Performance Evaluation of Ad Hoc Network over Moving Vehicles in a City

Md. Ibrahim Abdullah

Received: 6 December 2019 Accepted: 4 January 2020 Published: 15 January 2020

Abstract

A mobile ad hoc network (MANET) is a collection of wireless mobile nodes that can dynamically form a temporary network without the aid of any existing network infrastructure. Wireless connectivity on vehicles is an important mode of communication. It is more challenging to provide high-bandwidth networking over fast moving vehicles. Ad Hoc network can be formed on fast moving vehicles where the interior node acts as rely node. A dynamic routing protocol is needed for a node to exchange data with another. In this research work, we consider the traffic density of a typical district town where traffic density much lower than a metropolitan city and vehicle speed is regulated according to traffic law. We have studied two routing protocols AODV and DSR in city traffic. According to our study, AODV shows performance than DSR on city road

---

Index terms— MANET, routing protocols, end-to-end delay, throughput, routing overhead

1 I. Introduction

n an ad hoc network, mobile nodes self-organize to form a network without the need for infrastructure such as base stations or access points. Each mobile node acts as a router, forwarding packets on behalf of other nodes, creating "multihop" paths that allow nodes beyond direct wireless transmission range of each other to communicate. Routing protocols for ad hoc networks must discover such paths and maintain connectivity when links between nodes in these paths break due to factors such as node motion or wireless propagation and interference changes [1]. Ad hoc networks have seen tremendous growth in their popularity over the past decade. It may used in an interactive lecture, airport terminal, emergency rescue, business associates sharing information during a meeting, or in battle field.

People of modern society take the advantages of information technology in their everyday life such as web browsing, email, chatting. An executive always need to keep up to date information when he leave for a meeting. Or he needs to share information with other participants of the meeting when he moves. These can be enabled in a general way by equipping cars with access points for existing portable devices like note books or PDA's. Ad hoc users on road do not always satisfied due to limited radio range, obstacles in radio frequency propagation and lack of ad hoc devices. As a result, many packets are dropped and the overhead due to route repairs or failure notifications increases significantly, leading to low delivery ratios and high transmission delays.

To overcome the limitations of ad hoc users on road Vehicular Ad-hoc Networks (VANETs) is proposed. Similar to MANETs, nodes in VANETs self-organize and self-manage information in a distributed fashion without a centralized authority or a server dictating the communication. In this type of network, nodes engage themselves as servers and/or clients, thereby exchanging and sharing information like peers. Moreover, nodes are mobile, thus making data transmission less reliable and suboptimal. Apart from these characteristics, VANETs possess a few distinguishing characteristics [2], and hence presents itself as a particular class of MANETs.

The topology formed by VANETs is always changing as vehicles are moving at high speed. On highways, vehicles are moving at the speed of 60-70 mph (25 m/sec) and vary for different vehicles. If the radio range between two vehicles is 125 m then the link between the two vehicles would last at most 10 sec [3]. The highly dynamic topology results in frequently disconnected network. The problem is further worsened by varying node density where there are different frequency of nodes for different roads and highways. The propagation model in VANETs is usually not assumed to be free space because of the presence of buildings, trees, vehicles and other obstacles. A robust routing protocol is hence needed to recognize the frequent disconnectivity and to provide an alternate link quickly to ensure uninterrupted communication. The routing protocols of VANETs fall into two major categories of topology-based and position-based routing [2].

In this work we evaluate MANET routing protocols used in the VANET context. Objective of this work is to observe the performance of MANET routing protocols on a city road of a district town where traffic is less than metropolitan city. Traffic speed is restricted and directed by traffic authority. We evaluate two routing protocol DSR [6] and AODV [7] that common for both MANET and VANET.

2 I

Md. Shamim Hossain ? , Joyassree Sen ? , Md. Alamgir Hossain ? , M. Muntasir Rahman ? & Md. Ibrahim Abdullah ¥

The rest of the paper is organized as follows. In section 2, we present the routing protocols used for the evaluation. Section 3 of this paper describes related work. The simulation scenario and the evaluation results are discussed in section 4. Finally, the paper closes with a conclusion in section 5.

3 II. Routing Protocols in MANET

The routing protocols in a MANET can be classified as (i) Proactive (ii) Reactive and (iii) Hybrid [4] [5]. In Proactive routing protocol, each node in a network maintains one or more routing tables which are updated regularly. Destination Sequenced Distance Vector (DSDV), Fisheye State Routing (FSR) protocol are the examples of Proactive protocols. In reactive type of routing protocol, each node in a network discovers or maintains a route based on-demand. It floods a control message by global broadcast during discovering a route and when route is discovered then bandwidth is used for data transmission. Dynamic Source Routing (DSR), Ad-hoc On Demand Routing (AODV) is the examples of Proactive protocols. Hybrid Protocols of MANET is a combination of proactive and reactive protocols taking the best features from both worlds. An example of hybrid routing protocol is ZRP (Zone Routing Protocol). In this section we describe two reactive ad hoc routing protocols in the ad hoc networking that common to MANET and VANET.

Dynamic Source Routing Protocol (DSR): The Dynamic Source Routing (DSR) [6] protocol is an ondemand routing protocol based on source routing. In the source routing technique, a sender determines the exact sequence of nodes through which to propagate a packet. The list of intermediate nodes for routing is explicitly contained in the packet's header. In DSR, every mobile node in the network needs to maintain a route cache where it caches source routes that it has learned. When a host wants to send a packet to some other host, it first checks its route cache for a source route to the destination. In the case a route is found, the sender uses this route to propagate the packet. Otherwise the source node initiates the route discovery process. In route discovery, the source floods a query packet through the ad-hoc network, and the reply is returned by either the destination or another host that can complete the query from its route cache. Upon reception of a query packet, if a node has already seen this ID (i.e. it is a duplicate) or if it finds its own address already recorded in the list, it discards the copy and stops flooding; otherwise, it appends its own address to the list and broadcasts the query to its neighbors. For route maintenance when a route failure is detected the node detecting the failure sends an error packet to the source, which then uses the route discovery protocol to find a new route.

Ad hoc On-demand Distance Vector Routing (AODV): The AODV [7] is a reactive protocol, which combines both DSR and DSDV characteristics. AODV borrows the basic route discovery and routemaintenance of DSR as well as hop-by-hop routing, sequence numbers and beacons of DSDV. When a source node desires to establish a communication session, it initiates a route discovery process by generating a route request (RREQ) message, which might be replied by the intermediate nodes in the path to destination or the destination node itself with the route reply (RREP) message contains the whole path to destination. Failure of a link can be detected via hello messages. Failure to receive three consecutive HELLO messages from a neighbor is taken as an indication that the link to the neighbor in question is down.

4 III. Related Work

There are several works on mobility model of ad hoc network. Most of the works relates ad hoc network with cellular network. Qiao et al. [8] presented architecture for enhancing cellular networks called iCar, in which wireless relay stations are placed on the borders between cells and are used to improve the load balancing of the traffic among the cells and to decrease call blocking. Hsieh et al. [9] also proposed a system for enhancing a cellular network with ad hoc network routing, in which nodes use ad hoc routing to reach the base station along multiple hops and switch to cellular operation when the bandwidth available in ad hoc mode is lower than that achievable in cellular mode. Some models of vehicular motion have also been proposed in the literature [10] to model the movement of cars on highways based on driver behavior models. Today VANET is a promising research field for high speed vehicle. This work differs from VANET in that we consider only a pattern of ad hoc users on road who travels within limited speed.

5 IV. Simulation

In our simulation model, we assume a 2km road of a typical district town of where traffic density (number of vehicles) much lower than a metropolitan city. We assume that there are some vehicles that equipped with ad hoc devices. The node densities are 4/8/16/20/24/32 and there are one, two and three sources, each node move towards destination with maximum 14m/s on unidirectional waypoint. The User Datagram Protocols as transport layer protocol and the traffic application as CBR (constant Bit Rate). The sending data rate is 64kbps. The simulation parameters are summarized in table -1. We have used NS2 for simulation. For analyzing the performance of AODV and DSR, we considered three typical performance measures for ad hoc networks: end to end delay, throughput or packet delivery fraction (PDF) and routing overhead.

Average end-to-end delay is the time a data packet takes in traversing from the time it is sent by the source node till the point it is received at the destination node. This metric is a measure of how efficient the underlying routing algorithm is, because primarily the delay depends upon optimality of path chosen, the delay experienced at the interface queues and delay caused by the retransmissions at the physical layer due to collisions. 1 shows the relative delay performance of two routing protocols AODV and DSR .When the traffic density increases the end-to-end delay of packet delivery increases. This is because when a node establishes a route it requires more time due to lower traffic density. The packets need to be travel more interior nodes and held within the intermediate node until favorable forwarding paths appeared to reach desired destination, thus increasing the delay. The delay also increases as the number of sources increase because when more sources send packets, they contend to reach the destination. AODV shows the lowest end-to-end packet delay than DSR. This is due to the frequency of route discoveries in AODV is directly proportional to the number of route breaks but in DSR the route is discovered by only the sources. So the source need more time to collect the routing information for various destinations. Throughput forms an important metric for performance evaluation of an ad hoc routing protocol because, given similar scenarios, the number of data packets successfully delivered at the destination depends mainly on path availability, which in turn depends on how effective the underlying routing algorithm is in a mobile scenario.

Fig. 2 shows when the number of sources increases the packet delivery fraction (PDF) decreases. This is because when the traffic density increases there are more intermediate relay node between source and destination. In our scenario the distance between source and destination is more as increasing the node density. When the packets relay from source to destination more link will be break thus increasing the packet loss i.e. decreasing the packet delivery fraction. It is seen that the DSR shows approximately 100% throughput on single source but the AODV shows higher throughput than DSR when source increases. Thus we conclude the performance of DSR with fewer nodes is better but the AODV shows good throughput with more nodes and with more sources. In Fig. 3, we have plotted the normalized routing overload of the routing protocols AODV and DSR. The routing overload of AODV and DSR almost zero at lower traffic density. This is because once a rout discovery process is completed; there is no need to perform the discovery process again. The protocols impose different amounts of routing overload, as in the graph. DSR has the least routing overload than AODV and the routing overload increases slightly as traffic density increases. Because, the routing overload increased when there are many interior node between source and destination. And as the number of sources increases, it has to send more routing packets due to there are more destinations to which the network must maintain working routes i.e. for available nodes it has to send more routing packets to establish various routes, this is also because when a host wants to send a packet to some other host, it first checks its route cache for a source route to the destination. In the case a route is found, the sender uses this route to propagate the packet.

6 V. Conclusion

Ad hoc network is a rapid solution when there is not any infrastructure. In a road such infrastructure less environment comes in front. In this paper we have studied two MANET routing protocols when a user is moving in a city. The routing protocols are AODV and DSR. According to our study, on road side DSR has the higher end to end delay than AODV. Delay increases on number of sources and traffic density. When the number of sources increases DSR shows lower throughput than AODV. Moreover routing overhead of DSR is high than AODV. Though at lower traffic density, DSR shows low routing overload than AODV. But it increases when traffic density increases. According to our study AODV has better performance than DSR. Its mechanism of storing route information on intermediate nodes causes the lowest overhead. Moreover, it has the highest throughput and is able to deliver packets quite fast. [1] [2]

1

Parameter	Value
Examined protocols	AODV & DSR
Simulation duration	150 seconds
Node Buffer size	50 packets
Simulation area	2000 m x 30 m (flat grid)
Numbers of nodes	4,8,16,20,24,32
Maximum speed	14 m/s
Traffic type	TCP
Mobility model	Unidirectional waypoint
Data payload	512 bytes/packet
Rate	64Kbps
Node pause time	0 seconds
a) Simulation Results	

Figure 1: Table 1 :

[Broustis et al.] *A Comprehensive Comparison of Routing Protocols for Large-Scale Wireless MANETs*, I Broustis , G Jakllari , T Repantis , M Molle . http://www.cs.ucr.edu/~mart/preprints/iwwan06.pdf

[Hsieh et al. (2002)] 'A Hybrid Network Model for Cellular Wireless Packet Data Networks'. H.-Y Hsieh , R Siva , Kumar . *Proceedings of the IEEE Global Communications Conference (GLOBECOM)*, (the IEEE Global Communications Conference (GLOBECOM)) November 2002.

[Elizabeth and Chai-Keong ()] *A review of current routing protocols for ad hoc mobile wireless networks*, M R Elizabeth , T Chai-Keong . 1999. University of California and Georgia Institute of Technology, USA (Technical report)

[Perkins et al. ()] *Ad hoc On demand Distance Vector (AODV) routing*, C E Perkins , E M Royer , S R Das . IETFInternetDraft-www.ietf.org/rfc/rfc3561.txt 2003.

[Chen et al. (2001)] 'Ad Hoc Relay Wireless Networks over Moving Vehicles on Highways'. Z D Chen , H T Kung , D Vlah . *Proceedings of the Second ACM Symposium on Mobile Ad Hoc Networking and Computing*, (the Second ACM Symposium on Mobile Ad Hoc Networking and Computing) MobiHoc 2001. October 2001.

[Ranjan and Ahirwar ()] 'Comparative Study of VANET and MANET Routing Protocols'. P Ranjan , K K Ahirwar . *Proc. of the International Conference on Advanced Computing and Communication Technologies (ACCT 2011)*, (of the International Conference on Advanced Computing and Communication Technologies (ACCT 2011)) 2011. p. .

[Qiao and Wu (2000)] 'iCAR: An Integrated Cellular and Ad-Hoc Relay System'. C Qiao , H Wu . *Proceedings of the IEEE Conference of Computer Communications and Networks (IC3N)*, (the IEEE Conference of Computer Communications and Networks (IC3N)) October 2000. p. .

[Boukerche ()] 'Performance Evaluation of Routing Protocols for Ad Hoc Wireless Networks'. Azzedine Boukerche . *Mobile Networks and Applications 9*, 2004. Kluwer Academic Publishers. p. .

[Lee et al. (2009)] 'Survey of Routing Protocols in Vehicular Ad Hoc Networks'. Kevin C Lee , Uichin Lee , Mario Gerla . *Advances in Vehicular Ad-Hoc Networks: Developments and Challenges*, Oct, 2009. IGI Global.

[Broch et al. ()] *The Dynamic source routing protocol for Mobile Ad hoc networks*, J Broch , D Johnson , D Maltz , Y C Hu , G Jetcheva . www.ietf.org/rfc/rfc4728.txt 2001.