Performance Comparison of Wireless Mobile Ad-Hoc Network Routing Protocols

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Summary
The Efficient routing protocols can provide significant benefits to mobile ad hoc networks, in terms of both performance and reliability. Many routing protocols for such networks have been proposed so far. Amongst the most popular ones are Ad hoc On-demand Distance Vector (AODV), Destination-Sequenced Distance-Vector Routing protocol (DSDV), Dynamic Source Routing Protocol (DSR), and Optimum Link State Routing (OLSR). Despite the popularity of those protocols, research efforts have not focused much in evaluating their performance when applied to variable bit rate (VBR). In this paper we present our observations regarding the performance comparison of the above protocols for VBR in mobile ad hoc networks (MANETs). We perform extensive simulations, using NS-2 simulator. Our studies have shown that reactive protocols perform better than proactive protocols. Further DSR has performed well for the performance parameters namely delivery ratio and routing overload while AODV performed better in terms of average delay.

Key Words
AODV, DSDV, DSR, MANET Routing, NS-2, and VBR Traffic.

1. Introduction

Mobile Ad Hoc Networks are wireless networks which do not require any infrastructure support for transferring data packet between two nodes [1]. In these networks nodes also work as a router that is they also route packet for other nodes. Nodes are free to move, independent of each other, topology of such networks keep on changing dynamically which makes routing much difficult. Therefore routing is one of the most concerns areas in these networks. Normal routing protocol which works well in fixed networks does not show same performance in Mobile Ad Hoc Networks. In these networks routing protocols should be more dynamic so that they quickly respond to topological changes [2].

There is a lot of work done on evaluating performances of various MANET routing protocols for constant bit rate traffic but there is very little work done for variable bit rate traffic. In our paper we have evaluated performances of most widely used MANET routing protocols namely AODV, DSDV, DSR and OLSR for VBR in MANET using NS-2 [23] which is a discrete event simulator developed at Berkeley University. Our study has shown that reactive protocols perform better than proactive. Also DSR has performed better than AODV in terms of Delivery Ratio and Routing Overload while AODV performed better in terms of Average Delay.

The rest of this paper is organized as follows. In section 2 we briefly describe the routing protocols that we evaluate. In section 3 we discuss the most important previous studies on the subject and explain our work. Section 4 presents the Simulation environment used for evaluation of the said protocols. In Section 5 we present our simulation results and observations. Finally, section 6 concludes the paper.

2. Wireless Ad Hoc Routing Protocols

In this section we briefly describe the protocols that we investigate. A detailed discussion and comparison of most popular wireless ad hoc routing algorithms is available in [24].

DSDV Protocol
The DSDV described is a table-driven proactive protocol, based on the classical Bellman-Ford routing mechanism [3] [4] [5]. The basic improvements made include freedom from loops in routing tables, more dynamic and less convergence time. Every node in the MANET maintains a routing table which contains list of

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all known destination nodes within the network along with number of hops required to reach to particular node. Each entry is marked with a sequence number assigned by the destination node. The sequence numbers are used to identify stale routes thus avoiding formation of loops. To maintain consistency in routing table data in a continuously varying topology, routing table updates are broadcasted to neighbor's periodically or when significant new information is available. In addition to it time difference between arrival of first and arrival of the best route to a destination is also stored so that advertising of routes, which are likely to change soon, can be delayed. Thus avoiding the advertisement of routes, which are not stabilized yet, so as to avoid rebroadcast of route entries that arrive with node is supposed to keep the track of settling time for each route so that fluctuations can be damped by delaying advertisement of new route to already known and reachable destination thus reducing traffic. Fluctuating routes occurs as a node may always receive two routes to a destination with same sequence number but one with better metric later. But new routes received which take to a previously unreachable node must be advertised soon. Mobiles also keep track of the settling time of routes, or the weighted average time that routes to a destination will fluctuate before the route with the best metric is received. By delaying the broadcast of a routing update by the length of the settling time, mobiles can reduce network traffic and optimize routes by eliminating those broadcasts that would occur if a better route was discovered in the very near future.

AODV Protocol

The AODV algorithm is an improvement of DSDV protocol described above. It reduces number of broadcast by creating routes on demand basis, as against DSDV that maintains mutes to each known destination [4] [5] [6] [20]. When source requires sending data to a destination and if route to that destination is not known then it initiates route discovery. AODV allows nodes to respond to link breakages and changes in network topology in a timely manner. Routes, which are not in use for long time, are deleted from the table. Also AODV uses Destination Sequence Numbers to avoid loop formation and Count to Infinity Problem.

An important feature of AODV is the maintenance of timer based states in each node, regarding utilization of individual routing table entries. A routing table entry is expired if not used recently. A set of predecessor nodes is maintained for each routing table entry, indicating the set of neighboring nodes which use that entry to route data packets. These nodes are notified with RERR packets when the next-hop link breaks. Each predecessor node, in turn, forwards the RERR to its own set of predecessors, thus effectively erasing all routes using the broken link. Route error propagation in AODV can be visualized conceptually as a tree whose root is the node at the point of failure and all sources using the failed link as the leaves [5][6].

DSR Protocol

The DSR is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes [7][8][9]. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration. The protocol is composed of the two main mechanisms of “Route Discovery” and “Route Maintenance', which work together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network All aspects of the protocol operate entirely on DSR protocol include easily guaranteed loop-free routing, operation in networks containing unidirectional links, use of only “soft state” in routing, and very rapid recovery when routes in the network change. In DSR, Route Discovery and Route Maintenance each operate entirely “on demand”. In particular, unlike other protocols, DSR requires no periodic packets of any kind at any layer within the network. For example, DSR does not use any periodic routing advertisement, link status sensing, or neighbor detection packets, and does not rely on these functions from any underlying protocols in the network. This entirely on demand behavior and lack of periodic activity allows the number of overhead packets caused by DSR to scale all the way down to zero, when all nodes are approximately stationary with respect to each other and all routes needed for current communication have already been discovered.

The sender of a packet selects and controls the route usedfor its own packets, which together with support for multiple routes also allows features such as load balancing to be defined [7][8][9]. In addition, all routes used are easily guaranteed to be loop-free, since the sender can avoid duplicate hops in the routes selected. The operation of both Route Discovery and Route Maintenance in DSR are designed to allow unidirectional links and asymmetric routes to be supported.

OLSR Protocol

It is an optimization of pure link state algorithm in ad hoc network [10] [11]. It is designed to reduce duplicate retransmission in the same region. The routes are always immediately available when needed due to its proactive nature. Hop by hop routing is used in forwarding packets. Nodes exchange topology information with other nodes periodically. The use of MPRs (Multipoint Relay) selectors in OLSR is the distinctive feature over other classical link state protocols where every node retransmits each message. In OLSR, only nodes selected as MPRs forward control traffic that causes reducing the size of control message and minimizing the overhead from flooding control traffic. MPRs advertise link state information for their MPR selectors periodically in their control messages. MPRs are also used to form a route from a given node to any destination in route calculation. Each node periodically broadcasts Hello message for the link sensing, neighbor's detection and MPR selection process. Each node can get topology up to 2 hops from Hello messages. The information about the symmetric one hop and two hops neighbors is used to calculate the MPR set. Each node selects set of neighbor nodes as MPRs from among 1-hop neighbors with symmetric link, which covers all the two, hop neighbors and records in MPR selector table. MPR is recalculated when a change in one-hop or two - hops neighborhood topology is detected. Every node periodically broadcasts list of its MPR selectors instead of the whole list of neighbors. Upon receipt of MPR information, each node recalculates and updates routes to each known destination. In order to exchange the topological information, the Topology Control (TC) message is broadcasted throughout the network. Only MPRs need to forward TC messages each node maintains the routing table in which routes for all available destination nodes are kept because of the proactive nature [10][11].

3. Previous Work

In this section we analyse the most relevant previous studies concerning ad hoc routing performance comparisons. The authors in [6] [15] [16] [17] [22] use constant bit rate (CBR) for their analysis. Most of the previous work is limited on performing simulations for ad hoc networks with a CBR. Our work differs in that we use variable bit rate (VBR). We observe and comment on the behaviour of each protocol.

4. Simulation Environment

We have used network simulator ns2 for simulation, most widely used network simulator and freely downloadable. We simulated network for simulation time of 1000 sec and area of 1000 m *1000 m. Further increase in these values increased the time taken for completing simulation, to a limit which is not feasible due to various constraints. We have used Average Delay, Delivery Ratio and Normalized Routing Overload as performance parameters while varying various network parameters such as Pause Time, Burst Time, and Number of Nodes.

5. Simulation Result And Observations

In this section we present our simulation efforts to evaluate and observations that compare the performance of the protocols that we described previously in Section 2.

Effect of Varying Pause Time

Pause time can be defined as time for which nodes waits on a destination before moving to other destination. We used this as a parameter as it is measure of mobility of nodes. Low pause time means node will wait for less time thus giving rise to high mobility scenario. Figure 1 (1a, 1b, 1c) shows various performance parameters v/s pause time when other parameters were constant. From figure we can observe that normalized overload for DSDV and OLSR is almost constant. This is because of their proactive nature due to which they offer constant routing overhead in all cases. While for reactive protocols considered here as we increased pause time routing overload has decreased .This is because as routing pause time increases mobility decreases and thus link breakage become rare which in turn will decrease number of route request from sources and hence decreasing overhead. Also DSR outperformed AODV as it maintains multiple routes to a destination. In case of failure in one route other route will be used rather than initiating route request. Also from figure we can see that average delay for proactive protocol was better at high mobility as they use route already in the table, and no time is required to find route as opposite to reactive protocols as they will wait for route formation. But at lower mobility, we can observe that reactive protocols performed better in terms of average delay among which AODV outperformed DSR. This is because DSR may not use optimum path always unlike AODV. While delivery ratio for DSR and AODV was near to 100% with DSR performing better because of multiple path information in its route cache (AODV always stores best path). Also proactive protocols performed poor in case of high mobility.

Effect of Varying Number of Nodes

Number of nodes may be another varying parameter as it plays important role in performance. Figure 2 (2a, 2b, 2c) shows various performance parameters versus no. of nodes. From figure we can observe that routing overload for all protocol increased as no. of nodes increased but among them AODV performed poorer as this might be due to flooding of routing packets. We can observe that overhead for DSDV and OLSR also increased as increase in number of packet have increased the size of their routing table and also number of broadcast. While in case of less number of nodes all protocols performed poorer in terms of delivery ratio as nodes breakage may be more and no route may be available, again DSR outperformed all with respect to Delivery Ratio. In case of average delay, AODV was better than DSR but proactive protocols performed well due to their proactive nature.

Effect of Varying Burst Time

Burst Time may be another varying parameter. Burst time is the time for which source generates packets in a go. It plays important role in performance. Figure 3(3a, 3b, and 3c) shows various performance parameters versus Burst Time. From figure we can observe that routing overload for all protocols decreased with increase in burst time with DSR performing better than others. For reactive protocols route expiry has become less common thus reducing routing overload while for proactive which give constant overload irrespective of load, increasing burst increased data packet thus reduced normalized overhead. Also from graph it can be seen that

With increase in burst time delivery ratio decreases for all protocols as queue overflow might have started. In this case DSDV has outperformed all. Also Average Delay for various Protocols also increased with burst time as packet has to wait more in the queue. In this case OLSR performed better than others.

6. Conclusion

We have presented a detailed performance comparison of important routing protocols for mobile ad hoc wireless networks. AODV and DSR are reactive protocol while DSDV and OLSR are proactive protocols. Both reactive protocols performed well in high mobility scenarios than proactive protocol. High mobility result in highly dynamic topology i.e. frequent route failures and changes. Both proactive protocols fail to respond fast enough to changing topology. Routing overhead in Proactive protocols remain almost constant and OLSR being winner irrespective of mobility while in AODV it increases with increase in mobility.

Both AODV and DSR use reactive approach to route discovery, but with different mechanism. DSR uses source routing and route cache and does not depend on their timer base activity. On other hand AODV uses routing tables, one route per destination, sequence number to maintain route. The general observation from simulation is that DSR has performed well compared to all other protocols in terms of Delivery ratio while AODV outperformed in terms of Average delay. DSR however generates lower overhead than AODV while OLSR and DSDV generate almost constant overhead due proactive nature. Poor performance of DSR in respect of average delay can be accounted to aggressive use of caching and inability to delete stale route. But it seems that caching helps DSR to maintain low overhead.

7. Future Scope

Dynamic source routing protocol is designed for use in multi-hop wireless ad hoc networks of mobile nodes. DSR uses source routing and does not depend on timer based activities. So it is a fully reactive protocol which initiates a route discovery process only when it has data to send. Though there are some disadvantages of this protocol, it is a robust protocol for use in mobile ad hoc network. Our future works will include the modification to the basic DSR so as to reduce the routing overhead for the performance optimization. Our work can be extended to various other protocols like TORA.

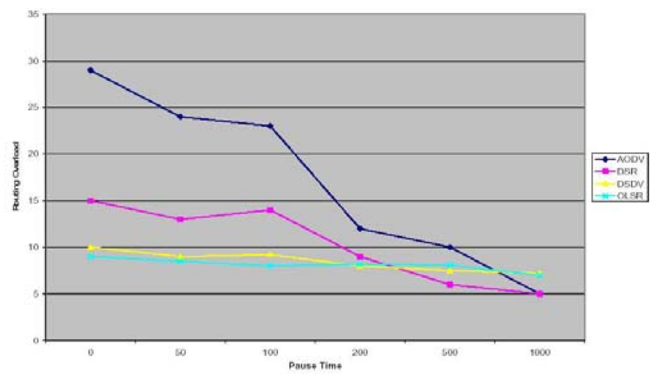

Fig. 1a Routing Overload v/s Pause Time (ms.)

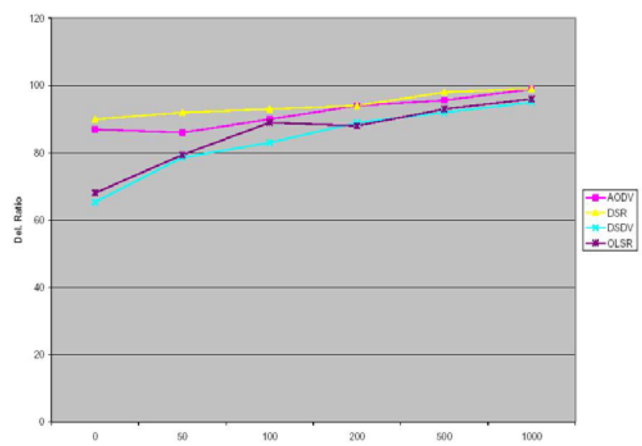

Fig. 1b Delivery Ratio v/s Pause Time (ms.)

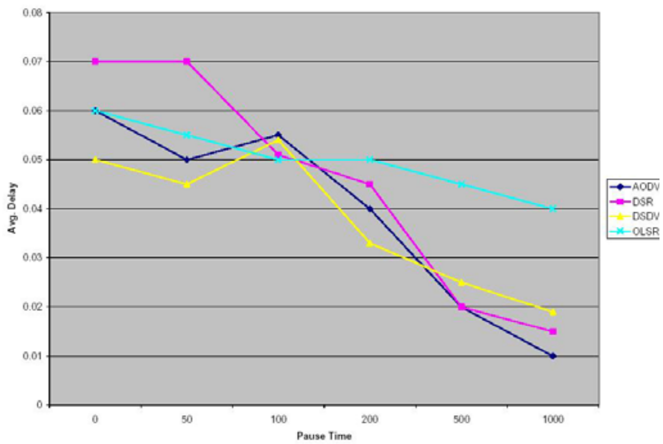

Fig. 1c Average Delay (ms) v/s Pause Time (ms)

Figure 1. Various Performance parameters versus Pause Time

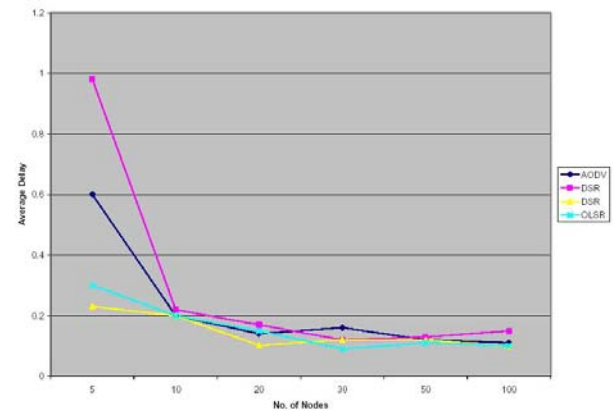

Fig. 2 c Average Delay (ms) v/s No. of nodes

Figure 2. Various Performance Parameter V/s No. of Nodes

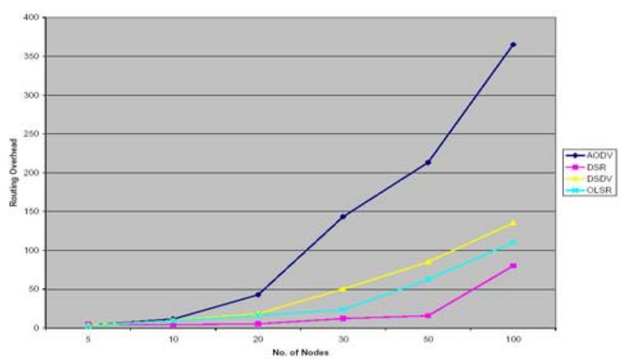

Fig. 2a Routing Overhead v/s No. of Nodes

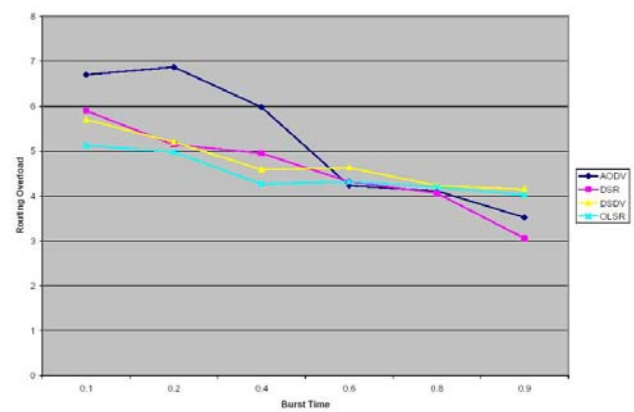

Fig. 3a Routing Overload v/s Burst Time (ms.)

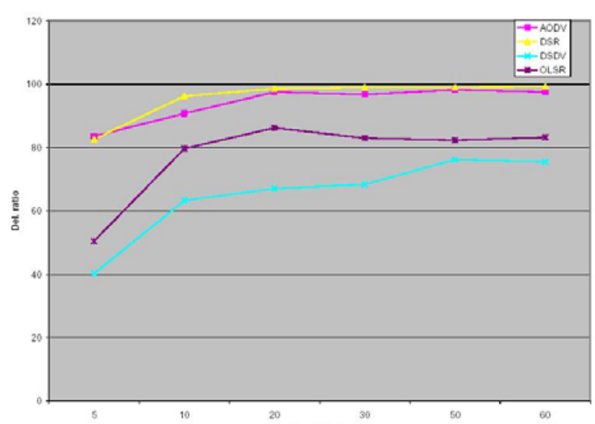

Fig. 2 b Delivery ratio v/s No. of Nodes

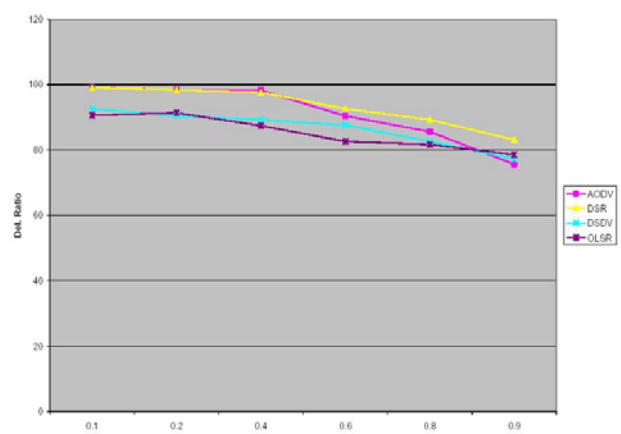

Fig. 3b Del. Ratio v/s Burst Time (ms.)

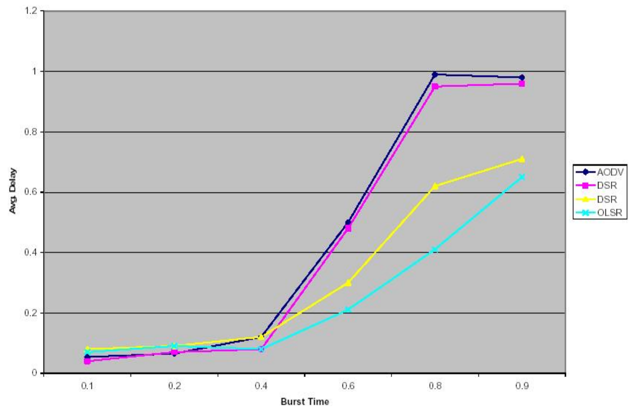

Fig. 3c Average delay (ms) v/s Burst Time (ms)

Figure 3. Various Performance Parameters versus Burst Time

We can also analyze performance of such protocols on the performance parameter like standard deviation, energy consumption, etc.

In this simulation study, we have not used large no of nodes and simulation time was 1000s. Increasing both of them will increase computational time which was limited due to various reasons. Thus, in future we will try to carry out more vigorous simulation so as to gain better understanding of such networks and subsequently helps in development of new protocols or modification in existing protocols.

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