Performance Improvement of AODV Protocol by Introducing Energy Factor Technique

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***Abstract*—Wireless Mobile Ad-hoc networks are very popular for their dynamic, infrastructure less and decentralized configuration capability with battery powered nodes. Routing in such networks is a key issue which decides network performance. AODV protocol is one of the reactive routing protocols in MANET used for various network conditions like sparse and dense network with different speeds of mobile nodes. Sometimes due to unbalanced node usage, some of the battery powered nodes drains out faster. This leads to route re-discovery causing larger average end to end delay and more control overhead. In this paper we are presenting Energy Factor based AODV (EFAODV) protocol, efficient modification to existing AODV protocol to take care of this problem for different network situations. The QualNet simulator is used for comparison of AODV and modified EFAODV protocol. There is significant decrease in average end to end delay and control overhead using EFAODV protocol while maintaining the other quality of service parameters useful for highly mobile network.**

Keywords*— *AODV, MANET, Link Failure, QualNet.

I. INTRODUCTION

A Mobile Ad-hoc network has its own beauty having mobile nodes transmitting wirelessly under no central administration and on pure cooperation basis. Every node can act as router when the two nodes which are communicating fall beyond direct range of transmission of each other. In Ad hoc networks, nodes are not familiar with the topology of their networks and are required to discover the topology [1]. So every node has to learn the topology and find route to destination. These features make these networks most preferable over other fixed and wired networks. The key applications includes emergency network set ups like in battlefield, natural calamities like earthquake, floods etc.

The routing protocol is an important aspect in such networks. Due to different mobility patterns of nodes and limited transmission range of nodes the routing of packets becomes very tedious. Different algorithms are proposed by researchers to solve routing issues at network layer. Proactive approach includes gathering complete network information and storing it in routing tables continuously. Optimum link state routing protocol is an example of this proactive approach. On the other hand there exists reactive approach towards finding routing path to the destination only when needed. This approach has been used in Ad-hoc On Demand distance vector (AODV) routing protocol [2]. AODV protocol has its unique features like high throughput, reliable packet delivery etc. over other protocols. Various network conditions requires different routing protocol to be used at network layer since no protocol is equally reliable and effective in terms of quality of service parameters to such vast network situations.

Besides these advantages of AODV protocol it also has some disadvantages. Since the path towards the destination is found only when needed, the average end to end delay for establishing the path is high. Energy consumption of individual nodes may vary if the network is unbalanced and soon some of the active nodes may drain out due to limited battery power. In that case the network has to start route rediscovery to send data again to the destination. This condition repeats because of unbalanced network and average end to end delay and control overheads go on increasing. This ultimately results into reduced network lifetime. This all occurs because the node's remaining energy is not considered while forwarding the packets. In this paper we are going to propose a new scheme, called EFAODV to reduce the average end to end delay and control overheads in existing AODV protocol. In EFAODV, energy factor of every node is calculated before it participates as router in route discovery process. Depending upon its energy factor that node decides whether to act as router or not. This implies that route to destination may not be the shortest route but it will be the stable route to avoid link breakages. Control overheads are not increased at all to implement this scheme in existing AODV protocol. This improves the overall network performance.

The rest of the paper is arranged as follows. Section II contains basic ideas used in existing AODV protocol and its modified versions which considered remaining energy of nodes. In section III the modified EFAODV protocol is discussed in detail. In Section IV we will discuss the performance evaluation parameters of EFAODV and analyze the results for impact of different network parameters on EFAODV and AODV protocol in section V. We have used QualNet 5.0.1 for the comparison of AODV and EFAODV protocols. Section VI gives some concluding remarks and possible future improvements to AODV protocol are explained in section VII.

II. Background and Related Work

AODV is a reactive routing protocol widely used in MANET. It minimizes the number of required broadcasts, by creating routes on demand basis [1]. When a source node don't have path to destination then route discovery procedure is initiated. During route discovery different control messages are sent over the network. Route request (RREQ) message is broadcasted by source with information like source address, source sequence number, destination address, destination sequence number. Sequence number is used to account for time at which the message is sent. Higher value of sequence number means that message is latest over the others. In response to RREQ, destination sends route reply (RREP) message. Once the route is established the data transmission can begin. Route error (RERR) message are sent by the nodes facing the problem of broken link during data session. To keep the link active periodic HELLO messages are sent. Failure in receiving periodic Hello message by one neighbor is considered as termination of link between node and that neighbor [3]. Over the past few years many researchers have modified the existing AODV protocol from residual energy point of view to get optimum performance in different network situations.

Mallapur Veerayya et al. proposed SQ-AODV, a stability based approach in which lifetime (calculated using the current Average-Energy-Drain-Rate (AEDR)) of node and make before break concept for avoiding breaking of links are used [4]. It works using cross layer approach. In this protocol stability of connection is taken as priority over other issues.

LIU Jian et al. presents an AODV with reliable delivery (AODV-RD), a link failure fore-warning mechanism, and metric of alternate node in order to better select, and also repairing action after primary route breaks basis of AODV-BR [5].

In [6], L.S. Jayashree and others have proposed E2LBC, which considers energy efficiency as a system-wide issue that focuses on improving the overall stability of operation of a wireless sensor network. This prolong the stability period of the network by balancing the load at each cluster head. It works well for clustered architecture.

III. Energy Factor based AODV

After studying above mentioned modifications to AODV, it is clear that there is need for considering energy factor for improvement of existing AODV which does not involve increased control overhead.

In this section we will discuss the details of EFAODV protocol, an improved modification of existing AODV protocol. The implementation of EFAODV is similar to AODV with some additional constraint on route discovery process. Generally in AODV, during route discovery process the remaining energy of node is not considered. Hence the routes containing nodes with lower remaining energy may go down soon and the overall link fails. Due to this the either local repair is initiated or the fresh route rediscovery is initiated. In EFAODV protocol the care is taken to account for the remaining energy of node. A new parameter is used to keep track of node's remaining energy. The energy factor of a node is defined as the ratio of its residual energy to initial energy [7]. Hence value of energy factor will range from 0 to 1.

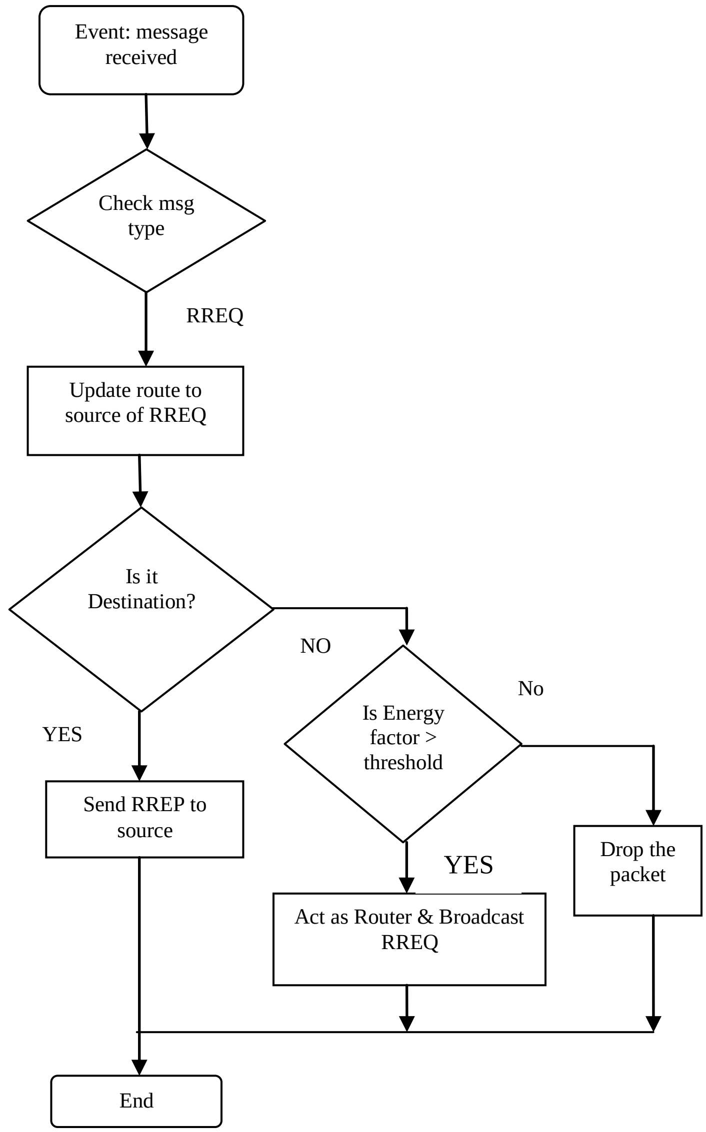

Figure 1. Flowchart showing processing of RREQ in EFAODV

Locally decision about being acting router is taken by every node depending upon this energy factor. So there is no need to pass its value of EF to neighbors through any of the control messages. In existing AODV protocol, whenever a node receives a RREQ message it is processed without considering its energy. In EFAODV, when a source node initiates a RREQ message and it reaches to its neighboring node, then that node first checks its energy factor. If its energy factor is greater than some threshold then only it will process the RREQ message.

Energy factor (EF) is calculated for every node when it receives route request packet. Due to this node saves its energy in processing of RREQ also. In other words this modification put a limit on how to broadcast a RREQ and who should participate in forming a route from source to destination. If a node participates in formation of route then it is supposed to have sufficient energy to work for that data session as a router. Since when an active node dies due to battery outage, then link breaks and route rediscovery has to be carried out. But due consideration of energy factor at local level network lifetime increases as well as number of broken links also decreases. The details of route discovery process in EFAODV protocol can be explained with the help of flowchart shown in fig.1; here we have shown how an intermediate node processes an incoming RREQ message. RREP, RRER and Hello message processing is ignored for simplicity.

IV. PERFORMANCE EVALUATION OF EFAODV

QualNet 5.0.1 network simulator is used for carrying out simulations. QualNet is a comprehensive suite of tools for modeling large wired and wireless networks. QualNet can support real-time speed to enable software-in-the-loop, network emulation, and hardware in-the-loop modeling. QualNet can model thousands of nodes by taking advantage of the latest hardware and parallel computing techniques. In this section we have discussed performance metric and parameters that are varied during simulations simulation set up used during experimentation is also discussed here.

A. Performance metrics used for comparison of protocols

Performance of EFAODV is measured in terms of quality of service parameters like packet delivery ratio, average end to end delay, energy consumption, control overheads and number of times link broke during a CBR (constant bit rate application). These parameters are compared for AODV and EFAODV protocol. Extensive simulations are carried out and rigorous analysis is done to compare two protocols for following parameters.

Throughput: It is the measure of the number of packets successfully transmitted to their final destination per unit time [8].

Packet delivery ratio: It is defined as the ratio of number of packets received by destination to number of packets sent by source.

Average end to end delay: It is measured as the time elapsed from the time when a multicast data packet is originated from a source and it is successfully received by all multicast receiver [1].

Control overheads: It is the sum of all types of control packets sent during route discovery and route maintenance during data transfer. It includes RREQ, RREP, and RERR messages also.

Number of times link broke: As the name suggest, it is the number of times link broke during data transfer due to various reasons.

B. Parameters varied during experimentation

Different parameters like pause time, packet sent rate etc. affect the network performance. We have varied these parameters one at a time during simulations to analyze the effect on performance metrics mentioned in ‘A’ part of section IV.

Pause time: It is the time for which mobile node take pause while moving. It is expressed in seconds. In mobile ad-hoc network, a node may take a pause for some time while moving. It may happen that some of the mobile nodes stop while others are moving. This makes the situation complicated to analyze. Hence effect of pause time variation on two protocols is studied. Maximum value of pause time is kept to be half of simulation time.

Speed: It is the maximum speed of mobile node. Nodes are considered to move with uniform speed with a definite pause. Mobile nodes move with different speed in random directions. Hence link breakages occur more frequently. Due to this route rediscovery is carried out more often. This leads to decrease in packet delivery ratio and increased control overhead. Here we have varied maximum speed of mobile nodes to analyze effect of speed.

C. Simulation set up for pause time variation and speed variation

As shown in table 1, for pause time variation we have taken scenario with 100 nodes over a field size of 1500x1500 sq.m.; simulation is carried out for 300 seconds means for 5 minutes. Pause time is changed from 10 second to 150 seconds. For speed variation all other parameters are similar to earlier case of pause time variation except pause time is kept constant at 30sec while speed is varied from 10 to 30 mps. Results are discussed in next section. Linear battery model and user specified energy model are used.

TABLE I. SIMULATION PARAMETER DETAILS

Parameters varied	Pause time	Speed
Steps for pause time (s)	10,20,30,50,70, 100,125,150	30 (fixed)
Steps for Speed (m/s)	10 (fixed)	10,15,20,25,30
Routing protocols tested	AODV, EFAODV	AODV, EFAODV
Packet sent rate (packets/s)	1	1
Mobility model used	Random waypoint model	Random waypoint model
Number of CBR applications	35	35
Battery Model	Linear	Linear
Energy Model	User specified	User specified

V. Results and Analysis

Following results are obtained by varying pause time and speed of the mobile nodes. From fig. 2 & 4, we see that throughput of the network decreases with increase in pause time for EFAODV and AODV protocol. Throughput for EFAODV is higher compared to AODV for variation in pause time and speed as shown in fig. 2 and 4. Average end to end delay is steady for both protocols as shown in fig. 3 and 5. EFAODV has lower values of delay compared to AODV.

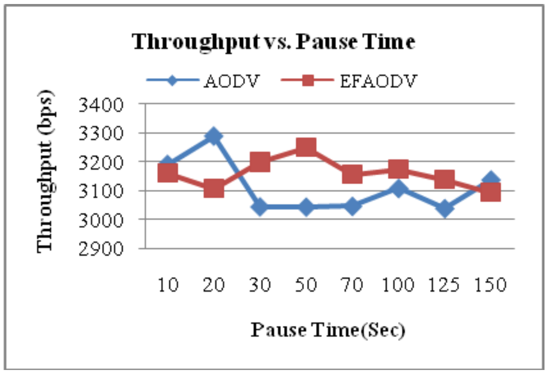

Figure 2. Throughput vs. Pause time

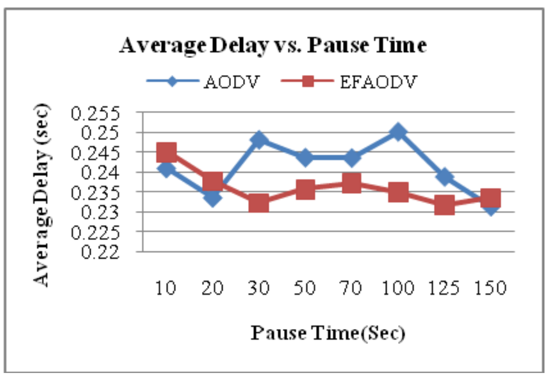

Figure 3. Average end to end delay vs. Pause time

For EFAODV, energy consumption and control overheads are lower than that of AODV protocol as shown in fig. 6, 7 respectively when pause time is varied. EFAODV performs better than AODV for higher pause time values. Since number of times link broken are lesser for EFAODV when pause time and speed are varied than AODV as shown in fig.8 & 11, EFAODV has given good results in terms of throughput, energy consumption etc. It indicates that as nodes tend to rest for more time while moving, EFAODV performs better than AODV. Increase in pause time of a node means nodes tend to more stationary rather than being more dynamic. We can see that EFAODV suites at almost all pause time values compared to AODV. With variation in speed, from fig. 5 and 9, EFAODV has lower average end to end delay and energy consumption except at the speed of 15mps. As expected we can see that the control overhead has decreased for EFAODV since the broadcast has been limited due to consideration of energy factor as shown in fig. 7 & 10. Number of times the link broke is an important parameter since we can decide which protocol is more stable while working at different speeds. As seen in fig. 8, less number of times links are broken for EFAODV compared to AODV protocol when pause time is varied. Similarly from fig. 11, it is clear that number of times link broke when speed is varied, are less for EFAODV protocol compared to AODV.

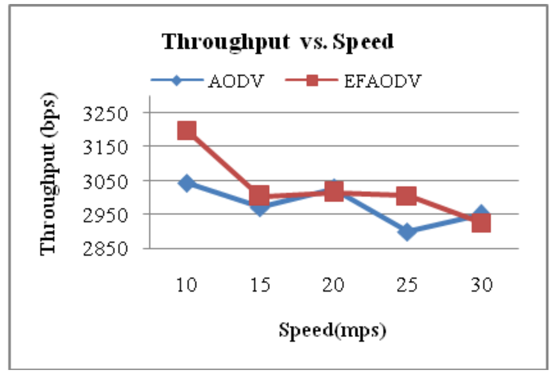

Figure 4. Throughput vs. Speed

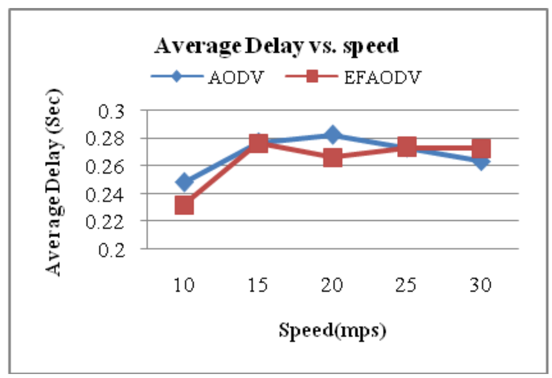

Figure 5. Avg. End to end delay vs. Speed

Due to consideration of energy factor at every node before that node participates in route formation, lifetime of routes has increased. As seen from fig. 11, number of times link broke goes on increasing for both protocols with increase in speed since the mobility affects existing links. Whereas the number of times link broke is steady with variation in pause time as shown in fig.8. Energy factor has made positive impact on number of times link breakages.

Pause time and speed of nodes are very important parameters in MANET, because they define mobility of nodes in MANET. EFAODV is working exceptionally better than AODV for these two mobility deciding factors. Hence we can say that EFAODV is working well for absolute mobile as well as stationary network situations.

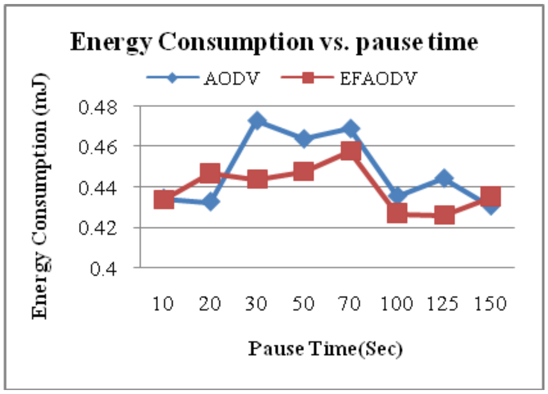

Figure 6. Energy Consumption vs. Pause time

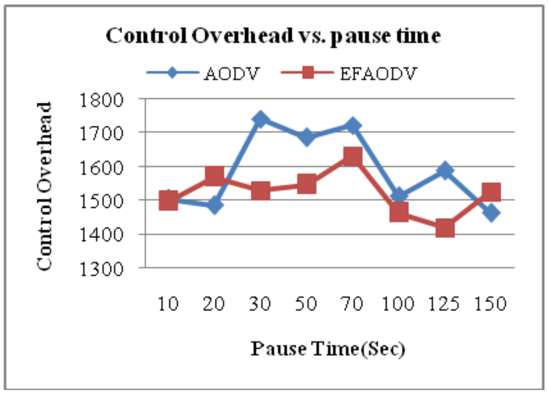

Figure 7. Control Overhead vs. Pause time

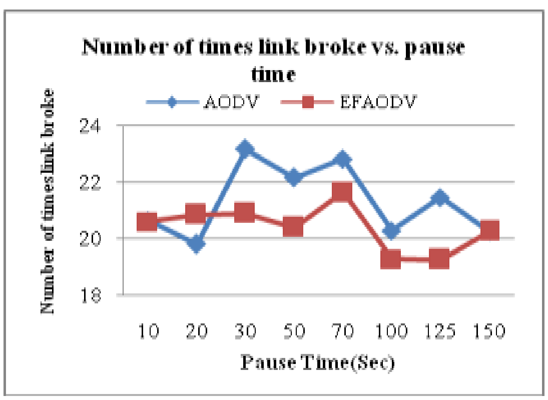

Figure 8. Number of broken links vs. Pause time

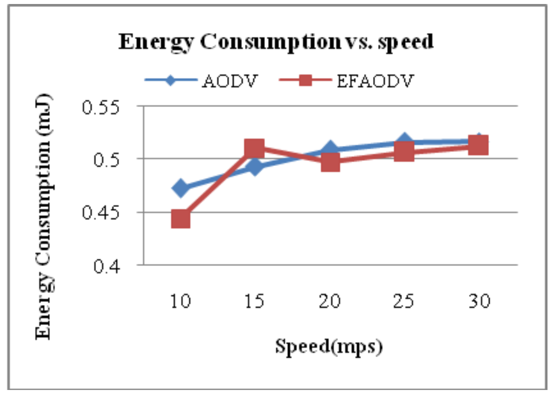

Figure 9. Energy Consumption vs. Speed

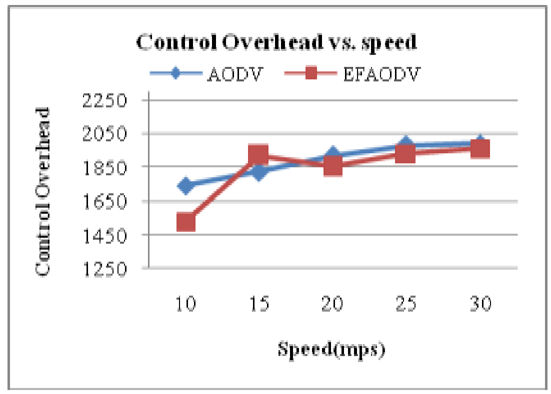

Figure 10. Control overhead vs. Speed

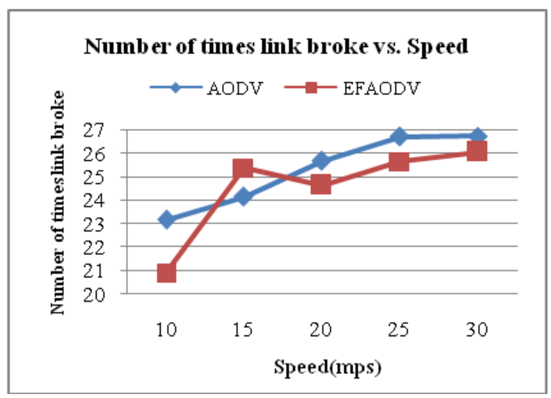

Figure 11. Number of broken links vs. Speed

VI. CONCLUSIONS

Consideration of residual energy of individual node is very crucial parameter in MANET, since every node act as a router. Link failure occurs if it is not considered during route establishment process and route rediscovery leads to increased energy consumption and control overheads. Energy factor of node at local level decides about participation in route formation in EFAODV. It doesn't require any control overhead. From results discussed in section V, EFAODV has significant performance improvement in all aspects of Quality of Service parameters over AODV. EFAODV has lower number of times link broke value for variations in pause time and speed compared to AODV proving stability of EFAODV protocol over AODV. More importantly pause time and speed which decide mobility of nodes and EFAODV has good throughput, lower delay and lower energy consumption in such mobile work conditions. Thus it can be concluded that EFAODV suites for MANET situations like highly mobile nodes.

VII. FUTURE WORK

Energy factor of individual node is currently compared with some independent threshold value. If this threshold is made dependent on network load then there is good chance of further improvement in EFAODV protocol.

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