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Simulation and Analysis of Ad-hoc routing protocols under varying density and mobility in VANET

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Abstract: Vehicular Network is a recently developed technology which will be very beneficial for reducing the roadside accidents which are caused due to the rapid increase in number of vehicles on the road. VANET is an ad hoc network where vehicles act as the communicating nodes. Communication among the vehicles and with roadside unit helps in maintaining coordination which ensures control of traffic congestion on roads which in turn reduces environmental pollution. For the proper implementation of the Vehicular Network, the most important aspect is efficient routing of packets in the network and hence a careful study is required to choose the best routing protocol. In this paper, a performance analysis of both proactive (DSDV) and reactive (AODV) protocol is carried out for different parameters like throughput, net routing load and end to end delay to compare their performance in different scenarios. Finally the pros and cons associated with each protocol are detected and a new approach is proposed which aims to solve the problems associated with routing

Keywords: AODV, DSDV, VANET, ITS, NS2**.**

1. Introduction

Ad hoc network is a multi-hop wireless network, which consists of wireless mobile hosts forming a temporary network without the aid of any centralized administration or standard support services regularly available on the wide area network to which the host may normally be connected. Minimal configuration, absence of infrastructure and quick deployment make Ad Hoc Networks convenient for emergency operations.

VANET as the name suggests, is an ad-hoc network in which nodes act as the vehicles. Each vehicle connected to the network acts as a router/node and initiates communication with other nodes or roadside units. Topology discovery in case of Vanet is very difficult because it is impossible to predict the topology of the network as the vehicles constantly keeps on moving in and out of the network. Routing in the field of vehicular ad hoc network (VANET) is one of the most emerging areas of research.

To establish a VANET, **IEEE** has defined the standard **802.11p**. The main objective of this is to describe the approach introduced by the **IEEE 802.11p WAVE**. WAVE stands for "*Wireless Access in Vehicular Environment*". WAVE makes changes in the overall IEEE 802.11 standard. The allocation of the *Dedicated Short Range Communication* (DSRC) spectrum arise this standardization process which is allocated by U.S. Federal Communications Commission (FCC) in 1999. This Commission allocated **75MHz** of spectrum in the **5.9 GHz** band for DSRC to be exclusively used for V2V & V2I communication. In contrast to regional standards of DSRC, WAVE is the only standard which can be followed across the world. The functionality of these standards is to define how applications work in the WAVE environment. [4].

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The most important application of VANET is Intelligent Transport System. ITS uses communication and information to control and manage vehicular infrastructure. The main aim of ITS is Vehicle Safety and reduction of fuel and time consumption. It also aids in drivers ease of control and improves decision making process. All this uses involves dissipation of messages and hence efficient routing of packets is the most important aspect of establishing a Vehicular Networks.

Fig. VANET in a city scenario. Vehicles are warned of the truck blocking the road, and alternate routes [6]

2. Literature Review

The RFC 2501 [20] by S.Corson and J.Macker gives a very good analysis of wireless networks. It is organized in the following manner. First the author explains the wireless networks, followed by the explanation of the different kinds of wireless networks namely infrastructure based wireless network and Ad-hoc networks. The paper also gives a very clear picture about the need of Ad-hoc networks with examples and the author also discusses in brief about the major routing protocols involved in wireless adhoc network.

"Routing in ad hoc networks of mobile hosts" by Johnson, D.B [7] explains in detail about the drawbacks of the conventional routing protocol and gives a clear idea of why the conventional routing protocols based on distance vector routing and link state routing do not best suit ad-hoc networks. Having discussed the drawbacks of conventional routing protocols the author also explains the importance of On-Demand routing in ad-hoc networks. To summarize Johnson.D.B explains why conventional routing protocols do not best suit ad-hoc networks and explains the more efficient methodologies that can be adapted for ad-hoc networks.

"Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for Mobile Computers" by C.E.Perkins and P.Bhagawat [1] give a very good explanation of the use of Distance Vector routing principles for adhoc networks. The authors also explain the modifications to the Bellman-Ford algorithm that were proposed for the use of distance vector algorithm in a self-starting and highly dynamic environment like ad-hoc networks. This paper also adds the modification for the basic network layer routing to support improved MAC layer for the ad-hoc networks.

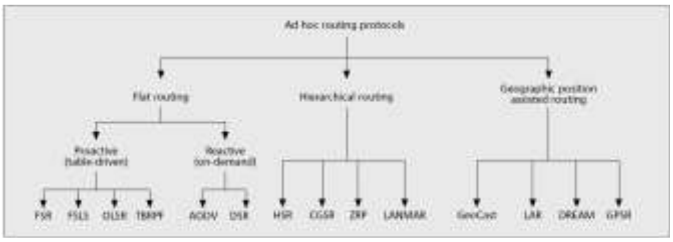
The paper "Ad-hoc On-Demand Distance Vector Routing" by C.Perkins and E.M.Royer [2] gives a good understanding of the AODV routing protocol for Ad-hoc networks. The authors start with the explanation of the importance of route discovery on an on-demand basis in ad-hoc networks since ad-hoc networks are infrastructure less and involve a lot of mobility. The authors also explains the basic operation of the AODV routing protocol which is basically a distance vector routing protocol but route to the destination is discovered only when there is a need for communication between the source and the destination. This is followed by the simulation which gives a very good idea on how the throughput and efficiency is affected under different scenarios like involving mobility of nodes and changing the density of the node.

The research paper "A Performance Comparison of Multi-Hop Wireless Ad Hoc Network Routing Protocols" by Josh Broch, David A. Maltz [12] is a very elegant paper that compares the major routing protocols in Adhoc networks on various aspects like mobility, density of the number of nodes and physical and MAC layer behavior of the different Adhoc Routing Protocol. The author gives a very good explanation that each and every protocol designed has a major functionality that's being concentrated like simplicity in the routing, mobility or the density of the node. So routing protocol that's being used in a particular domain basically depends on the major functionality of that domain. So interoperability plays a very important role when there needs to be a communication between different routing domains or across a different routing domain to reach a domain using the same routing protocol.

The paper "An energy based power-aware routing protocol in ad hoc networks" by Jing Nie and Zheng Zhou [11] gives a very good comparative study of the wireless ad-hoc networks. The author takes two on-demand routing protocols namely Dynamic Source Routing and Ad-hoc On-Demand Routing protocol for study. The gist of the paper is that even though both the routing protocols are based on the same routing principle the performance of the network varies with the load, mobility and the density of the network. It concludes that each of the protocol has its own pros and cons depending on the network design .Thus we can conclude that it would be a hard decision to go for a particular routing protocol leaving the other since each has its own advantage and disadvantage. The better option would be to use the routing protocol that better suits for the network design and implement interoperability between the routing protocols.

3. Ad-Hoc Routing Protocols

Routing protocol in VANET can be classified into several ways depending upon their network structure, communication model, routing strategy, and state information and so on but most of these are done depending on routing strategy and network structure. Based on the routing strategy the routing protocols can be classified into two parts: Table driven and Source initiated (on demand) while depending on the network structure these are classified as flat routing, hierarchical routing and geographic position assisted routing[3].



In this paper, an extensive analysis of the two most important routing protocol viz. AODV and DSDV is carried out under varying node density and pause time.

3.1 DSDV

Destination-Sequenced Distance-Vector Routing (DSDV) is a table-driven routing scheme for ad-hoc mobile networks based on the Bellman-Ford algorithm. It was developed by C. Perkins and P.Bhagwat in 1994. It eliminates route looping, increases convergence speed, and reduces control message overhead. In DSDV, each node maintains a next-hop table, which it exchanges with its neighbors. There are two types of next-hop table exchanges: periodic full-table broadcast and event-driven incremental updating. The relative frequency of the full-table broadcast and the incrementalupdating is determined by the node mobility. In each data packet sent during a next-hop table broadcast or incremental updating, the source node appends a sequence number. This sequence number is propagated by all nodes receiving the corresponding distance-vector updates, and is stored in the next-hop table entry of these nodes. A node, after receiving a new next-hop table from its neighbor, updates its route to adestination only if the new sequence number is larger than the recorded one, or if the new sequence number is the same as the recorded one, but the new route is shorter. In order to further reduce the control message overhead, a settling time is estimated for each route. A node updates to its neighbors with a new route only if the settling time of the route has expired and the route remains optimal [4].

3.2 AODV

The Ad hoc On-Demand Distance Vector (AODV) algorithm enables dynamic, self-starting, multi-hop routing between participating mobile nodes wishing to establish and maintain an ad hoc network. AODV allows mobile nodes to obtain routes quickly for new destinations, and does not require nodes to maintain routes to destinations that are not in active communication. AODV allows mobile nodes to respond to link breakages and changes in network topology in a timely manner. The operation of AODV is loop-free, and by avoiding the Bellman-Ford "counting to infinity" problem offers quick convergence when the ad-hoc network topology changes (typically, when a node moves in the network). When links break, AODV causes the affected set of nodes to be notified so that they are able to invalidate the routes using the lost link. Route Requests (RREQs), Route Replies (RREPs) and Route Errors (RERRs) are message types defined by AODV [4].

4. Simulation and Analysis

Simulation is carried out in NS2 under different situations by varying the node density and the pause times. The following metrics are used for the analysis of AODV and DSDV routing protocols.
i) Throughout
ii) Average End to End Delay
iii) Net Routing Load

Throughput:
It is the percentage of the packets which reach the destination.

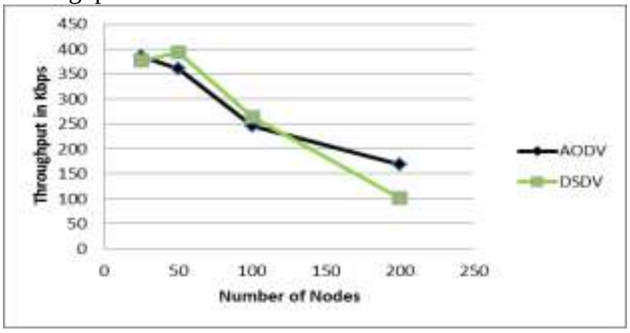
Net Routing Load: It is the ratio of the number of routing packets generated by the routing protocol to the total number of packets sent during the simulation. Increase in generation of routing overhead will decrease the protocol performance.

Average end-to-end delay of data packets
There are possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times. Once the time difference between every CBR packet sent and received was recorded, dividing the total time difference over the total number of CBR packets received gave the average end-to-end delay for the received packets. This metric describes the packet delivery time: the lower the end-to-end delay the better the application performance [15].

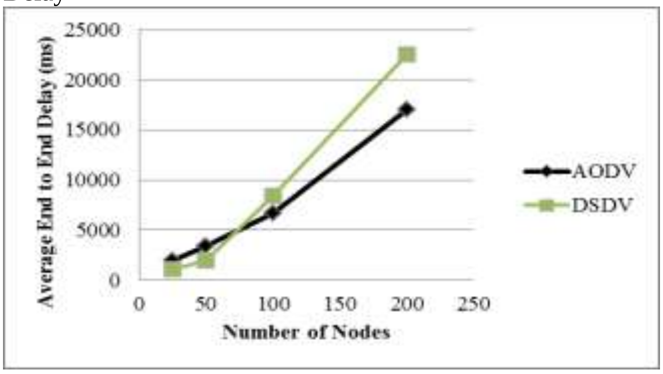
Simulation Results:

(i) Under varying node density

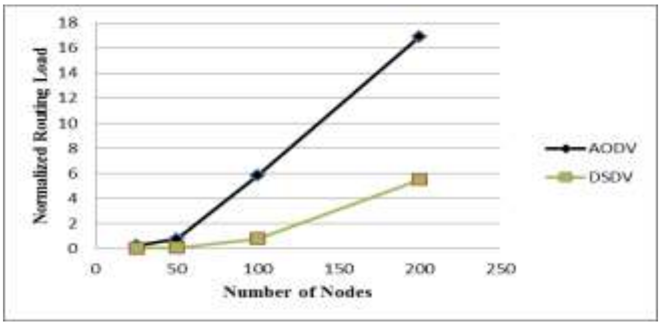
Throughput



Delay

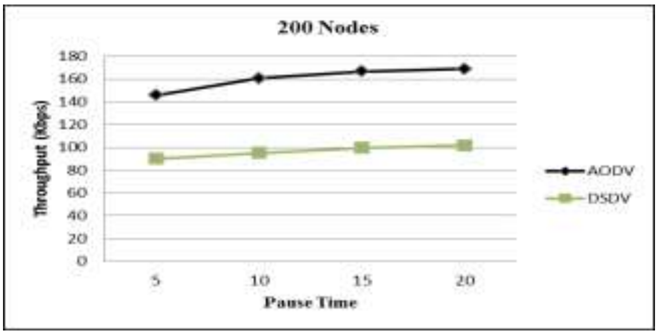


NRL

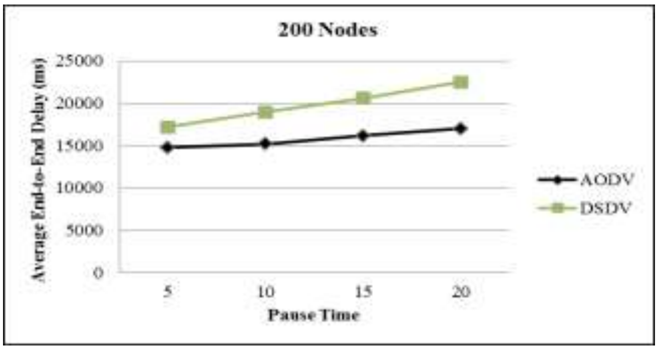


(ii) Varying Pause time:

Throughput:



Delay:



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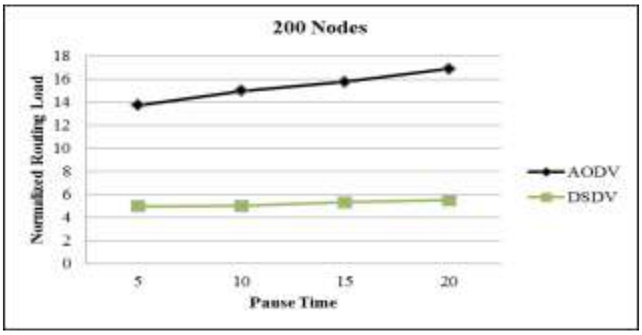

From the results obtained it can clearly be seen that the performance of AODV outperforms DSDV in terms of throughput and delay in both the scenarios but it can also be seen that the routing load of AODV is higher than DSDV in all the cases and this is because in order to establish and maintain links AODV exchanges a lot of control packets. If we can reduce the number of control packets generated then clearly we can enhance its overall performance to a great extent and make it optimal to use in VANET.

5. Proposed Method

AODV protocol can be optimized by reducing the number of control messages generated during the route discovery process. We propose a method to optimize AODV by using the idea of clustering the nodes of the network and managing routing by cluster heads and gateway nodes. Routing using clusters effectively reduces the control messages flooded during the route discovery process by replacing broadcasting of RREQ packets with forwarding of RREQ packets to Cluster Heads. It also reduces the number of unused routes generated during the route discovery process. Thus the overhead of network in routing packets can be reduced and the efficiency of the protocol can be improved.

6. Conclusion

In VANET, the network topology cannot be known as it keeps on changing continuously. Studies in MANET form the basis for study in VANET. But VANET includes new complexity of scalability and mobility. During the data transmission between the nodes, the data may get lost due to the node disconnection from the network. Hence, efficient routing approaches need to be adopted for the proper implementation of VANET. AODV and DSDV routing protocols were implemented in VANET environment to study their behaviour and the simulation was performed using ns2. The graphs were plotted based on the performance of the system and it shows that on an average the performance of AODV is better than DSDV. As a result we can see most of the research done in the field of Vehicular Technology uses AODV as the routing protocol. But it is evident from our study that AODV does not serve best results for the implementation of VANET and it suffers from high routing load in almost all the scenarios. Hence, we propose a modification to the traditional routing approach of AODV so that it provides better performance for the real world traffic environments

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