InVANETs for First Responders

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ABSTRACT
This paper provides a work in progress, inspired by a recently proposed novel chaos-reducing information dissemination approach for spatio-temporal traffic information related to first responders and evacuation scenarios using Vehicular Ad Hoc Networks (VANETs). Intelligent Vehicular Ad Hoc Networks (InVANETs) use WiFi IEEE 802.11 and WiMAX IEEE 802.16 for easy and effective Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communication. This paper discusses a comprehensive approach in VANETs, to bring about high End to End (E2E) network connectivity, so that not only are safety and comfort objectives met, but also minimum network contention and interference are achieved. Some challenges that this approach will face are also discussed. We use a realistic mobility and traffic model in our simulation. Simulation results show that our approach improves the results of the recently proposed protocol.

Categories and Subject Descriptors
C.2.2 [**Computer-Communication Networks**]: Network Protocols – *VANET contention and interference.*

General Terms
Algorithms, Performance, Design.

Keywords
VANET, Vehicular Ad Hoc Networks, Evacuation, Contraflow, Emergency Service Vehicles, VANET Applications.

1. INTRODUCTION
One of the major causes of traffic chaos is the confusion and failure to detect Emergency Service Vehicles (ESVs) (e.g. ambulances, police cars and fire trucks, etc.), which can lead to slow progress and even accidents involving the ESVs traveling towards their destinations. In addition to ESV scenarios, during an evacuation, there exists a tremendously challenging task for supply trucks to reach their destinations as quickly as possible and with minimal interruptions. Authors in [2] proposed a chaos-reducing information dissemination approach for spatio-temporal traffic information related to first responders and planned evacuation scenarios using Vehicular Ad Hoc Networks (VANETs). Their approach provided an emergency vehicle path clearing technique. Therefore, traffic confusion and chaos is lowered on evacuation and emergency vehicle routes. Since ESVs usually operate in higher traffic congestion, contention and interference effects deteriorate End to End (E2E) network connectivity. Timely and reliable information dissemination, packet routing, and high speed wireless communication in such highly dense networks is tremendously challenging. In order to prevent packet flooding in the affected area, we propose an efficient spatio-temporal adaptive information dissemination protocol. Due to the prohibitive cost of deploying and implementing such a system in real world, most research in VANET-based systems relies on simulations for evaluation. We use a realistic mobility and traffic model in our simulation. Simulation results show that our protocol improves the results of the recently proposed approach. Some challenges that a VANET-based approach like this will face in near future are also mentioned.

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2. BASIC OPERATION
As described in [2], all vehicles act as information servers relaying information for the VANET. We assume that every vehicle has a digital map and knows its geographical position and heading through a Global Positioning System (GPS) receiver. The building blocks of our approach are:

- Resources: ESVs, parking places, gas stations, hospitals, shelters, etc;
- Reports: Information periodically sent by resources;
- Broadcasting: We exploit broadcasting for information propagation and take the spatio-temporal character of reports into account;
- Selection strategies based on relevance.

Each vehicle in the path computes the time to intersection with the ESV based on the average ESV speed, ESV location, and current time received in the reports. With this computed time, a short period of clearing path time, 30 sec or 1 min before the ESV meets the other vehicle (the time range during which the motorist should clear the way for the ESV), can be provided to the motorist. Relevance describes the degree of applicability of a received report. The relevance of a resource report is calculated through a relevance function [2]. During a vehicle's trip, it receives resource reports from resources or other vehicles. Periodically, reports in a vehicle's database are sorted according to their relevance. The most relevant report is used for computing the clearing time. According to our newly introduced information dissemination protocol, a report is checked for time and space factors, described in the next section as a *rebroadcast-test*. If the packet passes the rebroadcast-test, and if the clearing time is finite, then it is computed, otherwise the most relevant report with a successful rebroadcast-test result is rebroadcast for other vehicles. Our efficient spatio-temporal adaptive information dissemination protocol rebroadcasts reports according to the vehicular density in the affected area to prevent packet flooding.

3. REBROADCAST-TEST

The rebroadcast-test consists of time and space factors. If the report passes both the time and space tests, i.e. gets 1 for each success, it is called a successful report. We briefly describe the tests here.

3.1 Time

An ESV periodically broadcasts a report containing information on its start and end points, route code, and a timestamp, denoting the time the report was sent by the ESV. This information can be used by every motorist who receives a report to compute the time it will take for the ESV to reach its destination. Before that time has been reached, the time test result for that report is 1, else 0. In this way, the report stops getting rebroadcast after the ESV has reached its destination.

3.2 Space

We compute the distance, *Rr*, between the current ESV location coordinates {cx,cy} and the ESV destination {dx,dy}. We construct a virtual circle called Relevant Circle, *Cr*, with radius *Rr* and center at {dx,dy}. If a motorist's current location is within *Cr*, then the report's space test result is 1, else 0.

4. REBROADCAST RATE

We set the rate at which the reports are rebroadcast to be inversely proportional to the vehicular density, computed by vehicles, in the Relevant Circle *Cr*. This way we reduce the flooding that might unnecessarily occur in high traffic congestion areas.

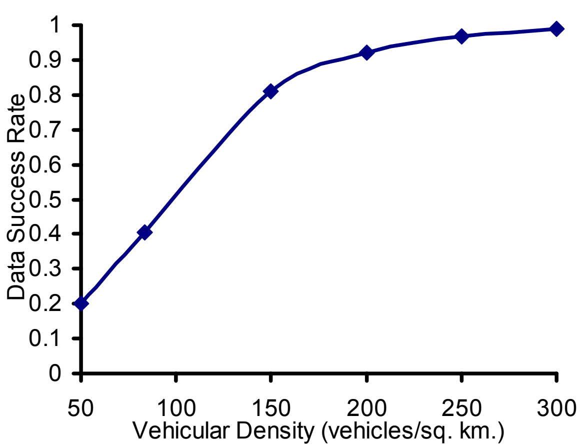

Figure 1. Data success rate as a function of the number of nodes. Resource report size = 64bytes; transmission range = 150m.

5. SIMULATION RESULTS

All the key simulation parameters are the same as in [2] except for the ESV transmission range which is now 1000m. In the recently proposed WAVE, the ESVs are equipped with longer-range (1-kilometer) systems [1]. We show the mean data success ratio over the various traffic densities and transmission ranges in Fig. 1 and Fig. 2, respectively. The data success rate is defined as the ratio of the number of vehicles on the ESV route that have received the message within a certain clearing path time to the total number of vehicles on the ESV route.

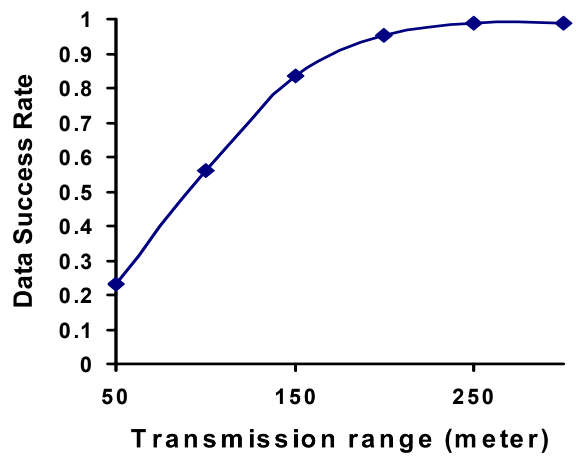

Figure 2. Data success rate as a function of the transmission range. Resource report size = 64bytes; vehicular density = 40 vehicles/ sq.km

6. CONCLUSIONS

Based on our simulation results, we conclude that approaches to reduce traffic chaos in emergency scenarios are potentially attractive rollout applications for VANETs. Using GPS, digital maps, and the selection strategies applied, we have achieved the goal of clearing the way for ESVs with minimal interruptions. It is assumed that GPS units and maps are preinstalled in every vehicle. It would take years before all the vehicles on the roads would be VANET-enabled. It would be interesting to see how the application performs with only a small percentage of VANET enabled vehicles on the road [3].

7. REFERENCES

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