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Traffic Aware Routing Protocol

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Abstract

Abstract—The fundamental component for the success of VANET (Vehicular Ad hoc NETworks) applications is routing since it must efficiently handle rapid topology changes and a fragmented network. Current MANET (Mobile Ad hoc NETworks) routing protocols fail to fully address these specific needs especially in a city environments (nodes distribution, constrained but high mobility patterns, signal transmissions blocked by obstacles, etc.). In our current work, we propose an inter-vehicle ad-hoc routing protocol called TAR (Traffic Aware Routing protocol) suitable for city environments**.** Our protocol addresses this problem by selecting an optimal route with the least probability of network disconnection and avoids carry-and-forward delay. This can be achieved using our new probabilistic model of network connectivity which takes into account a more realistic clustering phenomenon of vehicle traffic in city scenarios that is caused by traffic lights. In this paper, we give detailed description of our approach and present its added value compared to other existing vehicular routing protocols. Simulation results show significant performance improvement in terms of packet delivery ratio, end-to-end delay, and routing overhead. The rest of the paper is organized as follows. Section 1 explains the properties and characteristics of vehicular ad hoc networks. The existing position based routing approaches are presented in section 2.Proposed routing protocol is described in section 3.Section 4 presents the simulation and analysis and finally we conclude in section 5.

Introduction

The increasing demand of wireless communication and the needs of new wireless devices have tend to research on self organizing, self healing networks without the interference of centralized or pre-established infrastructure/authority. The networks with the absence of any centralized or pre-established infrastructure are called Ad hoc networks. Ad hoc Networks are collection of self-governing mobile nodes. Vehicular Ad hoc Networks (VANET) is the subclass of Mobile Ad Hoc Networks (MANETs). VANET is one of the influencing areas for the improvement of Intelligent Transportation System (ITS) in order to provide safety and comfort to the road users. VANET assists vehicle drivers to communicate and to coordinate among themselves in order to avoid any critical situation through Vehicle to Vehicle communication e.g. road side accidents, traffic jams, speed control, free passage of emergency vehicles and unseen obstacles etc. Besides safety applications VANET also provide comfort applications to the road users. For example, weather information, mobile e-commerce, internet access and other multimedia applications. The dynamic nature of network, high speed of nodes, frequent topological changes, and predictable mobility (constrained by the layout of road and traffic regulations) are a few characteristics which make VANETs different from traditional ad hoc networks .The mobility not only changes the topology of the network frequently but also leads to network partitioning resulting in increased packet delay and packet loss. Unlike ad hoc and sensor networks, energy is not an issue for the VANETs because vehicles have rechargeable source of energy. There are many other constraints such as communicating environment (city roads, highways), predictable mobility, and radio obstacles.

2. RELATED WORK

Routing in ad hoc network is a challenging job due to free movement of nodes and rapidly changing topology. The nodes in vehicular ad hoc networks are self-organized and communication is relayed by intermediate nodes. Routing protocols like Ad hoc On Demand Distance Vector (AODV) [6] and Dynamic Source Routing (DSR) [4] are designed for Ad hoc networks especially for MANET applications. The performance of ad hoc routing protocols (e.g., AODV and DSR) in VANETs is extensively studied. Ad hoc routing protocols perform well for static networks but they result in degraded performance when the nodes are mobile because of low communication throughput and poor route convergence. When the nodes are mobile, AODV is not capable of finding, maintaining, and updating routes quickly. Although GPSR [11] is stateless and can partially handle mobility of nodes, it still suffers from the problem of selecting the wrong next hop due to out-of-date neighbors information, routing loop and too many (detour) hops as stated in [12]. To address the local disconnection problem, [13] used the information on vehicle headings to predict a possible link breakage event prior to its occurrence and then avoid routing

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to a disconnected next hop. From the global perspective of connectivity, [14] introduced a new metric – expected disconnection degree (EDD) – to evaluate the probability that a candidate routing path would be broken.However, it requires the network is to be fully connected and can tolerate only a few seconds of network disconnection. These assumptions are often not true in VANET. Another issue in ad hoc routing protocols is the use of three-way handshake to establish a TCP connection. Therefore, for dynamic network such as VANETs, it is not feasible for TCP to establish a connection under AODV. GYTAR is a intersection based protocol that selects the junction dynamically. It selects junction based on traffic density and curvemetric distance. The main drawback of this protocol is that it doesn't consider the direction of the vehicles. To solve this problem Enhanced GYTAR (E-GYTAR) protocol is designed and implemented. In E-GYTAR protocol while selecting the next junction it considers traffic density, curvemetric distance as well as direction of the vehicles. Although it overcomes the drawback of GYTAR it uses carry and forward mechanism for local maximum problem which increases end to end delay and decreases throughput. Thus, some modifications are needed in existing ad hoc routing protocol to overcome the local-maxima problem.

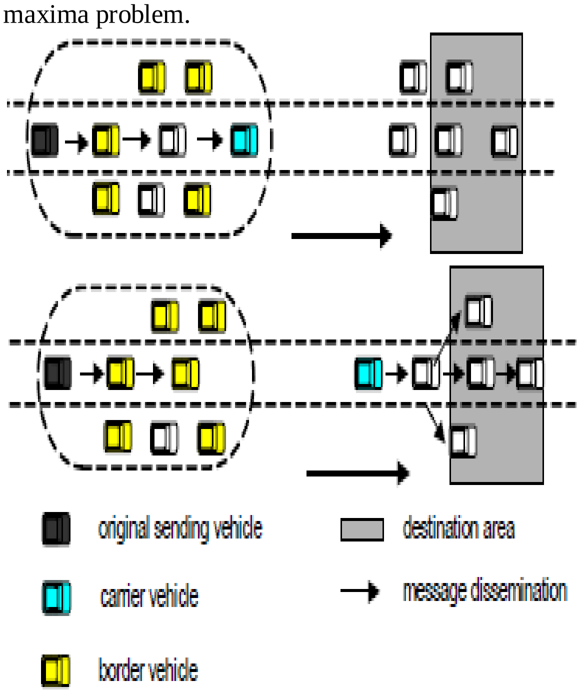

Figure 1. Problem in E-GyTAR junction selection mechanism.

3. SYSTEM MODEL

Since temporary disconnection in vehicular network is unavoidable and packet must been routed along the roads, choosing a route that will encounter as little disconnection as possible. This will not only increase the data delivery ratio but also decrease the transmission delay. Our proposed system considers the density, direction, the probability of connectivity of each road segment, impact of traffic lights and then selects the route to forward packets.

This protocol considers following metrics:

- Distance
- Density
- Direction

As a result, the proposed protocol can increase the packet delivery ratio and throughput and decreases the end to end delay and the delay is in the acceptable range as well. In the proposed TAR protocol, junctions are selected dynamically, one by one while considering the number of vehicles moving in the direction of destination, connectivity, impact of traffic lights and scoring each candidate junction accordingly. The junction with highest score is selected as a next destination junction and is geographically closest junction to the destination.

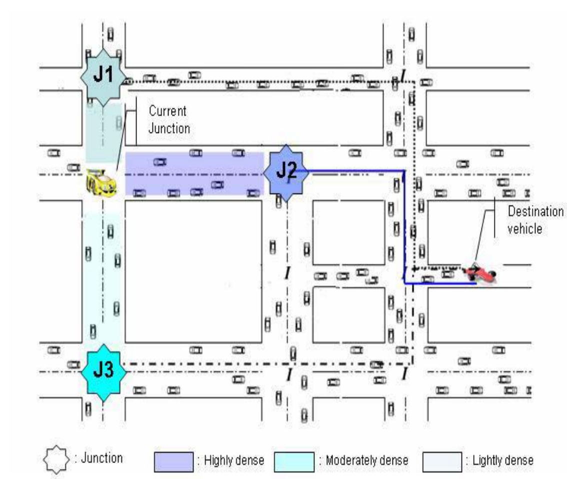

Figure 2.Junction selection in TAR.

A. Routing Algorithms.

Algorithm.1-Pseudo code for Enhanced Junction Selection Mechanism.

1. For all candidate junctions 'j'.
2. Nj= the next candidate junction.
3. Cj= the current junction.

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4. Dn= curvemetric distance from the candidate junction 'Nj' to the destination.
5. Dc= curvemetric distance from the current junction 'Cj' to the destination.
6. Dp= Dn/Dc (Dp determine the closeness of the candidate junction to the destination point).
7. T= total number of vehicles between 'Cj' and 'Nj' moving in the direction of 'Nj', which represents the directional density.
8. α+β=1 (the weighting factor for the distance and traffic density respectively).
9. score (Nj):= α×[1-Dp] + β×[T]

Algorithm 2.Pseudo code for TAR routing protocol

1.For all candidate junctions 'j'.
1.1. Li="Length of the lane".
1.2. n_i="Number of vehicles".
1.3 d="Average length of vehicles".
1.4 n^1_i="number of lanes".
1.5 m_i="Number of cells". m_i=Li/d.
1.6 k_i="Number of empty cells".
k_i={m_i-n_i, for n^1_i=1(single lane road) }
k_i={m_i-[n_i/n^1_i], multiple lane load }

$$1.7 \quad P_{dis} = \sum_{k=\max(m-n,n0)}^{\max(m-n/n,n0)} P\{\mu(n,m)=k\} \cdot P\{\phi(m,k)>n0\}$$

1.7.1 $P\{\mu(n,m)=k\}=C^k_m \times (C^n_{(m-k)\times n1} / C^n_{m\times n1}) \times P\{\mu(n,m-k) = 0\}$

$$1.7.2 \quad P\{\phi(m,k)>n0\} = 1-\sum_{i=k-n0}^{\min\{k,(m-k)\cdot n0\}} c[i]^{m-k}$$

1.8 $Pcon_{\_i}=1-P_{dis\_i}$.

1.9 score (Nj):= α×[1-Dp]+β×[T]+γ×[P_{con_i}]

2- Select the junction j with the highest Nj.

4.SIMULATION ENVIRONMENT & EVALUATION PARAMETERS

A number of network simulators are available which can be coupled with traffic modelers for simulating routing protocols in VANETs. The simulation tools, the environment setup and the parameters used for evaluating the proposed protocol are listed in this section:

A. Simulation Environment

The MOVE (Mobility model generator for Vehicular Ad Hoc Networks) simulators built on top of an open source micro-traffic simulator SUMO (Simulation of Urban MObility). A network simulator, NS2.34patched with extensions for 802.11p and ns2-MIRACLE is used. An urban environment with medium vehicle density is taken to evaluate our routing protocol.

B. Evaluation Parameters

The performance metrics used for evaluation are as follows:
1) Packet Delivery Ratio (PDR).
2) Average Packet Delivery Time (TD).
3) End-to-End Delay
4) Throughput.
5) Conclusion

This work presents TAR protocol which selects junction automatically on the basis of direction, density of vehicles, connectivity and impact of traffic lights. We hope that TAR achieves higher packet delivery ratio and lower end-to-end delay than existing E-GyTAR. In future, it would be interesting to investigate the behavior of E-GyTAR, GyTAR, and GSR in the presence of one-way road. Also, using one-hop information to predict the future neighbors may result in enhanced performance.

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