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Performance Evaluation of Quality of Service in Proposed Routing Protocol Ds-Aodv

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PERFORMANCEEVALUATIONOFQUALITYOFSERVICEINPROPOSEDROUTINGPROTOCOLDSAODV

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I. Introduction

The popularity of wireless portable and computing capable devices has made possible the dream of "Anytime and anywhere communication". Users can remain connected to the world while being on the move. This is mobile computing or ubiquitous computing or nomadic computing. Mobile Ad-hoc Networks, popularly called as MANETs, are infrastructure-less, multihop networks without any physical connections. MANETs consists of a number of mobile hosts that are connected by means of wireless links. These MANET nodes acts as routers and are themselves responsible for forwarding packets within a MANET without the need of a centralized authority. The key feature of Mobile Ad-hoc Networks is its easiness of deployment. As a result, establishing a correct and efficient routing protocol for MANETs is quite a challenging task to accomplish since traditional routing protocols may not be suitable for MANETs. Routing protocol design for MANETs is therefore, an active field of research.

II. Mobile ad-hoc Network

A Mobile Ad-hoc Network is a network consisting of a number of mobile hosts, also called MANET nodes, which communicate with each other over wireless channels without the need of base stations or any other centralized authority.

The interest in this field of research has been growing hugely over the last 20 years. MANETs provide wireless communication that is highly mobile, spontaneous and robust [1] in scenarios where it's not possible or quite difficult to provide centralized infrastructure, for example, Vehicle to vehicle networks (VANETs), battlefield communications, disaster recovery operations etc. MANET nodes are characterized by limited resources like limited battery, processing ability, memory, constrained bandwidth etc.[2]. Hence, designing a reliable routing strategy that efficiently uses these confined resources is quite a difficult task. In these networks, all nodes themselves act as routers and are responsible for forwarding and routing operations.

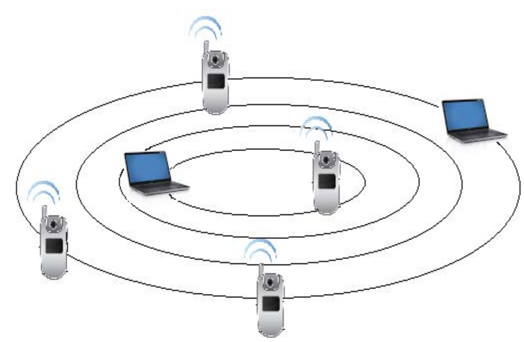

Figure 1 : A typical MANET system

a) *Characteristics*

Mobile Ad-hoc Networks are mainly characterized by:

i. *Scant Resources:* The wireless channels between MANET nodes have lower capacities compared to those in wired networks. Also, due to signal fading, noise and interference, the link capacity available is often lower than the total capacity of channel. Therefore, network congestions are more common phenomenon in these networks compared to fixed networks [3].

ii. *Decentralized Architecture:* Due to dynamic nature of MANETs, hosts are organized in a decentralized manner. Such architecture presents its usefulness by increasing ability to recover in case of breakdown and at the same time posing harder challenges in designing capable and effective protocols.

iii. *Continuous changing Topologies:* MANET hosts can freely move and due to their arbitrary movement, their topology will be changed frequently and repeatedly.

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b) MANET Routing Taxonomy

With these goals in mind, several strategies for routing have been designed for Mobile Ad-hoc Networks. The proposed routing protocols fall into two broad categories:

- Reactive (On demand) approach
- Proactive (table driven) approach

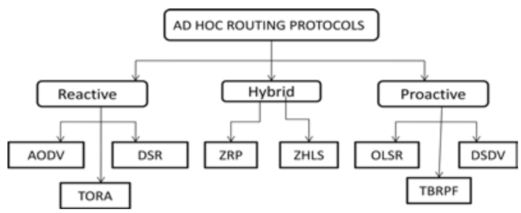

Figure 2 : Classification of routing protocols in MANETs

c) Ad-hoc On-demand Distance Vector (AODV) routing protocol

The Ad-hoc On-demand Distance Vector protocol is an ad-hoc network routing protocol that is purely reactive in nature because no routing tables are needed by the nodes to maintain any routing information. AODV is based upon DSDV and DSR routing protocols [2]. Being an on-demand protocol, AODV maintains information only "active" routes.

In AODV, a node can either be a source or a destination or an intermediate node. AODV inherits and enhances some of the typical features of DSDV protocol like periodic beaconing, multihop routing between participating nodes and sequence numbers.

AODV accomplishes the complete process of routing through the following two mechanisms:

- Route Discovery
- Route Maintenance

i) *Route Discovery*

AODV uses a combination of two messages for accomplishing route discovery in Mobile Ad-hoc Networks:

- Route Request (RREQ)
- Route Reply (RREP)

When a source node wants to establish a connection with a destination for data transmission, it sends the RREQ message to all its immediate neighbours. RREQ contains the IP address of the source and the destination, a pair of fields related to sequence numbers and a hop count field initialized to zero. Each RREQ message is uniquely identified by a RREQ ID which goes on increasing with each newly generated RREQ in the network [6]. If a node receives an already processed RREQ via some other neighbor node, it is discarded. The source broadcasts this RREQ to its immediate neighbours. The neighbor nodes on receiving the RREQ, generates a backward route to the initiating source. Also, the hop count (distance from source node) in RREQ message format is increased by one.

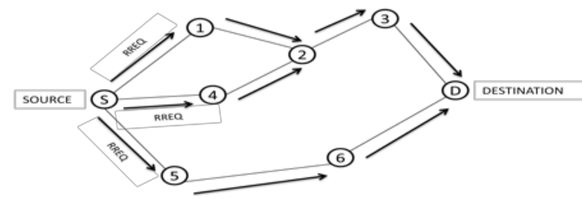

Figure 3 : Flooding of Route Request (RREQ) packet

On the other hand, if the node receiving the RREQ is itself the destination or it does have an unexpired route to the required destination with the sequence number of the path to that destination (indicated in node's routing table) greater than or equal to the sequence number mentioned in the RREQ message, the node creates a Route Reply (RREP) message and transmit that on the backward route it created towards the node that sent RREQ. Hence, the backward node that was created during RREQ broadcast from source is now utilized for sending RREP back to the source node.

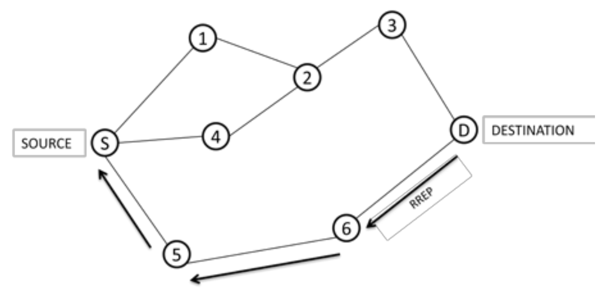

Figure 4 : Propagation of Route Reply (RREP) packet

As soon as the source node receives an RREP from the destination, the source start utilizing the discovered path for transmission of data packets, till it expires or the topology changes.

III. Quality of Service in Manets

With the proliferation of inexpensive and infrastructure-less mobile ad hoc networks (MANETs), research focus has shifted to issues related to security and quality of service (QoS) in these networks. MANETs are collections of mobile hosts (also called nodes), which are self-configurable, self-organizing, and self-maintainable. The nodes communicate with each other through wireless channels with no centralized control. Mobile hosts can move, leave, and join the network whenever they want, and routes need to be updated frequently because of the dynamic network topology [7].

In MANETs, one of the important issues is routing, that is, finding a suitable path from a source to a destination. Because of the rapid growth in the use of applications, such as online gaming, audio/video streaming, voice-over IP (VoIP), and other multimedia streaming applications in MANETs. It is mandatory to provide the required level of QoS for reliable delivery of data. In particular, it is important for routing protocols to provide QoS guarantees in terms of metrics, such as achievable throughput, delay, packet loss ratio, and jitter.

Despite the large number of routing solutions available in MANETs, their practical implementation and use in the real world is still limited. Multimedia and other delay- or error-sensitive applications that attract a mass number of users toward the use of MANETs have led to the realization that best-effort routing protocols are not adequate for them. Because of the dynamic topology and physical characteristics of MANETs, providing guaranteed QoS in terms of achievable throughput, delay, jitter, and packet loss ratio is not practical. So QoS adaptation and soft QoS have been proposed instead [8]. Soft QoS means failure to meet QoS is allowed for certain cases, such as when a route breaks or the network becomes partitioned [8].

QoS in MANETs is defined as a set of service requirements that should be satisfied by the network when a stream of packets is routed from a source to a destination [9]. A data session can be characterized by a set of measurable requirements, such as maximum delay, minimum bandwidth, minimum packet delivery ratio, and maximum jitter. All the QoS metrics are checked at the time of connection establishment, and once a connection is accepted, the network has to ensure that the QoS requirements of the data session are met throughout the connection duration [10].

Delay aware protocols reckon delay as the chief QOS metric for discovering routes for a source-destination pair, i.e., the paths are selected based on delay constraints provided by the application. Delay can be in the form of routing delay, end to end delay, propagation delay, delay jitter etc. [11]. A major issue with the routing strategies in current scenario is that they are not designed to support QOS metrics, hence delay aware protocols comes into picture to deal with this problem.

a) QOS provisioning in MANETs: Issues

The performance of QOS based solutions is hugely influenced by several design issues. In earlier routing protocols, no provision for QOS support existed. For an application to be QOS enabled, a route with ample resources to fulfill rigid QOS demands should be used.

b) Route Discovery

In this section, we will elaborate the working of our proposed protocol DS-AODV, focusing mainly on the route discovery, since route maintenance operation in DS-AODV will be same as that in the traditional AODV routing protocol. The DS-AODV protocol searches all available routes between a source and destination that lies within the specified delay constraints. The applications running at source and destination specifies their maximum allowable delay thresholds in the RREQ and RREP messages respectively during the route discovery operation. This is specified in the extra added field “max_delay” in both these message formats. We have shown in figure 5 the process of initiating a route discovery operation in DS-AODV. The main purpose of DS-AODV is to discover delay bounded paths and hence provide QOS to the requesting application in terms of delay metric which is quite vital for multimedia applications. To achieve this goal, before searching any route towards the destination, the source node has to specify its maximum allowable delay bound in the RREQ message before sending it. The field offset_time is initialized to zero. Also, the session admission control process assigns a timer to the source application so that when it expires, route discovery can be attempted again. In DS-AODV, the routing table contains an additional field route_delay, as discussed earlier. Each intermediate node will update this entry on receiving the RREQ message.

After initializing all the required fields, the RREQ message is created and broadcasted by the source node to its immediate neighbours. When a RREQ arrives at its destination, the destination creates a RREP packet by initializing all the fields including max_delay and offset_time and unicast it back towards the source Sthat originated the RREQ message.

Algorithm 1 shows the detailed proposed protocol DS-AODV and how RREQ and RREP messages are handled at each node in the network.

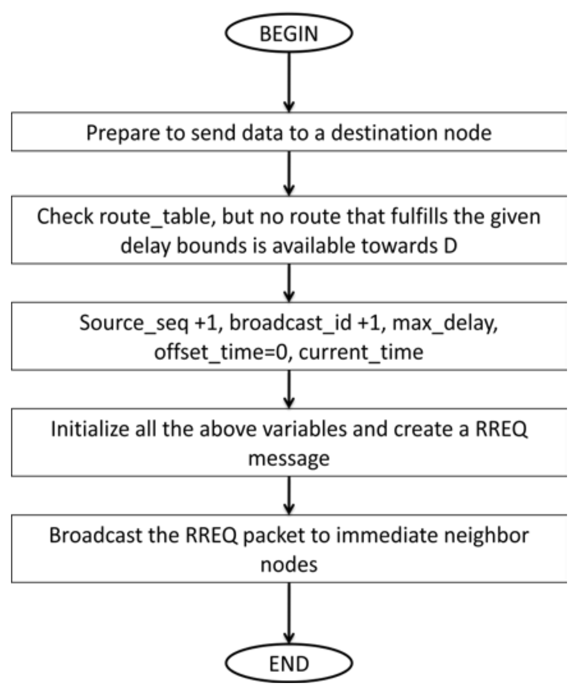

Figure 5 : flowchart for the initiation of Route Discovery process in DS AODV

Algorithm 1: DS AODV ALGORITHM

Variables used in the Algorithm:
S is the source node;
D is the destination node;

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l_delay is the link delay;

q_delay is queuing delay;

t_delay is transmission delay;

Max_delay carry the maximum delay specified by the requesting application;

Offset_time specifies the time that is spent by the RREQ(RouteREQuest packet) till the current node;

R_count is the average number of retransmissions over a fcartion of time ;

Difs, sifs, p_len, c_bwd are predefined MAC values;

Algorithm:

// Set the fraction of time to t seconds over which a node monitors the loss probability (Pl) by using the number of HELLO messages it receives

// The Pl is used to calculate the link loss probability using the equation:

Link_Pl = 1 – Pl

// Based on the retransmission policy of 802.11 MAC the approx. retransmission count can be calculated using the following equation:

R_count = 1/(1-Link_Pl)

Back_off_time= ((2 pow (5 + r_count) – 1)/2) * slot_time

//Back_off_time is set to initial contention window size specified in MAC 802.11 specification. Back_off_time increases with increase in number of retransmission of a data packet

t_delay= (difs + (p_len/c_bwd) + sifs + back_off_time) * (r_count + 1)

l_delay= p_delay + q_delay + t_delay

//offset_time is initialized with zero

For (each node N in route discovery phase)

l_delay= p_delay + q_delay + t_delay

Offset_timeN = l_delay + offset_timeN-1

If (l_delay is less than max_delay)

Then RREQ message is initiated

Else

Re-broadcast towards the destination

//D receives RREQ

//D initiates unicast RREP message that contain l_delay (link delay) in one direction

S receives RREP message

S calculates link delay (l_delayS)

If (l_delayS is less than max_delay)

Session is admitted by source S

Else

Source S rejects the session request

Repeat steps 1 to 6

We will explain the working of this protocol with the help of an example discussed in the following text. Figure 5 is the MANET scenario that has been considered for this example.

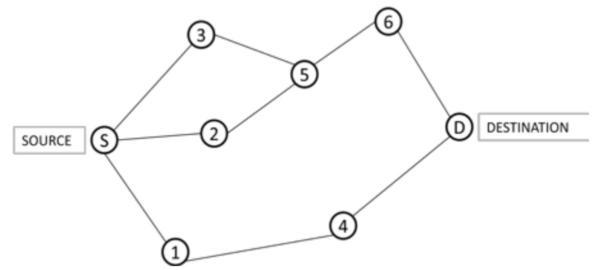

Figure 6 : Sample MANET scenario for DS-AODV example

Suppose S is the source node and D is the destination node in an infrastructure less MANET scenario. When S receives a data packet from an application running on it, it searches its route_table for a valid route towards D. If S already has an entry in its route_table for destination D, S will send the data to D using the next hop given in the routing table. Whereas if S does not have an existing valid route to D, it initiates a route discovery process. In this case, the route discovery is initiated using DS AODV that will discover routes that satisfies delay constraints specified by source application.

The source initiates the delay aware QOS routing by broadcasting the RREQ into the network to all its next hop nodes. RREQ is checked for duplicity as well as for whether the receiving node is itself the destination or not. When the source application first sends RREQ, it specifies its maximum supported delay constraint in max_delay field. Also, offset_time is initially set to zero which is updated by each node on arrival of RREQ.

Let node 1 received RREQ from S. Node 1 will now calculate its offset_time and update this field in the received RREQ. For this, it will refer its route_table for the route_delay value stored in it for the receiving node S. The route_delay stored against node S in route_table of node 1 is added to the offset_time in RREQ to get offset_time of node 1. This is updated in RREQ and hence, forwarded by node 1 to all its immediate neighbours. The route_delay entry is also checked by node 1 for whether it is greater than max_delay in RREQ.\

Now, let node 4 receives RREQ from node 1. Node 1 checks for RREQ duplicity as well as checks whether it is the required destination or not. It now checks its route_table for route_delay stored against node 1, this route_delay is added to offset_time field of RREQ to get offset_time of node 4. This is updated in the offset_time field of RREQ which is broadcasted to its next hop nodes. Now, let it is received by destination D. D will again perform the checks for RREQ duplicity with the help of seen_table as well as whether it is the destination node or not by looking the destination IP field of RREQ. Since it is the required destination, it will not forward RREQ anymore. It will again calculate offset_time by adding route_delay from node D in the offset_time stored in RREQ to get offset_time of D which is actually the cumulative link delay in one direction and will be stored in offset_time field of RREP created by D. The destination will receive multiple RREQ messages but it will send RREP packet on that link only having the least link delay/ cumulative offset_time out of all its immediate neighbours. After receiving RREP, the source S checks whether the link delay it received in offset_time field is less than max_delay. If offset_time sent by D is within the max_delay, session request is accepted by source, else discarded. Hence, in this way, DS-AODV is able to find valid routes that can send the application traffic from S to D within the specified delay constraints.

IV. Simulation Results and Analysis

This section will elaborate the performance evaluation of our proposed routing protocol DS-AODV based on the analysis of simulation results to validate its correctness and effectiveness.

In our analytical part, we have used Exata Cyber Developer Version 2.0 to design MANET scenarios as well as for generating simulation results.

a) Simulation Setup

This section provides a extended explanation of the implementation details of this simulation study. This section has been divided into 4 subsections. In section 4.1.1, we will provide a brief introduction of the simulator that has been used to carry out simulations in this research. In section 4.1.2, an overview of the mobility model has been provided, that has been used in the simulations. Section 4.1.3 mentions the network scenario being considered for simulations along with several simulation parameters with their values that have been used while conducting simulations. Section 4.1.4 will describe the various metrics based on which we will evaluate our proposed protocol.

i. *Simulation Tool: Exata Cyber*

This section will briefly introduce the simulation tool that has been used to carry out the research in this paper. We have used the trial version of the industry used commercial scalable network simulator Exata cyber to create various MANET scenarios.

Exata Cyber belongs to the breed of new software tool [12] developed specifically for incorporating in communication networks, cyber security capabilities [12]. Hence, Exata Cyber is most suited to simulate wireless mobile ad-hoc network due to their unprotected and mobile nature that makes them quite vulnerable.

Exata Cyber has simulation as well as emulation capabilities [13]. Using Exata Cyber, we can create different types of network scenarios, including mobile ad-hoc networks with different scenario parameters set to different values. It allows us to create Software Virtual Networks (SVNs) [14] by which it is possible to replicate physical networks in virtual space.

ii. *Mobility Model*

A mobility model denotes the pattern of movement of mobile nodes as well as variation in mobility speed and location over time. The role of mobility models is quite vital in performance evaluation of routing protocols since they simulate the movement of network's real world application in a reasonable manner else the results could be misleading.

The mobility model that has been considered for this simulation is the most common and widely used **"Random Waypoint Model"**. This model is quite easier to simulate and simple to use. In this model, the mobile node waits for a definite pause time in the beginning of the simulation, after which it randomly chooses any target node in the simulation area. It also picks a random speed with a uniform distribution between 0m/s to 20 m/s.

All the source-destination pairs are selected randomly in from the network. To model the source nodes as a data generating nodes we configure each source node in the network using the constant bit rate (CBR) application. The CBR generates data based on parameters like packet size, packet flow (packets per second) etc.

All the simulations performed in this paper run for a time period equal to 500 simulated seconds. Each data point shown in the graphs and tables are averaged on three runs with similar traffic models, but different randomly generated mobility scenarios by using different seed values.

iii. *Network Scenario and Simulation Parameters*

The network scenario that we have used in our simulation is depicted in figure 7. We have used a terrain with dimensions of 1000x1000 and deployed 60 nodes in it. Random Waypoint Mobility model has been used during simulation that decides the movement of these nodes in any random direction.

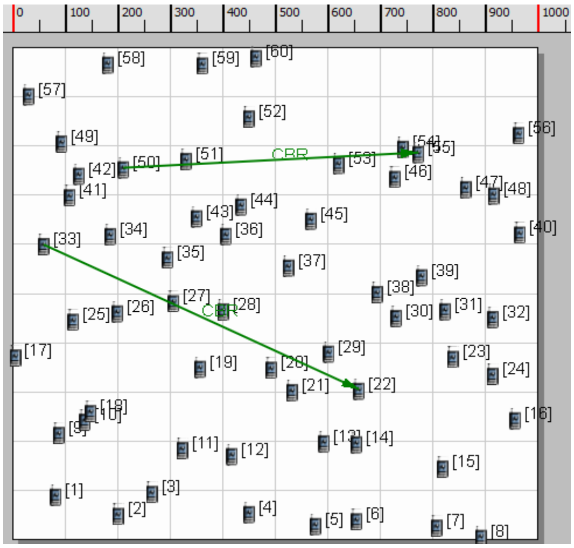

Figure 7 : Network scenario for simulation study

We have defined several parameters to evaluate the performance of our proposed protocol DS-AODV by comparing it with AODV.

In table 1, we have mentioned various parameters for designing a typical MANET scenario that we have considered to carry out our simulation study.

Table 1 : Simulation Parameters

Simulation Tool	Exata Cyber Developer Version 2.0
Topology area	1000x1000m
Simulation Time	300 sec
Application Traffic type	CBR (Constant Bit Rate)
Number of nodes	80
Node Placement model	Uniform
Routing protocols under study	DS-AODV, AODV
MAC Layer protocol	IEEE 802.11
Physical Layer protocol	802.11b
Data Rate	12 mbps
Node Mobility model	Random Waypoint model
Packet size	512
Flow specification	50 packets/second
Node pause time	20 m/s (for constant network load)

During the simulation, nodes start their movement from a source to a destination node, resulting in continuous changes in the network topology throughout the simulation [15].

iv. *Performance Metrics*

This section will provide an overview of the metrics that have been considered for evaluation of results produced by our study.

a. *Average End to End delay*

This metric refers to the time interval difference between the times at which the destination receives a data packet from the time when it is sent by the source. This is calculated by the destination node on receiving the packet completely by the help of its send and receives timestamp. On completion of the simulation, total time of the packets received at the destination is divided by total number of received data packets, i.e.

End to End Delay = delay of each successfully received packet/ total number of packets received.

In other words, it is the time taken by the data packet to traverse from a source to a destination node.

b. *Packet Delivery Ratio (PDR)*

It is defined as the ratio of total number of error free data packets received by the destination to the total number of packets sent by the source, i.e. , PDR = total number of packets received / total number of packets sent by CBR application

c. *Normalized routing Overhead (NRO)*

Normalized routing overhead is defined as the total number of control packets transmitted per data packet delivered successfully at the destination. It is calculated as the ratio of total number of routing control packets sent to the total number of data packets received by the destination.

b) *Simulation results*

In this section, we will evaluate the performance of our proposed routing protocol, DS-AODV, by comparing it with the traditional reactive routing protocol AODV over the three performance metrics discussed in previous section. The chief objective of this study is to demonstrate that DS-AODV will score above the reference protocol chosen here, i.e., AODV, in terms of varying scenario parameters like:

- Number of data sessions
- Mobility of nodes

The simulation results are calculated by averaging the values of 3 different runs. During simulation, initially we vary the number of source-destination pairs, i.e., number of CBR sessions keeping the node pause time constant and equal to 20 m/s. This is done to study the effect of varying network load in the network. We take values for number of data sessions equal to 2, 4, 6, 8, 10 and 12.

Next, we vary the node mobility speed from 5 to 45 m/s keeping the number of CBR sessions constant at 4. We collect results for this simulation at pause times of 5, 15, 25, 35 and 45.

i. *Varying number of data sources*

In this section, we will present the simulation results for the network scenario in which we have chosen constant pause time of 20 m/s, whereas we vary the network load by increasing the number of sources.

Number of sources is taken to be 2, 4, 6, 8, 10 and 12. Other parameters, as mentioned in table 1 are fixed.

a. *Normalized Routing Overhead*

The Normalized Routing Overhead of DS-AODV and AODV is depicted in figure 8. The graph shows that the Normalized Routing Overhead varies proportional to the network load. This is because increase in number of data sources increases the network congestion and therefore, the probability of packet collision also increases, thereby increasing the Normalized Routing Overhead. The graph in figure 8 supports the fact that DS-AODV has a lower Normalized Routing Overhead than AODV for moderate to high number of data sources. This is because DS-AODV avoids wrong admission of a new data flow into the network, hence preventing the network from being overloaded.

Table 2 : Effect of increased network load on routing overhead

Number of data sessions	DS-AODV	AODV
2	0.14	0.13
4	0.46	0.44
6	0.59	0.58
8	0.61	0.67
10	0.64	0.69
12	0.73	0.84

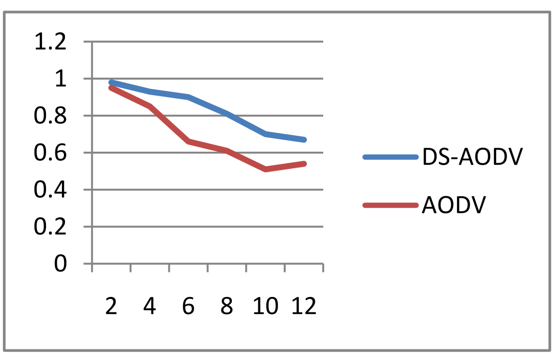

Figure 8 : Overhead with increased number of data sessions

b. *Average End to End Delay*

The comparison of average end to end delay of DS-AODV and AODV is shown in figure 8. It is quite evident that end to end delay of DS-AODV is quite lower than that of AODV and varies as a function of number of sources under all values of number of data sessions. This is due to the fact that DS-AODV is specifically meant for delay aware transmission of application data and due to additional delay oriented fields in request and reply messages, the discovered routes is bounded by a specific required delay. Hence the end to end delay of DS-AODV is drastically lower than that of AODV.

Table 3 : Effect of increased network load on end to end delay

Number of data sessions	DS-AODV	AODV
2	0	0
4	0.01	0.05
6	0.02	0.11
8	0.02	0.12
10	0.03	0.37
12	0.04	0.65

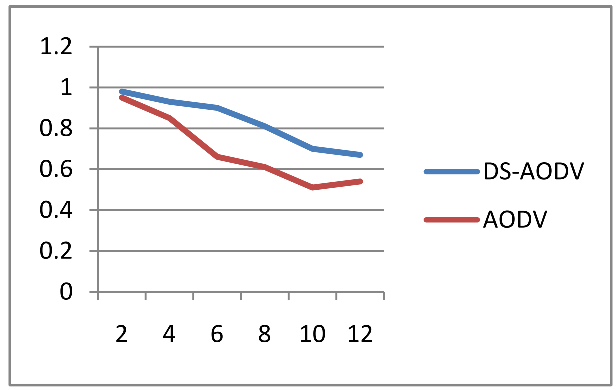

Figure 9 : Effect of increased number of data sessions on delay

c. *Packet Delivery Ratio*

The graph in figure 9 demonstrates the effect of varying number of sources on packet delivery ratio in DS-AODV protocol compared to AODV. The figure shows clearly that the on packet delivery ratio for AODV is quite lower than DS-AODV, with increasing network load. The AODV protocol drops a larger amount of packets with increase in number of sources. The on packet delivery ratio of DS-AODV decreases faster with larger number of sources but is found to be greater than almost 70% always. The reason behind this tradeoff is that a larger number of sources in the network increase the probability of congestion leading to packets being dropped.

Table 4 : Effect of increased network load on packet delivery ratio

Number of data sessions	DS-AODV	AODV
2	0.98	0.95
4	0.93	0.85
6	0.90	0.66
8	0.81	0.61
10	0.70	0.51
12	0.67	0.54

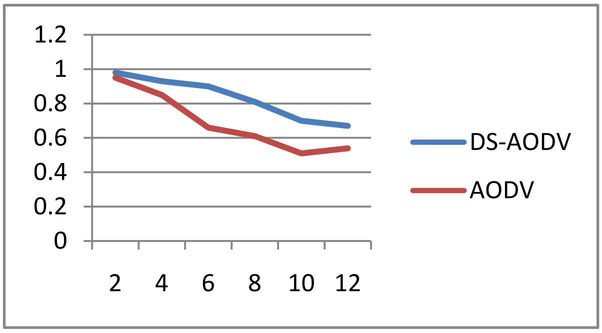

Figure 10 : Effect of increased number of data sessions on PDR

ii. *Varying Node Mobility*

In this section, we will demonstrate the influence of varying node speed (pause time) maintaining a constant number of sessions. The results are obtained by keeping number of data sessions equal to 4 and varying pause times at 5, 15, 25, 35 and 45 m/s.

a. *Normalized Routing Overhead*

The graph in figure 10 shows the variation of normalized routing overhead with changing node mobility for both protocols: DS-AODV and AODV. The normalized routing overhead is calculated as the ratio of total number of routing control packets sent to the total number of data packets received by the destination. This is quite a critical metric to estimate the efficiency of a routing protocol as well as scalability of the network by defining how much bandwidth is consumed by the control packets for a particular routing protocol. So this metric can be efficiently used to compare the performance of routing protocols.

The graph in figure 10 shows that DS-AODV has a higher routing overhead than AODV for almost all values of node pause time. This is because of the fact that in DS-AODV, due to increased node mobility, larger number of link breakages will occur resulting in higher number of route discovery processes to initiate, causing larger overheads. This limitation of DS-AODV can be rectified in its future extensions.

Table 5 : Effect of varying node mobility on normalized routing overhead

Node Speed (m/s)	DS-AODV	AODV
5	0.35	0.34
15	0.33	0.32
25	0.30	0.31
35	0.29	0.27
45	0.25	0.23

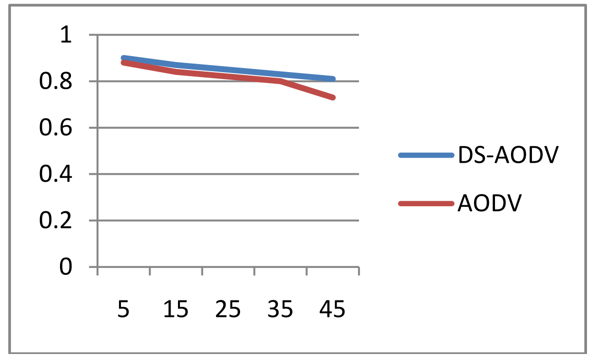

Figure 11 : Overhead with increased network mobility

b. *Average End to End Delay*

The moment the packet is generated and sent by the source till the time it is received by the destination is considered as end to end delay. There are certain factors that affect this metric. They are:

- Route discovery time
- Queuing delay (waiting time in buffer/queue before transmission)
- Route length (distance in hops between source and destination)

Figure 12 shows the variation of end to end delay with respect to change in node mobility. It can be clearly observed that average end to end delay is quite lower in DS-AODV, as compared to AODV. This is due to the fact that DS-AODV discovers routes within the delay requirements of the source application, hence, end to end delay cannot exceed beyond an acceptable limit, else the session would not have been admitted.

Table 6 : Effect of varying node mobility on delay

Node Speed (m/s)	DS-AODV	AODV
5	0.05	0.08
15	0.08	0.12
25	0.10	0.15
35	0.12	0.17
45	0.14	0.23

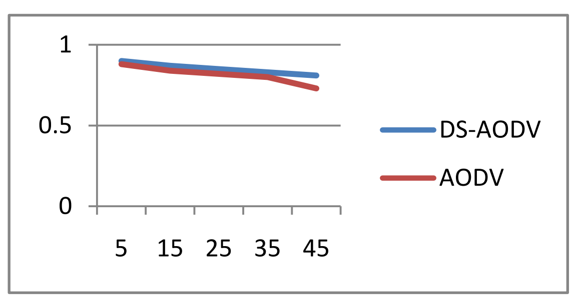

Figure 12 : Effect of increased network mobility on delay

c. *Packet Delivery Ratio*

It is the ratio of data packets delivered at the destination to those generated and sent by the CBR source. This is quite an important metric since it defines the loss rate of the application data which ultimately defines the overall throughput of the network.

The packet delivery ratio of the two protocols is depicted in figure 13. The graph shows the variation of packet delivery ratio with the changing node mobility values. The increase in nodes' movement results in high probability of route breakages causing an increase in number of packets being dropped. DS-AODV has a better packet delivery ratio than AODV for all values of node pause time. The simulation study shows that more than 80% data packets are delivered by DS-AODV to the specified destination for all node mobility values. Hence, DS-AODV is found to be more robust than AODV.

Table 7 : Effect of varying node mobility on packet delivery ratio

Node Speed (m/s)	DS-AODV	AODV
5	0.90	0.88
15	0.87	0.84
25	0.85	0.82
35	0.83	0.80
45	0.81	0.73

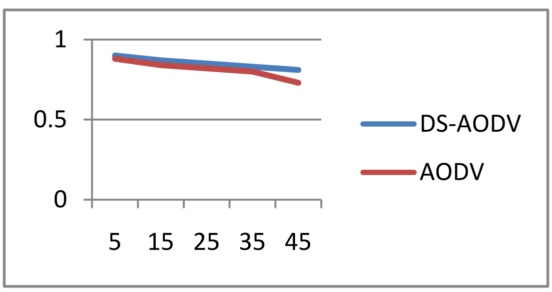

Figure 13 : Effect of increased network mobility on PDR

V. Summary

In this context, we have analyzed the performance of our novel proposed routing protocol DS-AODV, based on various performance metrics. This reactive routing protocol has been specifically designed for mobile adhoc networks and is based on the traditional protocol Ad hoc On-demand Distance Vector. The simulation study performed in this context demonstrates that DS-AODV is able to perform fairly well over a range of node mobility and network load values. The simulations have been performed on Exata Cyber simulator. The results produced by the simulations have been represented graphically for a better analytical understanding. These results have been used for comparing the performance of DS-AODV with AODV over various performance metrics. The analysis supports that the performance of DS-AODV is quite better as compared to AODV protocol.

VI. Conclusion

Delay sensitive applications like multimedia and real time applications require data transmission in a timely manner; otherwise the data becomes obsolete if it is received after the specified time. Therefore, the concept of delay aware routing becomes a vital research domain in the field of Adhoc networking.

In this paper, we have proposed and implemented a delay constrained reactive routing protocol based on AODV routing protocol. We have named it as DS-AODV (Delay Sensitive Adhoc On-demand Distance Vector). The chief objective of this protocol is to discover valid routes that are constrained by a maximum delay value during route discovery phase. The application running at source that needs to initiate a date transmission with the destination will specify its maximum allowable delay prior to route discovery. This value will be used as the reference for discovering routes that lie within these delay bounds. Simulation results are developed using a powerful simulation tool called as "Exata Cyber". The analysis of these results shows that our proposed protocol DS-AODV is able to perform better than AODV by delivering lower end to end delay values.

Looking at the future extensions in this research, we can try to implement this with node mobility models other than the random waypoint mobility model that we have followed in this paper. Also, in DS-AODV, route_delay values stored in routing tables of nodes may not always be up-to-date due to dynamic nature of mobile adhoc networks. A common synchronized update mechanism can be implemented to solve this problem.

Also, the robustness of DS-AODV can be verified in case of congestion of network. Lastly, we recommend a performance comparison of DS-AODV, based on various parameters, with other QOS aware protocols that have been proposed in recent past to verify its performance further in terms of various parameters, other than delay.

References Références Referencias

1. Lajos Hanzo II, Rahim Tafazolli, "Admission Control Schemes for 802.11 Based MultiHop Mobile Ad hoc Networks: A Survey," IEEE Communications Surveys &Tutorial., vol. 11, pp. 78–108, Fourth quarter 2009.
2. M. Tarique, K.E. Tepe, S. Adibi, S. Erfani, "Survey of Multipath Routing Protocols for Mobile Ad hoc Networks," Journal of Network and Computer Applications 32, pp. 1125–1143, Nov. 2009.
3. Y. Huang "Improving Signaling Performance of Proactive MANET Routing Protocols," Doctorate paper, University of London, U.K., 2007.
4. Vivek Kumar "Simulation and Comparison of AODV and DSR Routing Protocols in MANETs,"M.E. Paper, Thapar University,India., July 2009.
5. T. Larsson, N. Hedmen "Routing Protocols in Wireless Ad hoc Networks: A Simulation Study,"

Global Journal of Computer Science and Technology (E) Volume XIV Issue V Version I Year 2014

Master's paper, Lulea University of Technology, Sweden, 1998.
6. Stefano, M. Conti, S. Giordano, Ivan S., Mobile Adhoc Networking, A JOHN WILEY & SONS, INC., PUBLICATION 2004.
7. Chhagan Lal, Dr. V. Laxmi, Dr. M.S. Gaur, Book Context in Building Next Generation Converged Networks: Theory and Practice, "Taxonomy of QOS Aware Routing Protocols for MANETs", CRC Press, pp. 533–560, Publication 2013.
8. Chen, S., and K. Nahrstedt. "Distributed quality-of-service routing in ad hoc networks." Selected Areas in Communications, IEEE Journal, Aug. 17, 1999, 1488–1505.
9. Crawley, E., R. Nair, B. Rajagopalan, and H. Sandick. A Framework for QoS-based Routing in the Internet. RFC2386, IETF, 1998.
10. Reddy, T. B., I. Karthigeyan, B. S. Manoj, and C. S. R. Murthy. "Quality of service provisioning in ad hoc wireless networks: A survey of issues and solutions." Ad Hoc Networks, Jan. 4, 2006, 83–124.
11. S. M. Zaki, M. Ngadi, S. Razak, "A Review of Delay Aware Routing Protocols in MANETs" ISSR Journals, vol. 1, June2009.
12. Launch of Exata Cyber press release [online] http://www.prnewswire.com/news-releases/new-exatacyber-provides-advanced-emulation-for-cyber-security-capability-development-89422207.html
13. Scalable Network Technologies [online] http://web.scalable-networks.com/ content/ exata - cyber.
14. Exata Cyber [online] http://www.superinst.com /docs/snt/SNT_exata_cyber.pdf.
15. D. Vir,Dr. S.K. Agarwal,Dr. S.A. Imam, "A simulation study on node energy constraints of routing protocols of Mobile d hoc networks by use of Qualnet simulator," IJAREEIE., vol. 1, issue 5, pp. 401–410, Nov. 2012.