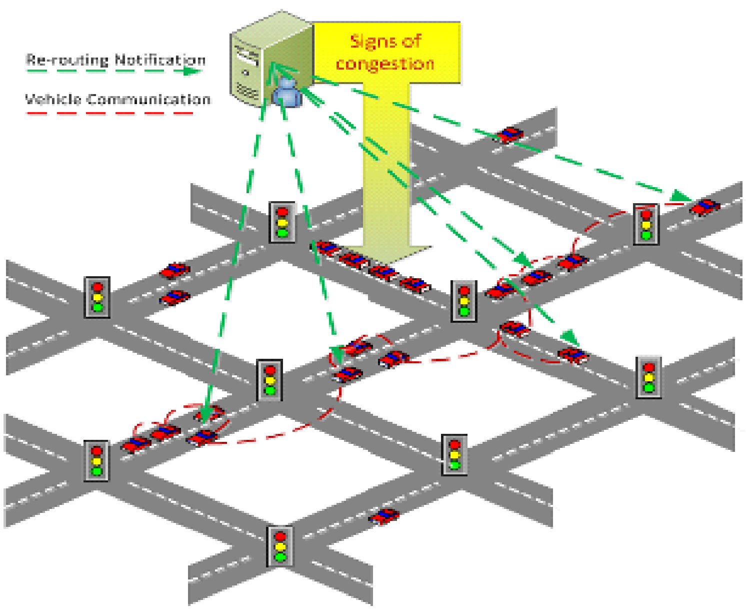

fig.1:Re-routing System Architecture

4. IMPLEMENTATION

Hierarchy Management Systems

The traffic management system is mainly divided into three subsystems, namely the sensor network subsystem, the traffic control subsystem and the safety subsystem. The sensor network subsystem collects real-time information and quickly directs that to the traffic control subsystem, which manages the traffic congestion for normal and emergency vehicles at intersections by using adaptive traffic algorithms. The last subsystem provides security to the wireless traffic control system against jamming and violation attacks. We can classify the functions of TMS into three categories, i.e., congestion avoidance, prioritizing emergency vehicles and reducing Average Waiting Time (AWT).

Sensing Evolution

The Sensor is a key element of any smart system and a course of action is taken based on its location. The control system gathers the data from a group of sensors and uses different variables to distinguish its location and modifies its actions consequently. The accessibility of a massive amount of various sensors and endlessly growing technology facilitates applications that were unfeasible in the earliest because of high prices and restricted handiness. Technological developments have driven the improvement behind sensors and also powered the small-scale devices by making use of the sensors at a low price. From the viewpoint of the desires of smart traffic

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management, an extensive handiness of the technology transforms to a great amount of chances in the sensing.

Traffic Sensing

The safe and efficient operation of a traffic management system relies largely on the application of advanced technologies. As a result, the past decade has witnessed the wide application of communication, sensing and computing technologies in traffic management, event detection, emergency response, fleet management and travel assistance. There is a requirement for effective traffic organization, to avoid congestion and optimize traffic flow at intersections. An approach to control traffic flow is to make use of sensor technologies. It lists a few types of traffic sensing technologies that are frequently employed in traffic for data collection.

Sensor Node Compression

A sensor is a transducer which transforms the physical nature parameters like light, temperature, velocity, pressure, moisture, etc. to an electronic signal. This electronic signal can be understood by humans or fed into a control system. A traffic monitoring sensor node typically comprises of four main modules as given below:

A sensing module:

This module acquires data.

A processing and storage module:

This module process the local data and stores it.

A radio module:

This module is for wireless data communication.

A power module:

This module is for energy supply.

A general sensor node normally includes a radio module for wireless data communication. The transmission range of wireless communication depends on the communication technology, which can be a few meters (Bluetooth, Zig Bee, Wi-Fi, etc.) to thousands of kilometers (Wi-MAX, GSM, etc.). The wireless communication has numerous technologies and standards, including Zig Bee, Bluetooth, GPRS, GSM, Wi-Fi and Wi-MAX.

5. RESULTS ANALYSIS

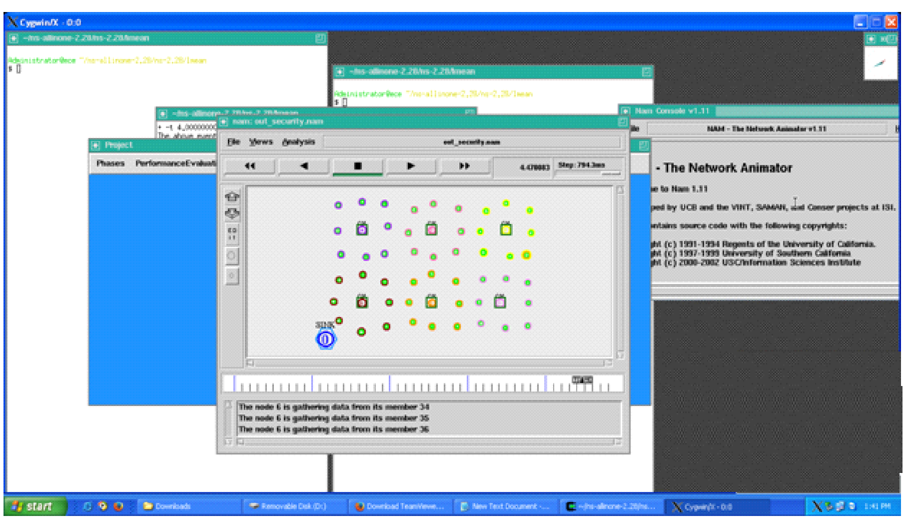

fig.2:Nodes identifying cluster

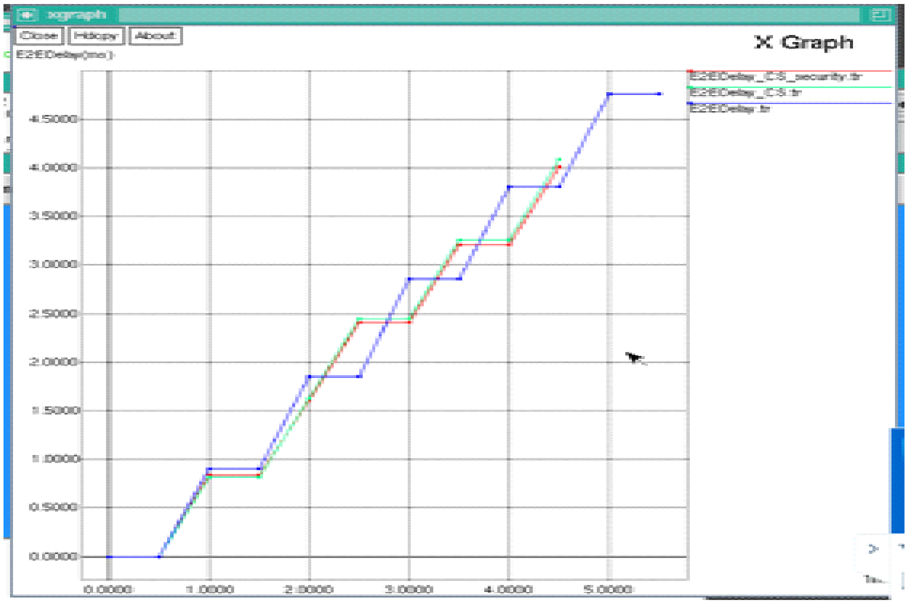

fig.3:End to End Delay

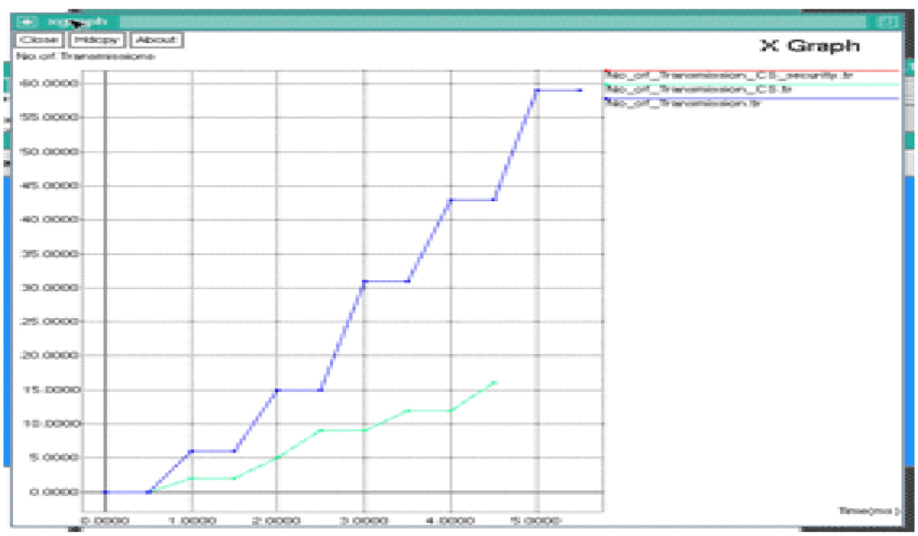

fig.4:No.of Transmission lines

6. CONCLUSION

The article demonstrates that a practical, cost-effective, and efficient traffic re-routing system can be implemented and deployed in real-life settings. This system, DIVERT, offloads a large part of the re-routing computation at the vehicles, and thus, the re-routing process becomes scalable in real-time. To make collaborative re-routing decisions, the vehicles exchange messages over VANETs. We have optimized VANET data dissemination to allow for efficient distributed re-routing computation. In addition, the system balances user privacy with the re-routing effectiveness. The simulation results demonstrate that, compared with a centralized system, DIVERT increases the user privacy substantially, while the re-routing effectiveness is minimally impacted.

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