PERFORMANCE EVALUATION FOR MULTICAST TRANSMISSIONS IN VANET

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ABSTRACT

Vehicular ad hoc network (VANET) is a network that is formed when vehicles with wireless transceiver have the need to communicate with each other. Although VANET shares some similarities with mobile ad hoc network (MANET), the dynamic nature of VANET has posed a challenge in designing routing protocols. This paper shows the performance evaluation between unicast and multicast routing protocols implemented in a vehicular environment that is based on Manhattan grid model for transmission between one sender and multiple receivers. Unlike multicast transmission in geocast routing, the multiple receivers for the paper scenario are not located in a specific geographic region. Performance is evaluated in term of average end-to-end delay, throughput, packet delivery ratio and routing overhead. The results reveal a consistent performance for multicast protocols as the number of receiving nodes increases during the transmission.

***Index Terms*—** VANET, routing protocol, performance

1. INTRODUCTION

Vehicular ad hoc network (VANET) is vehicle-to-vehicle and vehicle-to-infrastructure communications using wireless local area network technologies. In general, VANET is formed when vehicles need to transmit packets to each other using the wireless channel. Therefore, vehicles need to have wireless transceivers and computerized modules that let the vehicles to act as network nodes. There are a number of characteristics which differentiate VANET from other types of ad hoc networks. Due to the movement and speed of the nodes, VANET's topology is very dynamic compared to traditional mobile ad hoc network (MANET), and because of that, VANET's network is always partition, especially if the vehicle density is low. Unlike traditional MANET, VANET does not have any restrictions in term of energy and storage, since nodes in VANET are cars, not handheld devices. Other characteristics that differentiate VANET from MANET are geographical type of communication, mobility modeling and predication, various communications environments, hard delay constraints and interaction with on-board sensors [1].

As a result of VANET dynamic nature, finding and maintaining routes is considered a challenge. Many investigations have been done in this area and a lot of VANET routing protocols have been proposed. In [1], all protocols are categorized into five main categories, which are ad hoc, position-based, cluster-based, broadcast, and geocast routing. These protocols have different methods to find and maintain routes in VANET for either unicast, broadcast or multicast communication. However, unlike the traditional multicast communication, this type of transmission in VANET, which is normally handled by geocast routing, is between a source node to several destination nodes in a specific geographic region, or known as zone of relevance (ZOR) [1].

A number of simulations and testing have been done on most protocols in each category to evaluate the protocols' performances in a vehicular ad hoc network. This paper's main goal is to evaluate four most common unicast and multicast protocols used in MANET transmission between one sender to multiple receivers that are not located within a specific geographic region, which is different from multicast transmission using geocast routing.

The organization of this paper is as follows. Section II explains the motivation for this paper. Section III is the overview of routing protocols that are used in the simulation for this paper. Section IV explains the mobility and network models used in this paper as well as configuration setup used for the simulation. Section V presents the simulation results on the performance metrics and discussion for each result. Lastly, Section VI contains the conclusion of this the paper.

2. RESEARCH MOTIVATION

Figure 1 shows one of VANET scenarios for this research. In this scenario, a source node (S) is trying to send packets to multiple destinations, which are D1, D2 and D3. In this situation, the packets can be sent either using unicast or multicast transmission

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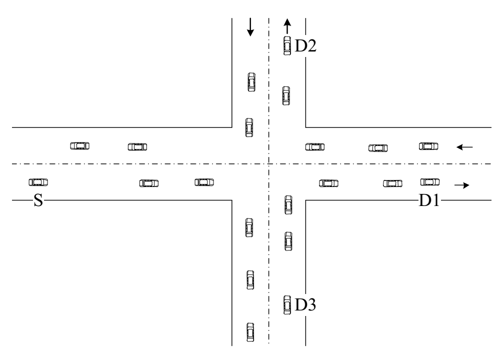

Figure 1: VANET example scenario

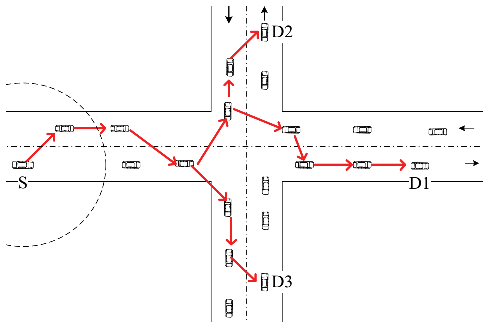

Figure 2: Multiple unicast transmissions from S to D1, D2 and D3

Figure 2 shows the three unicast transmissions that need to be done in order to send packets to D1, D2 and D3, if unicast routing protocol is used. Based on this research motivation, this paper's objective is to evaluate whether a multicast routing protocol can outperform a unicast routing protocol for these multiple transmissions.

3. Overview of Routing Protocols

3.1 Unicast Routing Protocols

VANET is similar to mobile ad-hoc network (MANET) in term of its basic principle, which it does not rely on fixed infrastructure for communication and data dissemination; however permanent network nodes in the form of roadside units can be useful in some conditions [1]. VANET also shares a few common MANET characteristics such as self-organization and self management, short radio transmission range and limited bandwidth [1]. Due to these similarities, most of the MANET routing protocols such as Ad hoc On-Demand Distance Vector (AODV) [2] and Dynamic Source Routing (DSR) [3] can still be implemented in VANET. Both AODV and DSR are reactive protocols. These protocols are designed for general purpose ad hoc network and do not maintain routes unless they are needed, which can help in reducing network overhead especially in small networks. DSR uses source routing, where the data packet carries a complete route that needs to be transmitted from a source to a receiver [3]. On the other hand, AODV depends on the routing table in the intermediate nodes that is dynamically established for the next-hop information [2].

3.2 Multicast Routing Protocols

As mentioned in previous section, multicast transmission in VANET is normally a transmission from a single source to multiple destinations within a specific geographic region, and usually handled by geocast routing. However, in this paper, multicast transmission concept is based on the traditional multicast transmission concept in a network, which is a transmission from a single source to a group of destination nodes without any geographic limitation. Many multicast routing protocols have been proposed in MANET [4]. Nevertheless, none of these protocols have been tested for inter-vehicle communication.

One of the earliest multicast routing protocols that were proposed for MANET is called On-Demand Multicast Routing Protocol (ODMRP). ODMRP is on-demand mesh-based routing protocol. It creates a forwarding group, which is a mesh of nodes that are responsible in forwarding multicast packets to any group member via flooding [5]. By maintaining and using a mesh topology, ODMRP provides path redundancy in forwarding multicast packets to all destination nodes. Since ODMRP is an on-demand protocol, the source establishes and updates group membership and multicast routes on demand and the protocol does not preserve any route information permanently [5].

Another multicast routing protocol that is often used for comparison is Adaptive Demand-Driven Multicast Routing (ADMR) protocol. Similar to ODMRP, the multicast route is established and maintained dynamically for groups that have at least one receiving node and one active sender in the network [6]. However, unlike ODMRP, ADMR uses tree topology in creating multicast trees or links between the sources, receivers and forwarding nodes [6]. Forwarding nodes are not receivers; their only purpose is to forward the multicast packets from the source to the receivers in the multicast forwarding tree.

4. Simulation Setup

4.1 Mobility Model Configuration

VANET simulation is implemented in a 600 x 700 meters grid model of city environment, which is based on Manhattan Grid mobility model, also known as City Section Mobility Model [7]. This model is based on several assumptions. The first assumption is that there are two directions in every street. For vertical direction, mobile node can move either to north or south, whereas for horizontal direction, it is either east or west. Based on this model, it is also assumed that mobile node can only move in the horizontal and vertical lines on the streets [7]. Figure 3 shows the city model that is used for the simulation. The distance between each intersection is by 300 x 200 meters. Traffic lights are used in a number of intersections to replicate the natural city environment. For simplicity, the types of vehicles do not affect the result of the simulation.

Table 1 shows the mobility mode configuration for this simulation. This paper also used a tool called MOVE (Mobility Model generator for Vehicular Network) [8], which provide a graphical user interface to set the simulation scenario with the parameters in Table 1. This tool is able to generate mobility trace using SUMO [9] engine and convert it to NS-2 [10] configuration to generate the network traffic trace.

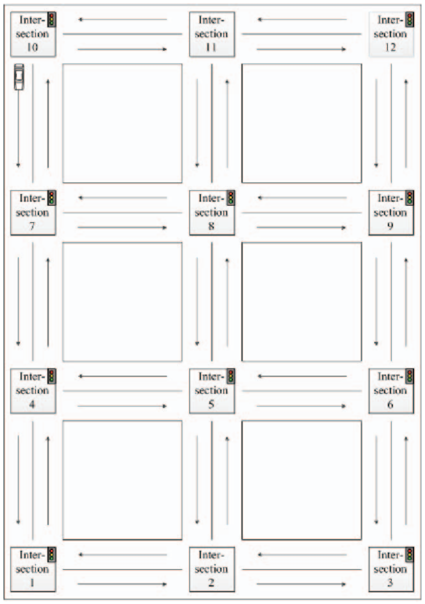

Figure 3. Manhattan Grid Model (600 x 700 m)

Table 1: Mobility Model Configuration

Micro-traffic Simulator	Simulation Urban Mobility (SUMO)
Number of vehicles	150
Speed (m/s)	10, 15
Number of lanes	2
Simulation time	300 seconds

4.2 Network Model Configuration

The network model is simulated using NS-2 using the mobility trace that is generated by the SUMO engine. All 150 vehicles are assumed to be equipped with IEEE 802.11b transceivers that allow the vehicles to act as mobile network nodes. The configuration shown in Table 2 is used to run two case scenarios in NS-2. The first case scenarios simulate unicast transmission from a transmitting node to maximum of fifteen receiving nodes. The second case will use the same parameters as the first case scenarios except for the routing protocols. In the second case scenarios, multicast routing protocols are used to transmit multicast packets to the group of receivers. These nodes are randomly picked without any preferences and the unicast transmissions are done without any background network traffic.

The simulation uses two unicast routing protocols, which are AODV and DSR; and two multicast routing protocols, which are ODMRP and ADMR.

These protocols are compared in terms of their performance using the following metrics:

- Average end-to-end delay – measures an average delay time from a sender to a destination in second.
- Network throughput – measures of the amount of data transmitted from the source to the destination in a unit period of time (second).
- Packet delivery ratio – measures the percentage of the transmitted data packets that are successfully received.
- Normalized routing load – measures the number of routing packets transmitted per data packet delivered at the destination.

Table 2: Network Model Configuration

Network Simulator	NS-2 version 2.34
Area	602 m x 702 m
Number of nodes	150
Maximum speed (m/s)	15 m/s
Propagation model	Nakagami
MAC	IEEE 802.11b
Transmission range	250 meters in radius
Simulation time	300 seconds
Traffic model	Constant bit rate (CBR)
Transmission rate	256 kbps
Packet size (payload size)	512 bytes

5. Simulation Results

The simulation of the ad hoc network, which consists of 150 vehicles or mobile nodes with movement that copy vehicle movement in a city environment, is executed for 300 seconds. In this section, results of average end-to-end delay, network throughput, packet delivery ratio, and routing overhead are presented.

From Figure 5 and Figure 6, it is evident that multicast routing protocols show an increase in network throughput and packet delivery ratio as the number of receivers increase from four receivers to 15 receivers. Figure 5 shows that ODMRP manages to sustain delivery ratio at around 51% and ADMR has a delivery ratio of 45%.

In contrast to multicast protocols, network throughput and packet delivery ratio for unicast routing protocols begin to drop for four destination nodes and more. In Figure 5, DSR's delivery ratio shows approximately 99% decrease from five receivers to 15 receivers, whereas AODV has approximately 56% decrease.

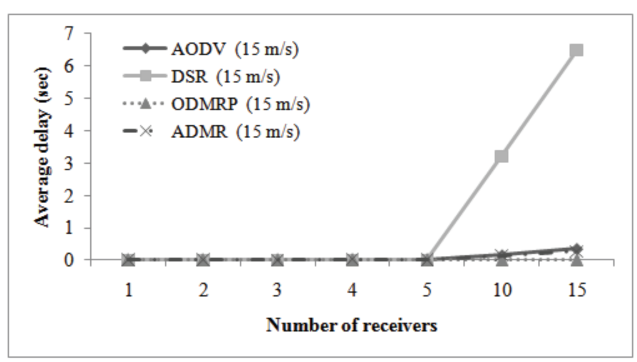

Figure 4: Average delay vs number of receivers

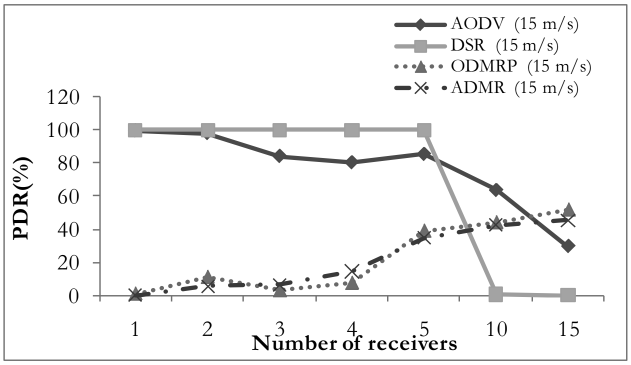

Figure 5: Packet delivery ratio vs number of receivers

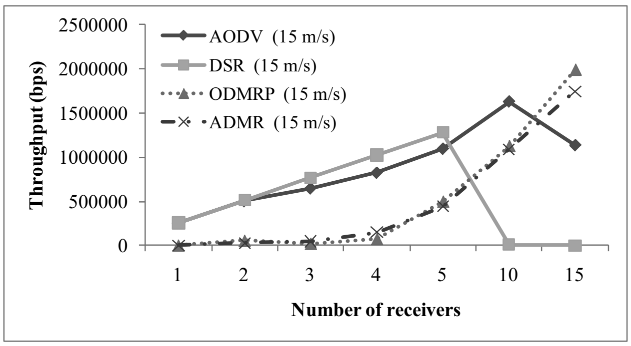

Figure 6: Network throughput vs number of receivers

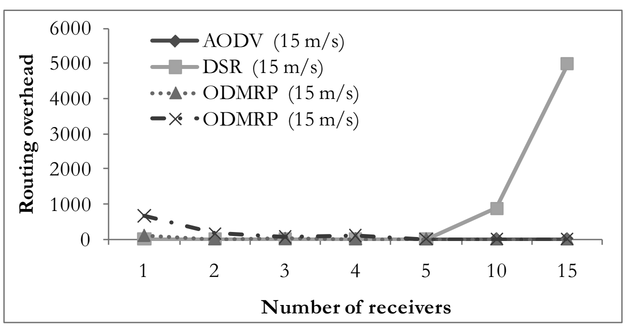

Figure 7: Routing overhead vs number of receivers

In addition, the results showed that DSR's performance decreases considerably as the number of receivers increase from five to 15 receivers. This may cause by DSR mechanism in maintaining the route for forwarding the packets. DSR uses source routing, which means all routing information is maintained at mobile nodes [3]. Each packet transmitted contains a complete route from the source to the destination. However, the protocol does not repaired broken links locally. In other words, if there is a broken link within the intermediate nodes, the node that detects the broken link will send error message to the source, and the source has to initiate route request all over again. Given that VANET is a dynamic network where each of the mobile nodes is constantly moving, link failures will always happen. This explains high average delay, low throughput and packet delivery ratio, as well as high routing overhead for DSR, as the number of receivers increase. It is found that DSR is suitable for wireless ad hoc network that has low mobility.

6. Conclusion And Future Works

This paper has presented a performance evaluation of four common unicast and multicast routing protocols used in MANET. These protocols are AODV, DSR, ODMRP and ADMR. The simulation is done in a vehicular environment that is based on 600 x 700 m Manhattan grid model with 150 vehicles, and is executed for 300 seconds. NS2 is used to simulate packet transmission from one transmitter to 15 different receivers that are not located in a same geographic region. From the results, it can be summarized that the multicast routing protocols show a consistent performance as the number of receivers increase. This paper concludes that a multicast protocol is needed to handle multiple transmissions for receivers that are not in specific geographic location in a vehicular ad hoc network.

7. References

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