Caching Strategies in MANET Routing Protocols

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Abstract- Route cache strategy is important in an on demand routing protocol in wireless mobile ad hoc networks. In on demand routing protocol the route discovery mechanism is used to transmit packets from one mobile node to other. In order to avoid such route discovery mechanism each time when the packet is transmitted, the route caching technique is used. Route caching is the major approach to decrease the flooding of the network by avoiding the route discovery operation as much as possible. Because the frequently use of route discovery mechanism is very costly in terms of delay and bandwidth consumption which can cause congestion and long delay. Therefore the efficient caching strategies have the great impact on the performance of the DSR and AODV routing protocol. This paper, presented the effect of the cache expiry time and active route timeout (ART) on the performance of the DSR and AODV routing protocols in terms of route discovery time, routing traffic overhead and throughput. The simulation results indicate that the performance of the DSR and AODV protocol decreases if we increase the cache size and ART parameters.

Index Terms- MANET, DSR, Route Cache, Cache Expiry time, Cache Size.

I. INTRODUCTION

Mobile ad hoc network is the important topic of research. Mobile ad hoc network is collections of wireless nodes that can allow people and devices to communicate with each other without help of an existing infrastructure. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. In MANET the mobile node can be work as a router or host. Because they are independent of any infrastructure therefore are used in military communication and rescue operations where the development of an infrastructure is neither feasible nor cost effective. There are three categories of Mobile ad hoc network routing protocols, which are Proactive (or periodic) routing protocols (DSDV, OLSR), reactive (or on demand) routing protocols (DSR, AODV, TORA) and hybrid routing protocols. Proactive routing protocols maintain the routes independent of the traffic pattern. On the other hand reactive routing protocols determine the route only if needed. Hybrid routing protocol (ZRP) combined the advantages of proactive and reactive routing. Reactive routing protocols have less overhead since routes are maintained only if they are needed but proactive routing protocols have higher overhead due to continuous route updating.

II. DSR PROTOCOL

Dynamic Source Routing (DSR) is a reactive, flexible and simple protocol. DSR is on demand routing protocol and uses the concept of source routing instead of routing tables like other protocols. When source node send packets to the destination node, the different packets may follow the different routes, even they have same source and destination. DSR allow the packets to be travel loop-free and avoid the need for updating routing information in the routing tables periodically that is required in table-driven approach. Therefore DSR routing protocol reduce the bandwidth consumption by the control packets in ad hoc mobile networks. The major difference between this and the other on-demand routing protocols is that it is beacon-less and hence does not require periodic hello packet (beacon) transmissions, which are used by a node to inform its neighbors of its presence. The DSR protocol is composed of two main mechanisms Route Discovery and Route Maintenance. When any mobile node or source node want to send a packet to any other node known as destination node and does not know a route to it, the source node initiates the route discovery. To initiate the Route Discovery, the source node floods a “Route Request” with a unique ID as a single local broadcast packet. DSR protocol implements the route maintenance mechanism while communicating the packets from source to destination. But when the communication link between the source and the destination is broken or else a change in network topology is noticed. It will lead to failure of the communication between source node and destination node. In this scenario DSR protocols uses the route maintenance mechanism, to detect any other possible known route towards the destination to transmit data. If the route maintenance fails to find an alternative known route to establish the communication then it will invoke the route discovery to find the new route to destination.

The Dynamic Source Routing (DSR) protocol is based on source routing, which means that the originator of each packet determines an ordered list nodes through which packet must pass while traveling to the destination. Flooding method is used in DSR protocol for route discovery, which cause the traffic load on the network. To decrease the flooding of the network Route Caching is used and the overall performance of the network can be significantly increased.

III. AODV PROTOCOL

AODV routing algorithm is a routing protocol design for mobile Ad-hoc networks and is using on-demand routing approach for establishment of route between nodes. As it uses on-demand routing therefore it built route to transmit data packets when the source node desired and is trying to maintain

ISSN 2250-3153

established route as long as they are needed. AODV protocol has quality to support unicast, multicast and broadcast routing with loop free, self starting and scalable characteristics. AODV protocol routes data packets between mobile nodes of ad hoc network. This protocol allows mobile nodes to pass data packets to required destination node through neighbor's node which cannot directly communicate. Nodes of network periodically exchange information of distance table to their neighbors and ready for immediate updates. AODV protocol is responsible to select shortest and loop free route from table to transfer data packets. In case of errors or changes in selected route, AODV is able to create a new route for the rest of transmission of establishment and maintenance. Route Management AODV routing protocol in ad hoc network communicate between mobile nodes through four types of different messages.

- Route Request
- Route Reply
- Route Error
- Hello Message

To establish a route between source and destination node Route Request (RREQ) and Route Reply (RREP) packet query cycle are used. Route Error (REER) and HELLO data packets are used for route maintenance.

IV. ROUTE CACHING

Route caching is carried out for two purposes; firstly, a cached route is readily available to the demanding node thus reducing the routing latency significantly. This is particularly important in real time communication like audio and video transmissions. Secondly, route caching avoids route discovery process and in that way reduces the control traffic that is required in searching for a new route. Route caching store the routes that have learned from the source node and avoid unnecessary route discovery operation that required each time a data packet is to be transmitted. Because that reinitiating of a route discovery mechanism in on demand routing protocols is very costly in term of delay, battery power, and bandwidth consumption due to flooding of the network, which can cause long delay before the first data packet sent. The performance of protocols mainly depends on an efficient implementation of route cache. Despite the advantage of reducing the route latency, prolonged caching may render the route obsolete due to frequent movement of the destination or intermediate node(s) in MANETs. When an invalid route cache is used, extra traffic overheads and routing delays are incurred to discover the broken links. One approach to minimize the effect of invalid route cache is to purge the cache entry after some Time-to-Live (TTL) interval. If the TTL is set too small, valid routes are likely to be discarded, and large routing delays and traffic overheads may result due to the new route search. On the other hand, if the TTL is set too large, invalid route-caches are likely to be used, and additional routing delays and traffic overheads may result before the broken route is discovered. Thus the efficiency of route caching lay between two contradictory conditions, how long the route has to be stored for subsequent use and how often to purge the same in order to avoid invalid routes. The aim in both cases is to avoid overheads and consequently save bandwidth and route latency.

V. RELATED WORK

B.S. Kawish et al. [1] described that the user defined interface to adjust the ART in AODV will have profound effects on the overall efficiency of the protocol. It will also improve the computational efficiency of nodes by saving it from processing routes during the defined fixed period.

Mobile ad hoc networks are power constrained as most ad hoc mobile nodes today operate with limited battery power. Hence power consumption becomes an important issue. It is important to minimize the power consumption of the entire network in order to maximize the lifetime of ad hoc networks. To accomplish this to a certain extent, **M. Tamilarasi et al. [6]** proposed Energy Aware Approach (EAA). This approach is a two-pronged strategy with load balancing approach and transmission power control approach. From simulation results they concluded that EAA AODV on an average reduces energy consumption per node by 20% and control packet load by 10% and increases the packet delivery ratio by 3.5% compared to standard AODV. The price paid for this improvement is the 52% increase in average end-to-end delay due to the inclusion of extra information in the packet header. EAA AODV decreases the number of control packets, increases the packet delivery ratio and reduces power consumption.

Fenglien Lee et al. [3] developed an efficient on-demand routing algorithm, called OCR-"On-Demand Routing Algorithm", for route discovery and management, and mobility handling. They applied the content-addressable and LRU replacement features in L-1(level one or primary) or L-2(level-2 or secondary) caches for route table creation, updating, and maintenance. The OCR algorithm with double-level route caches solved most problems in on-demand routing, such as route tables in "slow" main memory, long connection setup delay, broken link repairing, huge routing overhead for long routes, lengthy data packet in source routing, sending beacons periodically, control overhead for complicated IDs in data packets, to setup TTL (time to live) in a packet or route path, and to update the stale routes in the route table or cache frequency.

Shobha K.R. et al. [6] presents an analysis of the effect of intelligent caching in non clustered network, using on demand routing protocol. In Intelligent Caching technique a node not only saves the path discovered during route discovery for itself but also for others who are located close to it. This technique reduces the number of route request packets unnecessarily circulating in the network, when the path it requires is present in its neighborhood. This technique drastically increase the available memory for caching the routes discovered without affecting the performance of the DSR protocol in any way except for a small increase in end to end delay.

To avoid performing route discovery mechanism before each data packet is sent, DSR needs to formerly cache the routes discovered. **T.C. Huang et al.** proposed two mechanisms to improve cache performance of DSR: RERR-Enhance mechanism and hierarchical link cache structure as described in [**8],** the average end to end delays and routing overhead is improved with these mechanisms.

The route cache is used in DSR protocol to store all the routes are learned from the source node and to avoid unnecessary route discovery process. **Naseer Ali Husieen et al.** described in [3] with high mobility situations and high load network traffic stale routes will be generated. These stale routes can mainly affect the performance of DSR protocol which cause long delay, increase the packet loss, increase the overhead and reduce the efficiency of protocol. Therefore efficient mechanism for updating the route in the cache of DSR protocol is needed.

Shukla et al. [7] proposed new route cache maintenance in DSR protocol in order to improve the performance of the DSR protocol. This was achieved by allowing nodes to learn about the route caches of neighbors' nodes, instead of sending route error packets to the source, due to link failure, before forwarding the packet to the destination.

VI. SIMULATION FRMEWORK

Simulation is done using OPNET Modeler 14.5 simulator tool. OPNET 14.5 is a network modeling and simulation software tool. OPNET Modeler 14.5 executes four phases in order to complete a simulation process. These phases are: modeling of the network, choosing the required parameters, running the simulation of the created model, and viewing and analysis of the results.

VII. SIMULATION PARAMETERS AND RESULTS

Simulation was done for a campus sized network. The mobile nodes have a common traffic source generated by a MANET traffic generator and they are WLAN mobile clients transmitting a power of 0.1W and a data rate of 11Mbps. The traffic generator also has a data rate of 11Mbps but a transmitting power of 0.5W. Application configuration is used to supporting applications as HTTP (heavy browsing). Profile configuration is used for configuring the user profiles and objet profiles. Mobility configuration is used configuring the objects. Random waypoint mobility model was used for the simulation. This model ensures that the mobile nodes are configured with mobility status.

Table 1. Simulation Parameters

Simulation Area	700X700 m
Data Rate	11Mbps
Operational Mode	802.11b
Routing Protocol	AODV
Start Time	20 sec
Pause Time	240 sec
Transmit Power	0.1 W
Bit rate	Constant
Packet Size(bits)	Uniform(140,160)
Mobility Model	Random waypoint
Nodes speed	10 m/s
Simulation time	5 min

We consider the different scenarios having varying Active Route Timeout (ART) and cache size. The performance of AODV and DSR routing protocol is evaluated in terms of route discovery time, routing traffic overhead and throughput. Simulation is done for 20, 30 and 50 nodes and 80 nodes.

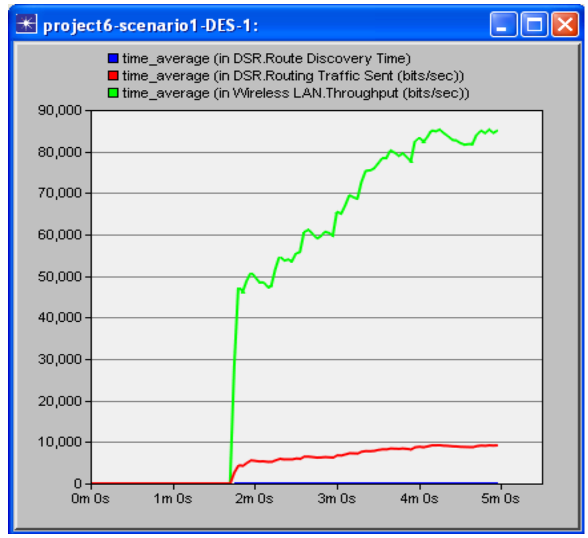

Fig.1 Performance of DSR protocol for 20 nodes having cache size 10 and cache expiry time 10

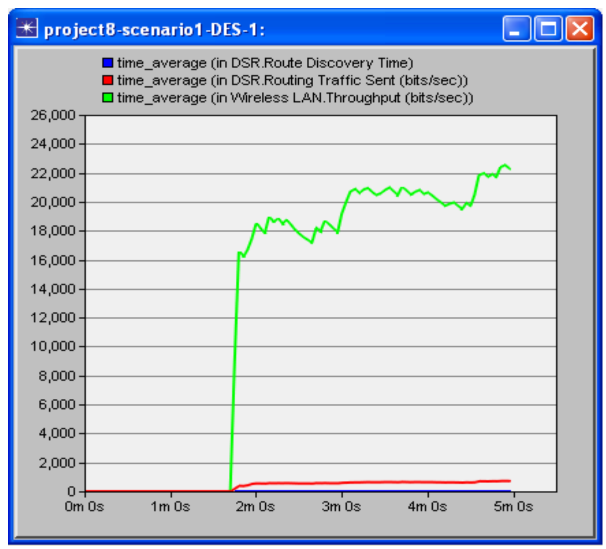

Fig.2 Performance of DSR protocol for 20 nodes having cache size 15 and cache expiry time 10

Figure 1 and 2 shows the results for 20 nodes with cache size 10 routes, cache expiry time 10 seconds and cache size 15 routes and cache expiry time 10 seconds respectivelly. Green line indicates the throughput, red line ndicates the traffic overhead and blue line indicates the route discovery time. Iin figure 1 the value of throughput is nearabout 85,000 bits/sec but in figure 2 the value is aproximate 22,000 bits/sec. Terefore throughput decreases from 85,000 bits/sec to 22,000 bits/sec with increase in cache size. The traffic overhead increases to its maximum value and then becomes constent as red line indicates in figure 2. The blue line indicates the route discovery time which is very less or negligible because routes are alreasdy stored in the route cache

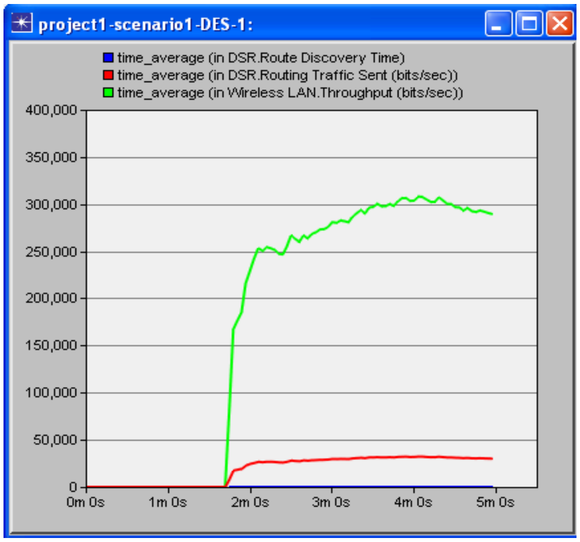

Fig.3 Performance of DSR protocol for 30 nodes having cache size 10 and cache expiry time 10

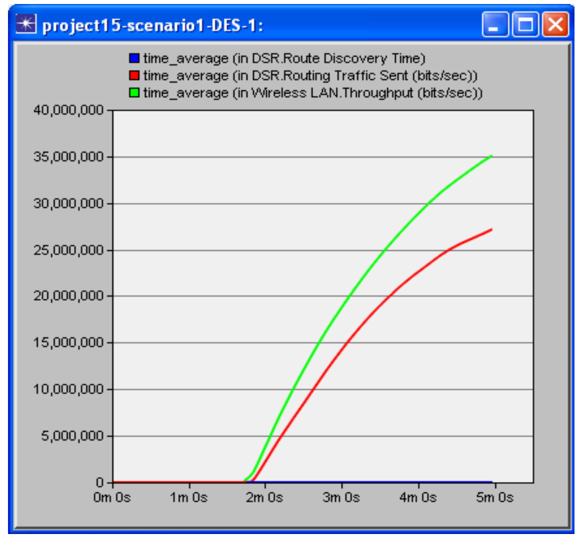

Fig.5 Performance of DSR protocol for 80 nodes having cache size 10 and cache expiry time 10

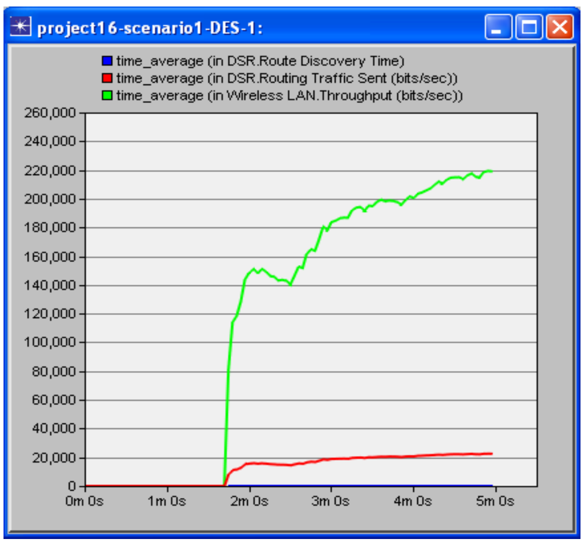

Fig.4 Performance of DSR protocol for 30 nodes having cache size 15 and cache expiry time 10

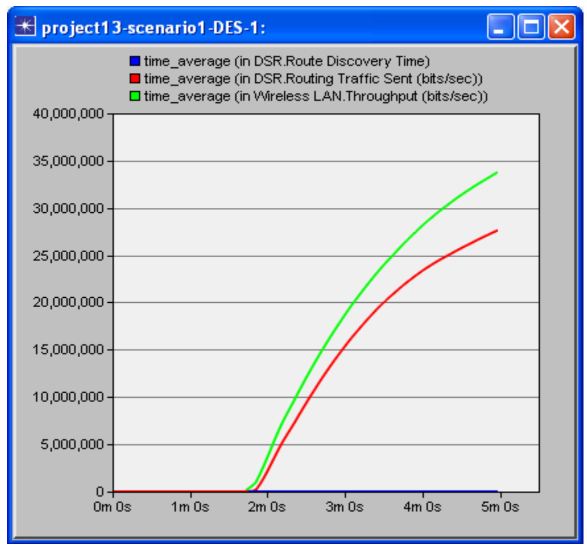

Fig.6 Performance of DSR protocol for 80 nodes having cache size 15 and cache expiry time 10

Fig. 3 and 4 show the results for 30 nodes having cache size 10 and 15 respectively. Green line indicates the throughput which is 300,000 bits/sec for cache size 10 but decreases to 220,000 bits/sec for cache size 15 as shown in fig. 4. The blue line indicates the route discovery time which is very less or negligible because routes are alreasdy stored in the route cache. Traffic overhead is indicated by red line which reduced from 35,000 bits/sec to 21,000 bits/sec with increase in cache size.

Fig. 5 and 6 shows the results for 80 nodes. Results from these figures shows that with increase in the cache size, the traffic overhead reduced but throughput decreases. Value of throughput is 35,000,000 bits/sec for 80 nodes having cache size 10 and expiry time 10 (fig. 5), but reduces to 34,000,000 bits/sec as shown in fig. 6. Red line indicate the routing traffic overhead which shows that routing traffic overhead increases as the number of nodes increases within the network as shown in figure 5 and 6. The blue line indicates the route discovery time which is very less or negligible because routes are alreasdy stored in the route cache.

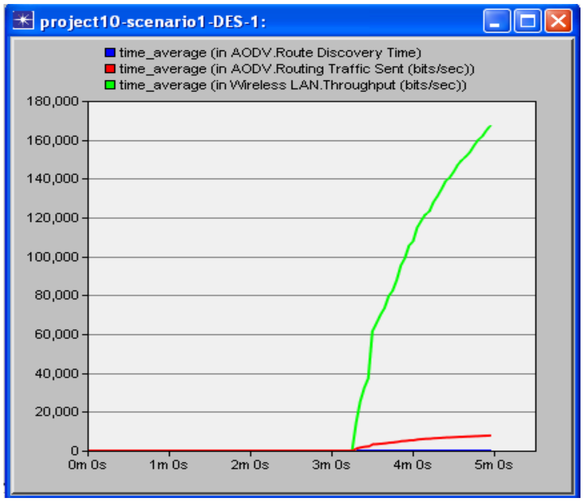

Fig.7 Performance of AODV protocol for 30 nodes having ART=20

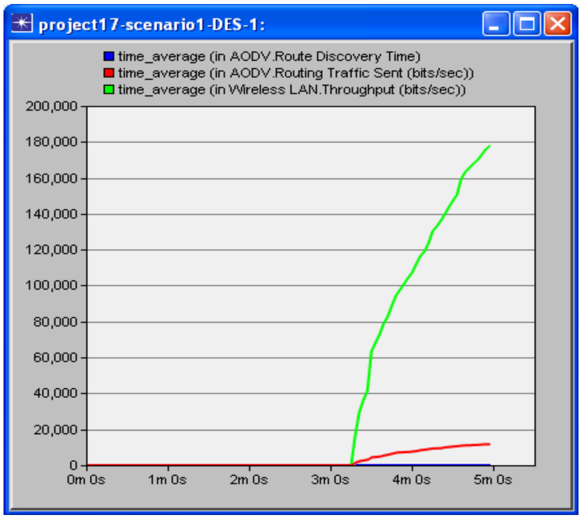

Fig.8 Performance of AODV protocol for 30 nodes having ART=15

Fig. 7 and 8 show the results for AODV protocol with 30 nodes having ART value 20 and 15 respectively. The green line indicates the throughput, red line indicates traffic overhead and blue line indicates the route discovery time. Caching reduces the discovery time as the blue line indicates in the fig. 8. Value of throughput is 180,000 bits/sec and traffic overhead is 18,000 bits/sec with ART value 15 but throughput decreases to 168,000 bits/sec and traffic overhead reduces to 8,000 bits/sec as ART value is increases to 20 seconds.

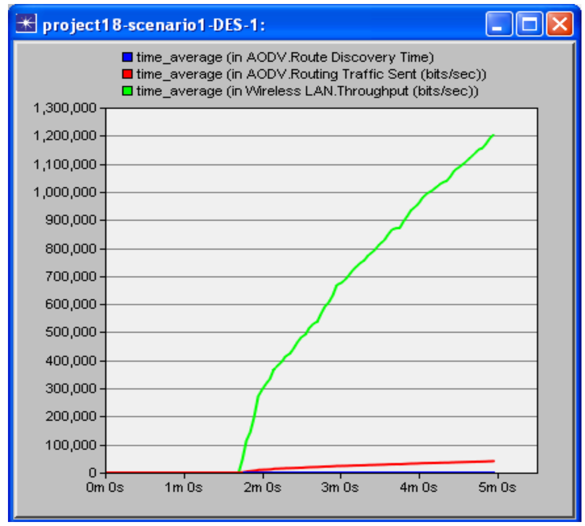

Fig.9 Performance of AODV protocol for 50 nodes having ART=15

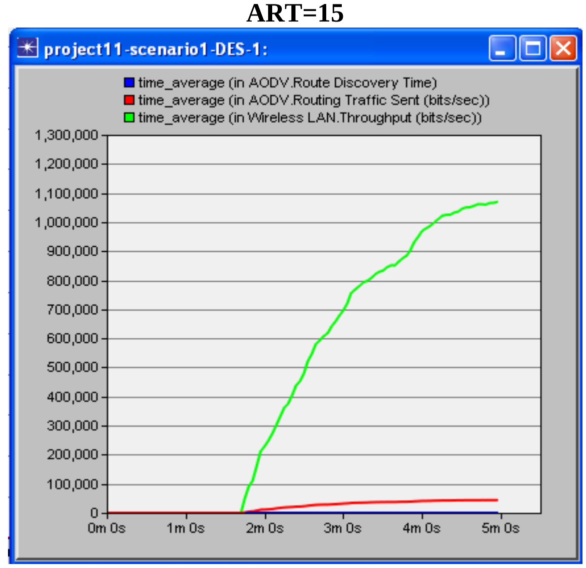

Fig.10 Performance of AODV protocol for 50 nodes having ART=25

Fig. 9 and 10 show the results for AODV protocol having 50 nodes with ART 15 and 25 seconds respectively. The value of throughput is 1,200,000 bits/sec and the routing traffic overhead is 48,000 bits/sec approximately for ART value 15. Throughput indicated by the green line in the graph as shown by fig. 10 is approximately 1,100,000 bits/sec. Therefore throughput decreases from 1,200,000 bits/sec to 1,100,000 bits/sec with increase in ART value.

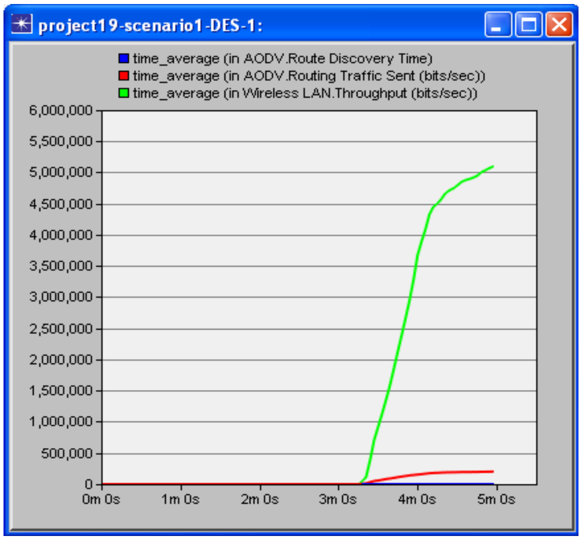

Fig.11 Performance of AODV protocol for 80 nodes having ART=10

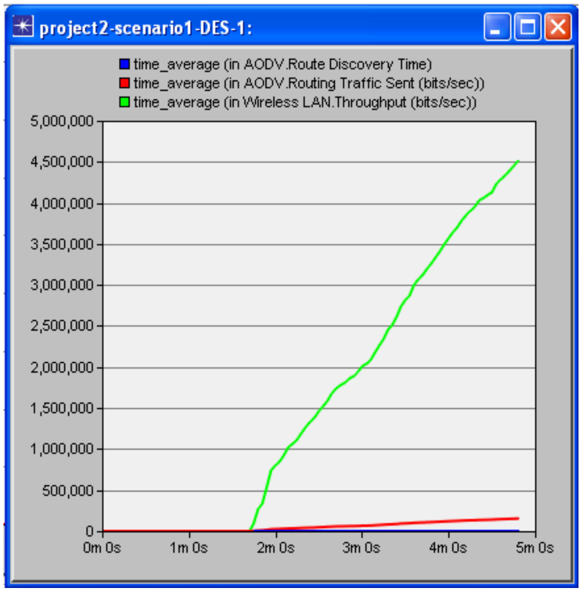

Fig.12 Performance of AODV protocol for 80 nodes having ART=25

Fig. 11 and 12 show the results for 80 nodes having ART value 10 and 25 respectively. Throughput of the AODV protocol for ART value 10 seconds is 5,100,000 bits/sec indicated by green line and traffic overhead is 25,000 bits/sec indicated by red line but for ART value 25, throughput is 4,500,000 bits/sec and traffic overhead is 23,000 bits/sec. Therefore the results indicate that if the ART value increases the throughput of the protocol decreases but the routing traffic overhead reduced. The route discovery time reduces to minimum value due to caching. The blue line indicates the route discovery time which is very less or negligible because routes are alreasdy stored in the route cache.

VIII. CONCLUSION

Route caching is the major approach to decrease the flooding of the network by avoiding the route discovery operation due to this congestion and long delay are also decreases. Therefore the efficient caching strategies have the great impact on the performance of the AODV and DSR routing protocol. In general, our intuition was that the larger the value of cache size and ART parameter, the better the routing protocol should perform. However, smaller cache size and ART value actually can have an indirect effect in improving performance. By increasing the cache size and ART parameter, throughput decreases because of stale routes that are generated in the cache, due to the mobility of the nodes which decrease the performance of the routing protocol.

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