Performance evaluation of broadcast techniques in VANETs

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Abstract: Broadcast is mainly used in VANETs for communication intended to reduce collision, contention, redundant messages and hidden node problem. It also improves the message reliability. But there is no comprehensive analysis and performance evaluation of broadcast exists. In this paper we briefly discuss the existing broadcast techniques their pros and cons in sparse and dense network. Thereafter we also measure the performance of broadcast schemes with help of NS-2 simulator in VANETs scenario.

Keywords: VANETs, flooding, AODV, MDDV DSR, UMB, network congestion.

Introduction

Vehicular ad-hoc networks (VANETs) is the most popular application of wireless communication technologies (Choi & Jung, 2009). Vehicle to vehicle (Yang et al., 2004) and vehicle to roadside (Jhang & Liao, 2009) enable the passengers to share safety and comfort information. Traffic management, collision avoidance, safety warnings are the safety applications (Saleh et al., 2007). The comfort application (Guette et al., 2008) gives facility to passenger by sharing information like parking or hotel information and petrol or gas station information etc. Security is also an essential requirement in VANETs. VANETs are prone to security attack due to lack of infrastructure, high mobility (Inhyeok et al., 2008) and dynamic network topology as compare to any other network (Nguyen & Nguyen, 2006; Mao et al., 2003).

Jayachandran et al. (2007) explains communication and its techniques of broadcast is mainly used in VANETs. A variety of broadcast schemes has been proposed for MANETs and VANETs. But none has done performance evaluation in VANETs scenario. This paper presents a comparative study of broadcast techniques in VANETs. In addition, with help of NS-2, we evaluate the broadcast scheme and measure their performance in terms of throughput and redundant messages.

This paper is organized as follows: In section 2, different broadcast approaches are described. In section 3, comparison of broadcast approaches is performed. In section 4, we evaluate the performance of broadcast schemes and in section 5, conclusion and future work is given.

Related work

With help of broadcast, unicast and multicast protocols establish and maintain route in VANETs (Al-Shurman et al., 2005). Dynamic Source Routing (DSR) (David et al., 2003), Ad Hoc On Demand Distance Vector (AODV) (Charles et al., 2003), Zone Routing Protocol (ZRP) (Zygmunt, 1997) and Location Aided Routing (ZAR) (Young-Bae & Nitin, 1998) are example that use broadcasting for their route establishment and maintenance in VANETs (Zhang & Jiang, 2004). A variety of broadcasting schemes exist such as simple flooding, probability based approaches, area based approaches etc. In this section we will briefly discuss all the broadcast schemes and their pros and cons.

Flooding is a simple broadcast technique (Zhang & Jiang, 2006) for communication. Vehicles send information to other vehicle and this process continues until all vehicles get same information. It works fine in sparse network but in dense network it produces collision, contention and redundant messages.

Probabilistic scheme (Ryu et al., 2004) reduces the collision, contention and redundant messages in dense network as it broadcast the messages with some fixed probability. But in sparse network, all the vehicles can’t receive the same packets with small probability. If the probability is increased it works much like flooding (Brad & Tracy, 2002). Hence, its performance becomes greater in dense network as compare to sparse network.

Counter based technique is used to analyze the redundant messages. We use counter to record the redundant message. Whenever the redundant message is received, we increment the counter by one. We compare the counter with certain threshold value if it is less than it we forward the packet otherwise the packet is discarded (Zhang & Jiang, 2004).

Distance based scheme first calculates the distance between itself and its neighbor vehicles. Then it compares the distance with threshold. If the distance is greater than threshold it forward the packet otherwise it ignore the message (Brad & Tracy, 2002).

Location based scheme first calculates the coverage area with help of sender location. The vehicle will ignore the packet if area is smaller than a threshold value, otherwise the packet will be broadcast (Brad et al., 2004).

Neighbor knowledge methods (Joon et al., 2003) maintain a table that contains the information of its neighbor node. A vehicle decision depends upon this information to forward message or not. All vehicles share hello packets with their neighbors to get current information. They store this information in their table for future use. Neighbor knowledge methods totally rely on the exchange of hello packet. Contention and collision can be happen if the interval is short and large interval degrades the performance of network due to mobility.

Broadcast can also be done by using trees. But it is not fit for ad hoc networks, due to the dynamic nature. An efficient and reliable tree based broadcasting technique was proposed which is stable in dynamic network (Korkmaz et al., 2006). It first maintains a spanning tree in
the network, and then forwards the messages with help of it. Urban MultiHop Broadcast Protocol (UMB) is proposed to resolves the reliability, broadcast storm and hidden node problems, without sharing information among the vehicles. Directional broadcast and intersection broadcast are the two main steps of UMB (Korkmaz & Ekici, 2004). Source vehicle selects the furthest vehicle for communication in direction broadcast where as in intersection broadcast installed repeaters at road segments forward the packets to destinations.

A Mobility-Centric Data Dissemination Algorithm for Vehicular Networks (MDDV) is a mobility centric scheme that merges the idea of opportunistic, trajectory and geographical forwarding (Hao et al., 2004). Trajectory based forwarding (Dragos et al., 2003) is a scheme to forward the packets along a predefined curve in dense vehicular ad hoc network. Geographical forwarding is used for routing decisions. To forward packet to the destination, a vehicle broadcast the packet to a vehicle that is near to the destination (Pai-Hsiang Hsiao & Jingyi, 2001). An opportunistic forwarding (Daniele et al., 2006) has three functions (store, copy and forward), which give rise to epidemic spreading. MDDV enhance the delivery efficiency and solve the broadcast storm problem (Hao et al., 2004). But it still have some short coming that it does not differentiate between message types and forward surplus messages without knowing its relevance.

Relevance based approach is designed for vehicular adhoc network as the speed of vehicles are very high and they have limited time to exchange message so they forward only relevant and important messages and discard the low priority messages. Relevance based approach methodology (Adler et al., 2006) is defined as, first we compute the relevance value of message with the help of three resources (vehicle context, message context information context) and then we allocate the medium to the messages according to their importance (Kosch et al., 2006). In this way low priority traffic can’t get the medium more than high priority traffic. Relevance scheme has certain drawbacks that it does not provide internal resorting of packet queue using 802.11e (Rahim et al., 2009) and it consider the ideal situation that all vehicles are reliable and error free, no concept of malicious node as it is not possible in real scenarios (Eichler et al., 2006).

Multi-Hop Vehicular Broadcast (MHVB) (Zhang & Jiang, 2004) uses two algorithms i.e. Congestion Detection and Backfire algorithm. With the help of Congestion Detection it removes surplus messages and send packet to destination by using Backfire algorithm.

An adaptive broadcast protocol (Balon & Guo, 2006) is proposed to improve the message reliability in VANETs scenario. But it still has to face many challenges like hidden node problem and no priority mechanism in VANETs for providing reliable broadcast. Sequence numbers of packets are useful in order to analyze the Network congestion. With the help of sequence number vehicles dynamically adjust the contention window and improve the performance. Sheela and Raja (2009) also proposed an algorithm to control the network congestion by queue management scheme.

**Comparisons of Different Protocols**

Comparison of different broadcast protocols is shown in the Table 1. We analyzed the protocol in terms of various parameters for e.g. contention, collision, congestion, performance, reliability. None of existing schemes is ideal for all scenarios. Simple flooding works better in sparse network and probabilistic works better in dense network.

**Table 1. Comparison of broadcast protocols for VANETs (Rahim et al., 2008)**

<table>
<thead>
<tr>
<th>Protocols</th>
<th>Reliability</th>
<th>Performance</th>
<th>Congestion</th>
<th>Rebroadcast</th>
<th>Collision</th>
<th>Contention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Flooding</td>
<td>Very high</td>
<td>moderate</td>
<td>Very high</td>
<td>redundant</td>
<td>severe</td>
<td>Very high</td>
</tr>
<tr>
<td>Probabilistic Scheme</td>
<td>moderate</td>
<td>moderate</td>
<td>Low</td>
<td>Controlled</td>
<td>moderate</td>
<td>low</td>
</tr>
<tr>
<td>Counter-Based Scheme</td>
<td>moderate</td>
<td>moderate</td>
<td>Low</td>
<td>Controlled</td>
<td>moderate</td>
<td>low</td>
</tr>
<tr>
<td>Distance Based Approach</td>
<td>moderate</td>
<td>moderate</td>
<td>Low</td>
<td>Controlled</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td>Location Based Approach</td>
<td>high</td>
<td>high</td>
<td>Low</td>
<td>Efficient</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td>Neighbor Knowledge Methods</td>
<td>moderate</td>
<td>moderate</td>
<td>moderate</td>
<td>controlled</td>
<td>Period</td>
<td>Period</td>
</tr>
<tr>
<td>Tree Based Broadcast</td>
<td>high</td>
<td>high</td>
<td>Very low</td>
<td>Efficient</td>
<td>low</td>
<td>Very low</td>
</tr>
<tr>
<td>UMB</td>
<td>high</td>
<td>high</td>
<td>moderate</td>
<td>controlled</td>
<td>low</td>
<td>moderate</td>
</tr>
<tr>
<td>MDDV</td>
<td>high</td>
<td>high</td>
<td>Low</td>
<td>controlled</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Relevance-based approach</td>
<td>moderate</td>
<td>High</td>
<td>Low</td>
<td>Efficient</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>MHVB</td>
<td>high</td>
<td>high</td>
<td>Very low</td>
<td>Efficient</td>
<td>high</td>
<td>low</td>
</tr>
<tr>
<td>Adaptive broadcast protocol</td>
<td>high</td>
<td>high</td>
<td>moderate</td>
<td>Inefficient</td>
<td>high</td>
<td>high</td>
</tr>
</tbody>
</table>

**Table 2. Simulation parameters**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel</td>
<td>Wireless</td>
</tr>
<tr>
<td>Vehicles</td>
<td>50</td>
</tr>
<tr>
<td>MAC protocol</td>
<td>802.11</td>
</tr>
<tr>
<td>Radio Propagation Model</td>
<td>Two-Ray Ground</td>
</tr>
<tr>
<td>Time</td>
<td>50 s</td>
</tr>
<tr>
<td>Routing Protocol</td>
<td>DSDV</td>
</tr>
</tbody>
</table>

**Proposed Study**

In this study we evaluate the performance of simple flooding and relevance based approach in VANETs scenario. The mobility model we use is Manhattan Mobility Model (Bai et al., 2003) and Generic Mobility Simulation Framework generates the traffic (Baumann et al., 2008). We perform simulation with help of Network Simulator (NS-2) (NetworkSimulator,
First we evaluate the simple flooding in VANETs scenario and measure its performance. We also analyze the redundant message produced by it. Then we simulate the relevance based approach and measure its performance in terms of priority.

Performance evaluation of simple flooding

In this study we have fifty vehicles, moving with a speed of 20 to 30 m/s and simulation time is 50 seconds. Fig. 1 shows the number of packets received by all vehicles during the simulation.

Simple Flooding has the problem of collision, contention and redundant messages. Fig. 2 shows the redundant messages produced during simulation. The number of redundant messages increases with time because every node has sent the packet to its neighbor no matter if its neighbor already has that packet.

Simple flooding does not discriminate between safety and route messages and give all messages same importance. The problem is to improve the simple flooding so that it can consider the importance of messages and less redundant messages are produced.

It is clear from Fig. 1 and 2 that a lot of redundant message are produced if we use simple flooding in VANETs. In the beginning, the number of redundant messages is greater than number of actual message received. But with time, the redundant messages increase gradually than the number of actual message received.

Performance evaluation of relevance based approach

Fig. 3 shows the performance of relevance based approach. Four different types of messages i.e. safety messages, route messages, weather messages, common messages are exchanged between fifty vehicles having speed of 72Km/hr to 108Km/hr.

Existing broadcast techniques has no mechanism of message differentiation and assign the equal priority to all messages. But relevance based approach is the technique that assign higher priority to safety messages, discard the surplus messages and share only relevant messages within VANET.

Fig. 3 reveals that safety messages have higher priority and it get more medium than route, weather and common messages.

The relevance based approach using 802.11e does not provide internal resorting of the packets in a packet queue and does not consider the network control. The author considers the ideal situation where all nodes are doing their work fair but it is not possible in practical. The problem is to enhance the mathematical model of relevance based approach or to design a new data dissemination scheme that is secure and it consider not only the user traffic but also the network control.

Conclusion and future work

The existing broadcast techniques were analysed for their pros and cons in sparse and dense network. Simulation shows that simple flooding produces a lot of redundant messages. It works fine in sparse network but in dense network its performance is not fair and lacks priority mechanism. Relevance approach has less redundant message while giving priority to safety messages than other messages. But it still has some drawbacks. It does not consider network control and propose for ideal scenario where no malicious node exists. In future, we will enhance the relevance approach so that it can consider the network control and simulate it in real scenario by considering the impact of malicious node.

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References


