Performance Analysis of Mobile Ad-hoc Network Using AODV Protocol

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Abstract

This research work proposes a new protocol that modifies AODV to improve its Performance using *Ant Colony algorithm*. The mobility behaviour of nodes in the application is modelled by the random waypoint model through which random locations to which a node move are generated, and the associated speed and pause time are specified to control the frequency at which the network topology is changed. The *Optimized-AODV* protocol, incorporates path accumulation during the route discovery process in AODV to attain extra routing information. It is evident from the results that *Optimized-AODV* improves the performance of AODV under conditions of high load and moderate to high mobility.

Keywords: MANET, Optimized-AODV, Ant Colony algorithm (ACO),

1.0 Introduction

Today's Internet has been developed for more than forty years. Recently many researchers are studying networks based on new communication techniques, especially wireless communications. Wireless networks allow hosts to roam without the constraints of wired connections. People can deploy a wireless network easily and quickly. Hosts and routers in a wireless network can move around. Wireless networks play an important role in both military and civilian systems. In the recent years Mobile Ad- hoc network has found applications especially to overcome the limitation of Bandwidth in wireless communication.

One of the main difficulties in MANET (Mobile Ad hoc Network) is the routing problem, which is aggravated by frequent topology changes due to node movement, radio interference and network partitions. Many Routing protocols have been proposed in past and reported in the literature [1]. The proactive approaches attempts to maintain routing information for each node in the network at all times [2, 3], where as the reactive approaches only find new routes when required [5, 6, 7, 8] and other approaches make use of geographical location information for routing [8]. The biological swarms like ants or honeybees often contain thousands of individuals [10, 11, 12]. They perform extraordinarily complex tasks of global optimization and resource allocation using only local information. The wireless network topology is dynamic and unpredictable. Traditional routing protocols used for wired networks cannot be directly applied to most wireless networks[22] because some common assumptions are not valid in this kind of dynamic network, like a node can receive any broadcast message sent by others in the same subnet. The bandwidth in this kind of network is usually limited. Although the researchers have suggested other techniques to enhance the overall network bandwidth by integrating wireless network with Optical network [23]. Thus, this network model introduces great challenges for routing protocols. There are some algorithms that use ant-like mobiles agents to maintain routing and topology discovery for both wired and wireless networks [13]. We focus on improving performance of the reactive ad hoc routing protocols using the ideas from swarm intelligence, particularly the ant colony Meta heuristic.

2.0 AODV System

AODV (Ad-hoc On-demand Distance Vector) is a loop-free routing protocol for ad-hoc networks. It is designed to be self-starting in an environment of mobile nodes, withstanding a variety of network behaviours such as node mobility, link failures and packet losses. The AODV protocol consists of two important mechanisms, Route Discovery and Route Maintenance. AODV is chosen for the obvious reason that it is simple and has a low overhead and its on-demand nature does not unduly burden the networks.
The optimized Ant Colony protocol has been designed using communication based design methodology. The first step in this design flow is the capture of specifications and functional decomposition at the system level.

The optimization of AODV is based on the recent draft of the AODV specification [4]. The essential functionality of AODV includes:

- *RREQ* and *RREP* messages (for route discovery)
- *RERR* messages, HELLO messages, & precursor lists (for route maintenance)
- Sequence numbers
- Hop counts
- Expanding ring search

The following fields exist in each route table entry of AODV:

- *Destination IP Address*: The IP address of the destination for which a route is supplied
- *Destination Sequence Number*: It is associated to the route.
- *Next Hop*: Either the destination itself or an intermediate node designated to forward packets to the destination
- *Hop Count*: The number of hops from the Originator IP Address to the Destination IP Address
- *Lifetime*: The time in milliseconds for which nodes receiving the RREP consider the route to be valid
- *Routing Flags*: The state of the route; up (valid), down (not valid) or in repair.

Suppose S would like to communicate with D Figure 1, the node broadcasts a RREQ to find a route to the destination. S generates a Route Request with destination address, Sequence number and Broadcast ID and sent it to his neighbour nodes. Each node receiving the route request sends a route back (Forward Path) to the node.

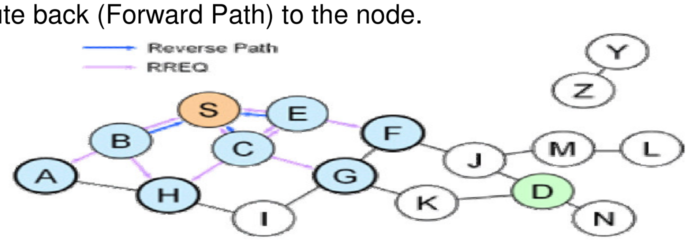

FIGURE 1: Path finding in AODV

A route can be determined when the RREQ reaches a node that offers accessibility to the destination, e.g., the destination itself.

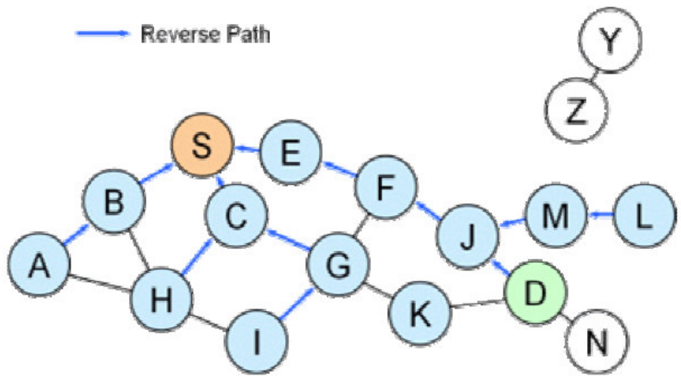

FIGURE 2: Path finding in AODV

The route is made available by unicasting a RREP back to D and is written in the routing table from S Figure 2. After receiving the route reply every node has to update its routing table if the sequence number is more recent.

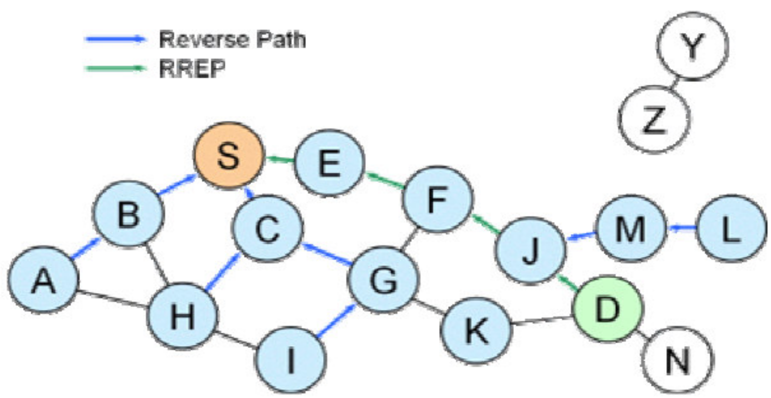

FIGURE 3: Path finding in AODV

Now node S can communicate with node D, Figure 3, 4.

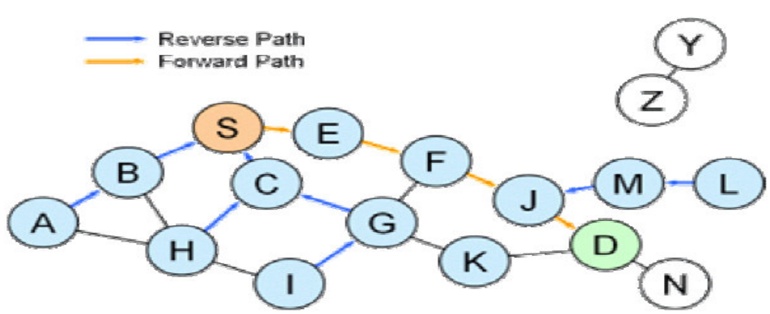

FIGURE 4: Path finding in AODV

When a link break in an active route is detected, the broken link is invalid and a RERR message is sent to other nodes, Figure 5. If the nodes have a route in their routing table with this link, the route will be erased. Node S sends once again a route request to his neighbour nodes. Or a node on the way to the destination can try to find a route to D. That mechanism is called: *Local Route Repair.*

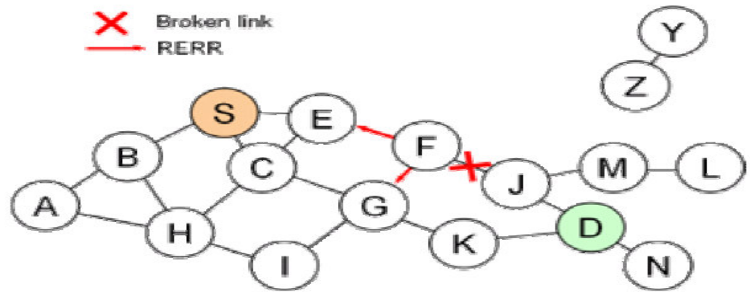

FIGURE 5: Path finding in AODV

The *Ant Colony Algorithm (ACO)* [10, 13] is designed to use the Object oriented tool command language. The following set of core properties characterizes ACO instances for routing problems:

- Provide traffic-adaptive and multi path routing,
- Rely on both passive and active information monitoring and gathering,
- Make use of stochastic components,
- Do not allow local estimates to have global impact,
- Set up paths in a less selfish way than in pure shortest path schemes favouring load balancing,
- Show limited sensitivity to parameter settings.

2.1 Optimized AODV

In the optimized protocol, the interactions of ant like packets are used to proactively maintain the un-expired route connectivity following the stigmergy paradigm. The artificial ants (ant-like packets) are divided into two classes: *forward ant* and *backward ant*. The *forward ants* traverse the network to collect network traffic information, which mimics the ant in the searching mode and the *backward ants* utilize this information to update routing tables and other data structures, which mimics the ant in the carry mode. For simplicity, it is assumed that all of the *forward ants* will eventually find the destination and do not consider the ants in return mode. At the same time as using the proactive process to maintain the unexpired route connectivity, the reactive features of the original AODV protocol are retained for the new route discovery and route error handling.

Simulation Parameters

- IEEE 802.11 is used as the MAC layer protocol.
- The radio model simulates with a nominal bit rate of 2Mbps
- Nominal transmission range of 250 meters.
- The radio propagation model is the two-ray ground model.
- First 100 nodes are deployed for one experiment and then 1000 nodes are used for another experiment in a rectangular field of 3000m X 600m.
- The traffic pattern is CBR (constant bit rate) with a sending rate of 4 packet/seconds and the packet lengths are all 512 bytes.
- The mobility model used is the *Random Waypoint Model*
- Each node moves with a randomly chosen speed uniformly from 1-20 m/sec.
- The *pause time* of the node mobility as the independent variable that reflects the degree of the node mobility. The small pause time means intense node mobility and large pause time means slow node mobility. The ant trip time *T is used* as the reinforcement signal
- The simulations are performed with 7 different pause times 0, 30, 60, 120, 300 and 600 seconds.
- The simulation time is 600 second.

To avoid the broadcast storm problem, the gossip-based probability scheme of [14] is used. The Network Simulator 2 [15, 18] is used as the simulation tool.[17]

3.0 Results and Discussion

The investigation has been carried out by mainly considering the following four different scenarios:
1. The packet delivery ratio
2. The average end-to end delay
3. The normalized routing overhead
4. Throughput

3.1 The packet delivery ratio

With the first scenario the robustness of the routing protocol are compared

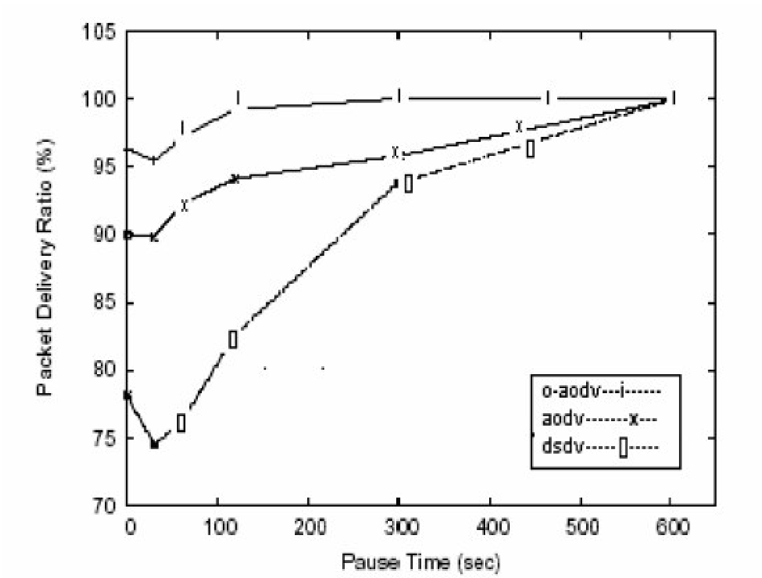

FIGURE 6: Packet Delivery Ratio with 100 nodes

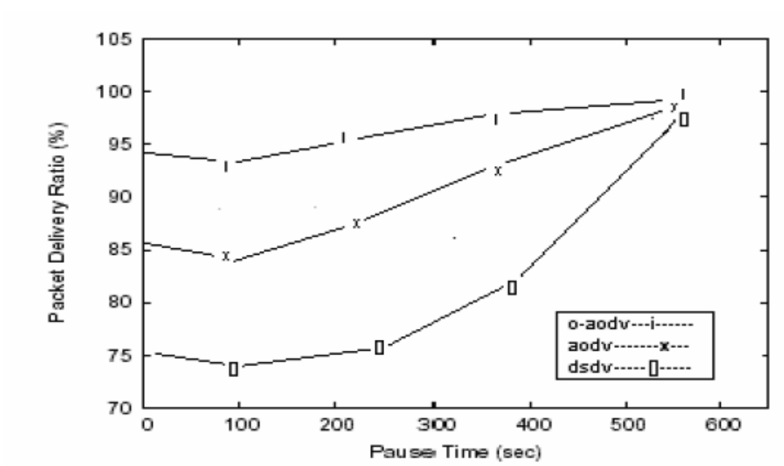

FIGURE 7: Packet Delivery Ratio with 1000 nodes

Fig. 6 and Fig. 7 show the delivery ratio comparisons, for *Optimized-AODV*, AODV and DSDV for 100 nodes and 1000 nodes respectively. In the case of high mobility, only *Optimized-AODV* performs well, delivering most of the data packets. DSDV performs worst due to its simply dropping data packets for which there is no valid route. With the mobility decreasing, the routing status becomes relatively stable. Fig. 7 shows the case of higher node density, in this case performance of DSDV is worst, *and Optimized-AODV* still gives stable performance, as more numbers of paths are available to send the packets. At the low mobility end the performance of all three protocols is close. When nodes are not moving path finding process is not required. Hence we observe that *Optimized-AODV* gives stable results.

3.2 The average end-to end delay

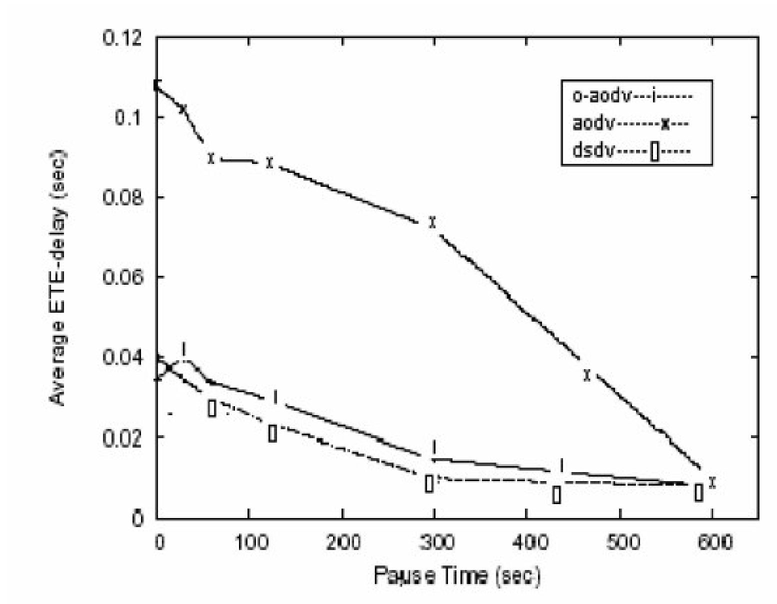

FIGURE 8: Average ETE-delay with 100 nodes

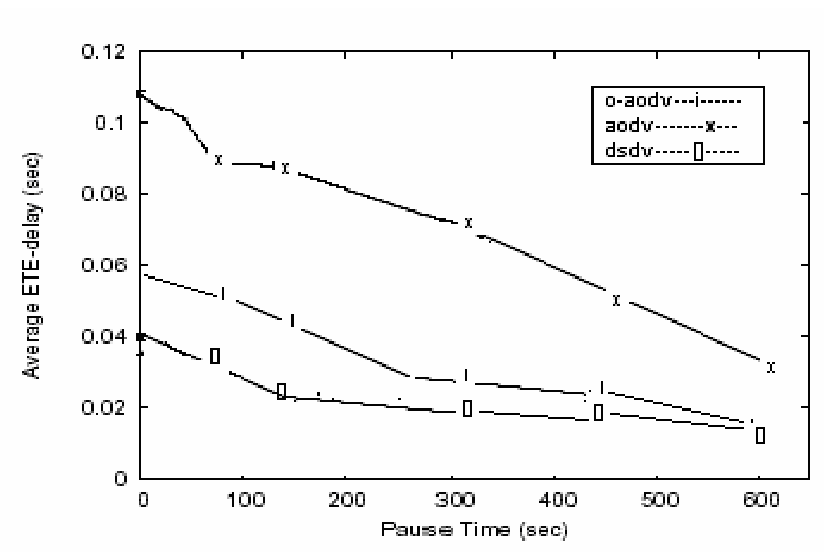

FIGURE 9: Average ETE-delay with 1000 nodes

The quality of service provided by the protocols can be compared with the average delay. Fig.8 and Fig.9 present the comparisons of the average end-to-end delay for *Optimized-AODV*, AODV and DSDV for 100 and 1000 nodes. The average ETE delay decreases with reduced mobility for all three protocols. AODV shows largest delays in situations with high mobility due to its single path nature and inefficient manner to handle route failure. *Optimized-AODV*, on the other hand, shows low delays in all cases. This is because, instead of buffering data packets for a new route to be found, *Optimized-AODV* forwards the data packets through alternative routes. DSDV exhibits a low delay because of its continuous maintenance of routing information and no data buffering for the data without valid routes. With the higher node density, overall end-to-end delay for all the cases increases as number of hopes increases. In these cases the packet needs to cover long distance to reach the destination.

3.3 The normalized routing overhead

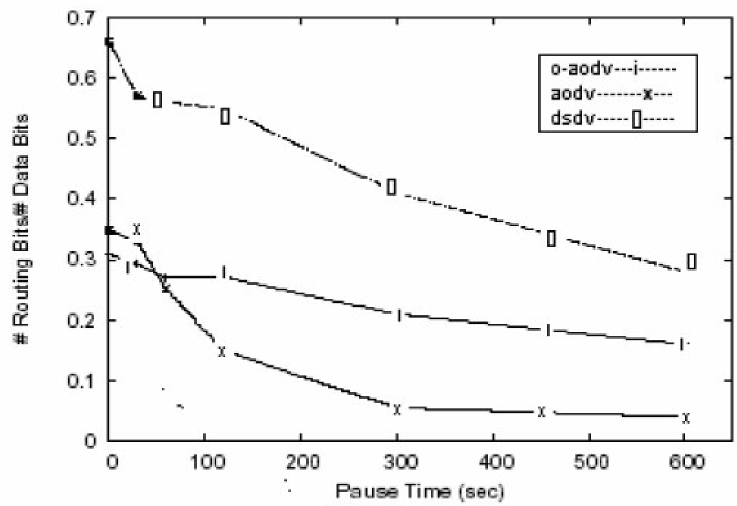

FIGURE 10: Routing Over head with 100 nodes

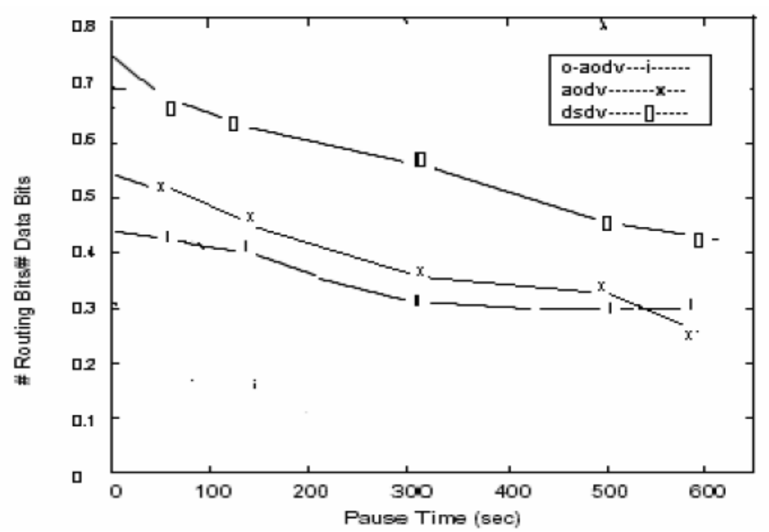

FIGURE 11: Routing Over head with 1000 nodes

Fig. 10 depicts the number of control packets per data packet needed to perform the routing work for *Optimized-AODV*, AODV and DSDV. Bits used for routing, is counted because the different routing protocols generate the routing overhead in very different ways. In the case of very high mobility it is obvious that *Optimized-AODV* creates the least overhead compared with AODV and DSDV. With high node mobility, route failure occurs more frequently, and AODV will cause flooding of large number of route finding packets, while the number of routing packets in *Optimized-AODV* is independent of node mobility. With less mobility, the performance of *Optimized-AODV* still remains stable and the overhead of AODV is slightly less than *Optimized-AODV*. DSDV shows a very high difference in comparison to the other two protocols. In the case of high-density as shown in Fig. 11 over all routing over heads increases. Here *Optimized-AODV* is more advantageous as it gives minimum overheads.

3.4 Throughput

Throughput comparison between three protocols with 300 pause time

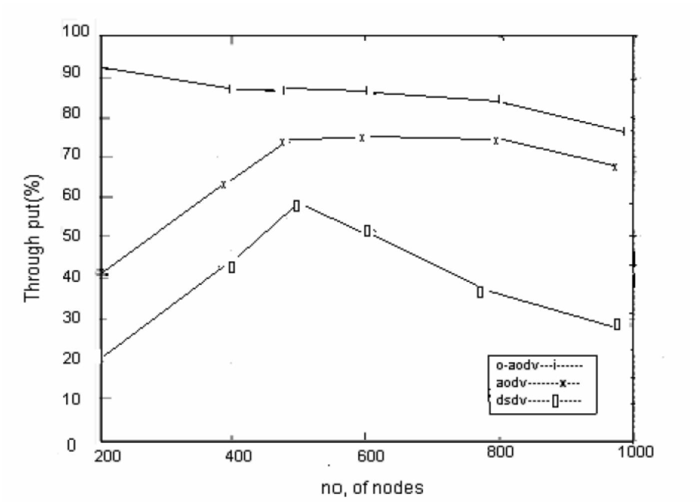

FIGURE 12: Throughput comparison

Fig. 12 shows the throughput comparison of three different protocols. *Optimized–AODV* shows approximately constant graph indicating the scalability of protocol. With the change in density its throughput is stable. In case of AODV protocol when number of nodes increases, initially throughput increases as large number of routes are available but after a certain limit throughput becomes stable due to increase in end-to-end delay. DSDV gives comparatively lower throughput as the large number of routing bits is required. Increase in overhead reduces the throughput.

The above investigation and subsequent discussion reveals that *optimized-AODV* is capable of overcoming the limitations posses by AODV and DSDV algorithms. Our study therefore recommends optimized-AODV protocol for routing of data at different dynamic nodes of large mobile ad hoc network.

4.0 Conclusion and Future scope

During the study of packet delivery ratio of data packets, *Optimized-AODV* scales better than AODV in large networks. The performance of *Optimized-AODV* remains stable, for low node density as well as in the high node density. At the low mobility end the performance of all three protocols is close. When nodes are not moving path finding process is not required. During the study of End to End delay, *Optimized-AODV* shows low delays in all cases, as instead of buffering data packets for a new route to be found, *Optimized-AODV* forwards the data packets through alternative routes. During the study of routing overhead, it was found that with high node mobility route failure occurs more frequently, and AODV will cause flooding of large number of route finding packets, while the number of routing packets in *Optimized-AODV* is independent of node mobility. With less mobility, the performance of *Optimized-AODV* still remains stable and the overhead of AODV is slightly less than *Optimized-AODV*. DSDV shows a very high difference in comparison to the other two protocols. In the throughput comparison, *Optimized–AODV* shows approximately constant graph, which indicates the scalability of *Optimized-AODV* protocol. With the change in density its throughput is stable. In case of AODV protocol when number of nodes increases, initially throughput increases as large number of routes are available, after a certain limit throughput becomes stable due to increase in end-to-end delay. DSDV gives comparatively lower throughput as the large number of routing bits is required. Increase in overhead reduces the throughput. The difference in the routing load of *Optimized-AODV* and DSDV decreases with an increase in the load. *Optimized-AODV* can be used either as an alternative to AODV or as an optimization under moderate to high load scenarios. Based on these simulated results, it is clear that the *Optimized-AODV* could also be suitable if overall routing load or if the application oriented metrics such as delay and packet delivery ratio are important consideration for the ad hoc network application. Optimized AODV is recommended as a better protocol especially for large Mobile Ad hoc Networks.

This protocol can be tested for real data set. We have discussed the behaviour of our proposed ant algorithm with mobility model that represent multiple mobile nodes MANETs whose actions are completely independent of each other. One of our future research studies is the study of the behaviour of our proposed algorithm with mobility models such as Point Group Mobility model which represents multiple MANETs moving together [20] and similar swarm based clustering [19,21].

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