AODV_HPR: A High Power Ad Hoc Routing for Highly Mobile Short Time Military Communication Applications

Janani A.P.¹, Sakthivel M.², Saravanan M.³

¹Department of Information Technology, Sri Subramanya College of Engineering and Technology, Tamilnadu, India.

 ² Department of Mechanical Engineering, Anna University Regional Centre, Coimbatore, Tamilnadu, India.
 ³ Department of Mechanical Engineering, C.R. Engineering College, Alagarkovil, Madurai, Tamilnadu, India,
 ¹ janani97@gmail.com
 ² sakthi_vel_m@yahoo.com
 ³ drmsaravanan@yahoo.com

Abstract—: Improving the performance of Mobile Ad hoc Network (MANET) routing protocols under highly mobile time sensitive communication scenario, like a military rescue operation, is a complex task since it reaches its optimum level of performance only after sometime. Our work proposes a modified version of AODV termed as AODV_HPR where certain nodes are assumed to be high energy transmission nodes known as High Power Routing (HPR) nodes, utilized for routing. The route is established only through HPR nodes which are capable of communicating to long distance. The simulation is performed in NS2 under varied node density with 50 percent HPR nodes and the results are compared with DSDV and AODV. The proposed AODV_HPR provided significant improvement in throughput and Packet Delivery Fraction (PDF) and significant reduction in dropped packets, end-to-end delay, MAC Load, routing load, energy consumption and overhead than conventional AODV.

Keyword- MANET, AODV, AODV_HPR, performance analysis, short time scenario

I. INTRODUCTION

Ad hoc network [1], [2] is a group of mobile nodes forming an instant network dynamically with the primary goal of providing communication between users without a centralized infrastructure. The ad hoc networks are applied in many areas ranging from classroom to battlefields. It is also used in military rescue operations, where a quick deployment of nodes is needed. Energy management in MANET is very much important since only limited energy is available in the wireless devices. As the energy consumption in a wireless network is more, the energy cost need to be minimized.

The performance of proactive and reactive protocols is always questionable if used in a highly mobile short time communication scenario such as military rescue operation that happens only for a few seconds. Here, the routing protocols require certain time for achieving stable performance due to the periodic route discovery and maintenance mechanisms in their inherent design. Even though the reactive routing protocol AODV [3] outperforms the other protocols, it fails to adapt well in such a highly mobile short time communication scenario that may end in few seconds, like 100 to 300 seconds. Improving the performance in such a scenario is a complex task since the protocol will be only in its warming up state and takes some time to produce an optimum performance. Moreover the availability of limited energy in the wireless devices should be managed efficiently. Since the consumption of energy in wireless communication is significantly more, the energy costs need to be minimized.

In this paper, the performance of AODV is improved by identifying certain nodes as HPR nodes which involve in routing and the rest of the normal nodes which receive the routing packets are not allowed to process those requests. HPR nodes can be assumed as higher capability nodes which are having sufficient battery power and they may be deployed as HPR nodes and behave as HPR nodes during the entire life of the network. It is also possible to change the node status as HPR node or normal node in a random dynamic fashion for balanced power consumption in all the nodes in a normal network of similar capability nodes. Anyway, a HPR node can transmit or allowed to transmit to higher distance than normal nodes. HPR nodes can also be a source or destination node but, a route can be established only through HPR nodes. The modified AODV termed as AODV_HPR is simulated in NS2 and the results are compared with those of DSDV and normal AODV for various performance metrics.

This paper is organized as follows: Section2 deals with literature survey, section3 discusses the existing protocols AODV and DSDV, section4 deals with the proposed AODV_HPR and section5 discusses the

simulation environment. Section6 analyses the results for various metrics. The last section8 deals with the conclusion and future work.

II. LITERATURE REVIEW

Several qualitative and quantitative performance analyses have been performed on AODV and a few modifications have been proposed to improve its performance. MA_AODV [4] proposed by Yaser et al. shows improvement in overhead and PDR. The performance analysis of MANET routing protocols done by Kavita and Ashok proves the reliability of AODV [5]. A study about stable AODV under various mobility models is performed by Krunal and Tejas[6].

The proposed Enhanced AODV1, Enhanced AODV2 and Adaptive AODV by Shobha and Rajanikanth show improvement in overhead, PDR and end-to-end delay respectively [7]. AODVUU [8] shows increase in PDR and FVB_AODV [9] shows increase in throughput and bandwidth utilization. Modified AODV proposed by Loganathan and Ramamurthy [10] show high throughput and PDR. R_AODV proposed by Nishat et al.[11], AODV_BRL proposed by LiuYu and Linchen[12], Mobility and load aware scheme proposed by Yaser et al. [13] and AODV_UI proposed by Abdusy and Riri [14] are all variances of AODV to improve its performance. Modifications are also proposed on the conventional AODV to improve the security in military applications [15], [16].

The literature review shows that many modified versions of conventional AODV are proposed to improve its performance in terms of some standard metrics in a normal MANET scenario. But our research work considers the performance of the reactive MANET routing protocol AODV, in a highly mobile time sensitive network such as a military scenario which may end in few seconds. In the previous work, Janani et al. [17] conducted a performance analysis on reactive and proactive MANET routing protocols in a highly mobile short time communication scenario. Since the simulation results proved the superiority in performance of AODV, in such a scenario, AODV is considered as a candidate to be improved in its performance.

III. THE EXISTING PROTOCOLS: DSDV AND AODV

A. Destination-Sequenced Distance Vector (DSDV) Routing

DSDV [18] is a hop-by-hop proactive routing protocol where messages are exchanged between one hop neighbours. Periodical or triggered updates keep the routing table updated continuously. When there is any change in the routing tables in one of the neighbouring nodes, then updates are triggered. The routing queries are sent from a node while a packet for the unknown route is cached until route replies are received from destination.

B. Ad hoc On-Demand Distance Vector (AODV) Routing

The reactive routing protocol AODV combines the route discovery and maintenance mechanism of DSR and the sequence number technique and beacons of DSDV routing protocol. Whenever a source node needs to communicate with a destination node it sends a ROUTE REQUEST if there is no existing route. The request is flooded into the network until the destination or a node with the latest route is reached. The intermediate nodes create a reverse route for itself from the destination. The destination or intermediate node sends a ROUTE REPLY with the number of hops to destination. The latest route is identified by the highest sequence number. Every node involved in the forwarding of the reply to the source node creates a forward route to destination.

IV THE PROPOSED AODV_HPR

Consider a normal AODV route discovery process. For example, if the node S starts a route discovery process by broadcasting a RREQ message, then all the neighbours of S will receive the request and process the request. If a neighbouring node knows the route, then it will send a reply otherwise, it will forward the RREQ message by re-broadcasting it again. In fact, all the nodes in the network will receive that RREQ message. If the message will reach the destination D, then D will send a RREP message. Let us assume that the grey nodes are the normal nodes and the blue nodes are the HPR nodes.

In our proposed routing scheme, as shown in fig.1, the HPR nodes only will be allowed to forward the RREP and RREQ messages. In other words, between S and D, a route can be established only through HPR nodes. Since the normal nodes will not rebroadcast the RREQ or forward RREP messages, it will reduce a lot of overhead as well as transmission power.

Since the HPR nodes are capable of passing messages to longer distances, it will reduce the overall path length. The reduction in path length will reduce the end to end delay. Further, the normal nodes will only need to transmit up to the next nearest HPR node where the transmission (tx) power is reduced according to that distance, which reflects in the overall power consumption.



Fig.1. The proposed AODV-HPR scenario

The tx power to transmit packets from a HPR node to another HPR node will be constant and the established link will not be affected by a little mobility. The tx power to transmit packets from a normal node to another HPR node will be dynamic since it depends on the distance between the normal node and the nearest HPR node.

A. HPR Node Selection

HPR nodes can be assumed as higher capability nodes which are having sufficient battery power and they may be deployed as HPR nodes and behave as HPR nodes during the entire life of the network. On the other hand, even the status of a node can be changed as HPR node or normal node in a random dynamic fashion for balanced power consumption in all the nodes in a normal network of similar capability nodes. Anyway, a HPR node can transmit or allowed transmit to higher distance than normal nodes. HPR nodes can also be a source or destination node but anyway, a route can be established only through HPR nodes.

B. The Wireless Physical Layer

In NS2, the default transmission power of a node will be constant and usually can be set before starting the simulation. A function is added in the wireless physical layer to change the default transmission of the nodes which is called by the AODV routing agent code itself. This enables a node to set its transmission power from the routing layer itself. The following sub section outlines the changes made in AODV routing protocol for the implementation of AODV_HPR.

C. The Modifications in AODV

The following pseudo code illustrates the simplified version of modified AODV routing protocol for the implementation of AODV-HPR.

On_AODV_Startup()

{ Set the node as HPR node according to policy; Do the other AODV initialization steps ();

On_Receiving _AODV_Route_Request()

{
 If (I'm the source and recently heard this)
 If (I'm the source and recently heard this)
 {
 Drop_The_Request();
 Return ();
 }
 If (this is a HPR_Node)
 {
 Set high tx power
 }
}

wifp_setPt(Pt_High); Update the RoutingTable(); ForwardtheReqest(); }

If (this is the destination) //this may be a normal or HPR node Send_Reply(); Return(); } Else { DropTheRequest(); } On_Receiving_AODV_Route_Reply() *if (the Reply is for this node) {* Use the reply message information } else { if (this is a HPR_Node){ *ForwardTheRequest();* }else{ DropTheRequest(); }}}

D. Advantages of AODV-HPR

Since there is no routing overhead for the normal nodes in the network, the end-to-end delay will be reduced very much. A route cannot be established through any arbitrary node in the network; hence the security in communication increases. In a typical MANET, mobility causes link failures and results in increased overhead and reduced performance. In the proposed AODV_HPR, the HPR nodes uses little bit of higher energy, so that it is resistant to mobility to some extent. Since the HPR nodes are capable of communicating to high distance, little bit of mobility in individual nodes will not cause frequent link failures. Since the route is established only through HPR nodes, the other nearby normal nodes which will receive the routing packets will not process those requests and reduce the message overhead in a typical on-demand routing protocol.

Further, there is also another possibility to reduce power consumption in normal node (if it happens to be the destination node) since it communicates with the nearest HPR node.

V SIMULATION AND METRICS

The simulation is performed by using NS2 [19]-[21] to evaluate the performance of the algorithms. The AODV protocol available in the default installation of NS2 is used and the necessary modifications and improvements are implemented to make it as the proposed AODV_HPR protocol. So the source code files of the wireless physical layer (wireless-phy.cc and wireless-phy.h) and AODV routing agent (aodv.cc and aodv.h) are modified for the implementation of AODV_HPR.

Simulation time	100 seconds
Area of the Network	800 x 800 sq.m
Channel type	Wireless Channel
Radio-propagation model	Two Ray Ground
Antenna type	Omni Antenna
Interface queue type	DropTail/PriQueue
MAC type	802_11
Max packet inQueue	50
Number of Nodes	20,30,40,50
Routing Protocols	DSDV,AODV, AODV_HPR
HPR Node Percentage	50%
Tx Range of Normal Nodes	≈250m
Tx Range of HPR Nodes	≈350m
Mobility Model	Random Waypoint
Mobility	10 m/s
Pause Time	10 seconds
Traffic Type	CBR
Transport Protocol	UDP
CBR Rate	0.1
Packet Size	512 bytes
Number of CBR sources	in 25% Nodes
Number of Sinks	in other 25% Nodes

TABLE I Simulation Parameters

In practical applications, even lesser percentage of HPR nodes can be used to achieve an improved performance. But in our experiments, 50% nodes are used as HPR nodes to test the performance in an ideal worst case situation.

VI RESULTS AND ANALYSIS

The proposed modification in AODV is successfully implemented for the design of AODV_HPR. The performance of AODV, DSDV and the proposed AODV_HPR are evaluated with respect to eight metrics as discussed under the following subsections. A new functionality is being added in the wireless physical layer, so that a node can be able to set its default transmission power from the routing layer itself according to the protocol.

A. MAC Load

MAC Load refers to the mean number of MAC messages generated with respect to each successfully delivered data packet at the destination.

Fig.2 and fig.3 show the Number of Nodes vs MAC Load and the average MAC Load of the three protocols respectively. The MAC Load in the case of proposed AODV_HPR is lower than the normal AODV and even very much lower than DSDV.



Fig.3. The average MAC Load

B. Throughput

The number of packets arriving at the sink per second is termed as throughput.

Fig.4 and fig.5 show the Number of Nodes vs Throughput and the average throughput of the three protocols respectively. The throughput in the case of proposed AODV_HPR is higher than the normal AODV as well as DSDV. The average graph clearly shows the significant improvement in throughput.



Fig.4. Number of nodes vs throughput



C. Number of Dropped Packets

The total number of all the dropped packets in the layers of all the nodes is considered as an important metric highly mobile, short duration communication scenario.

Fig.6 shows the Number of Nodes vs Dropped Packets and fig.7 shows the average Dropped Packets in the case of the three protocols. The proposed AODV_HPR protocol dropped lesser packets than normal AODV as well as DSDV.



Fig.6. Number of nodes vs dropped packets



D. Overhead

Overhead is considered as the total number of routing/control messages generated in the network while transmitting data packets from source node to destination.

The following graphs 8 and 9 show the Number of Nodes vs Overhead and the average overhead in case of the three protocols respectively. The overhead in the case of proposed AODV_HPR is lower than the normal AODV. Even though, DSDV seems to be providing lower overhead, in fact, it is not appreciable; because it is not capable of forwarding/supporting much traffic like AODV and AODV_HPR. It is clear from the PDF and throughput graphs.





Fig.9. The average routing overhead

E. End-to-End Delay

End-to-end delay is calculated by the time taken by a packet to travel across a network from source to destination. Here, the average end-to-end delay is considered.

Fig.10 and fig.11 show the Number of Nodes vs End-to-end delay and the average end-to-end delay in case of the three protocols respectively. The end-to-end delay in the case of proposed AODV_HPR is lower than the normal AODV. Even though, DSDV seems to provide lower end-to-end delay, it is not appreciable since it is incapable of supporting much traffic as the other two protocols do. So, lower end-to-end delay in the case of DSDV is only because of free resources of the network due to lower traffic.







Average End to End Delay

Fig.11. The average end- to- end Delay

F. Network Routing Load

It is the ratio of the total number of routing messages forwarded at network layer to the number of data packets delivered at application layer.

The following graphs 12 and 13 show the Number of Nodes vs Routing Load and the average Routing Load of the three protocols respectively. The Routing Load in the case of proposed AODV_HPR is lower than the normal AODV. Even though, DSDV seems to be providing lower routing load, it is not favourable since it doesn't support much traffic like AODV and AODV_HPR. The graphs for PDF and throughput depict it.



Fig.13. The average routing load

G. Packet Delivery Fraction (PDF)

The ratio between the number of packets received by the sink and the number of packets sent by the application layer is termed as PDF. PDF measures the reliability of the protocol.

The following graphs 14 and 15 show the Number of Nodes vs Packet Delivery Ratio/Fraction (PDR/PDF) and the average PDF of the three protocols respectively. The PDF in the case of proposed AODV_HPR and normal AODV are almost equal in low density network and the performance of AODV_HPR seems to be higher than normal AODV in high density network. On comparing the above graphs it is found that the proposed protocol gives good PDF with less effort and lower overhead. The Average PDF graph clearly shows the improvement in performance. The DSDV provided less PDF than other two protocols.









H. Average Energy Consumed

The average of the energy consumed by all the nodes in a network is the average energy consumed, measured in Joules.

Fig.16 and fig.17 show the Number of Nodes vs Consumed Energy and the average Consumed Energy of the three protocols. The Consumed Energy in the case of proposed AODV_HPR is lower than the normal AODV. The average graph clearly shows the difference in consumed energy. The DSDV seems to be consuming lower energy in high density network because it was not using much resources of network since it doesn't support much traffic.





It may look strange, why there is a decrease in total energy consumption even if there are 50% nodes that are using slightly higher power than normally used power. It is because, i) the HPR nodes only will participate in route discovery and routing in general. The other normal nodes will preserve power by avoiding the routing of messages; ii) the slight increase in transmission power increases the communication range and hence the end-to-end the link failure rate are reduced. The increase in transmission range avoids lot of rebroadcasts and resends of messages (the performance is proportional to the rate of link failures). So, little increase in transmission power in a portion of nodes in a network, under a scenario like this, reduces the overall energy consumption of the network.

VII CONCLUSION AND FUTURE WORK

The MANET communication scenario is considered as a time sensitive military rescue network scenario and an extensive evaluation has been performed on three protocols by increasing the number of mobile nodes in the network. The simulation is repeated several times with different network size and the average of results is taken into consideration to confirm the improvement in performance of the proposed AODV_HPR.

The proposed AODV_HPR provided significant improvement in throughput, PDF and significant reduction in dropped packets and end-to-end delay. AODV_HPR outperforms the conventional AODV by showing significant reduction in Network Overhead, MAC Load and Routing load.

Since the scenario under consideration is a very short time scenario, during the simulation, the HPR nodes were selected randomly and assumed to behave as HPR nodes throughout the simulation. But, if the same technique is to be applied for a normal MANET scenario which may run for a longer period of time, then the role of HPR node may be changed in a dynamic fashion to enable uniform energy consumption in all the nodes.

In that case, any node can become a HPR node and behave as a HPR node for a short duration. Future works may address much improved ways to select a node as HPR node in a dynamic fashion.

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