INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Energy Efficient Ad hoc on-demand Distance Vector Routing Protocol (EE-AODV) for Mobile Ad-hoc Network

Saurabh Jain
Bachelor of Engineering (B.E), K. J. Somaiya College of Engineering, Mumbai University, Mumbai, India
Sneha Trivedi
Bachelor of Engineering (B.E), K. J. Somaiya College of Engineering, Mumbai University, Mumbai, India
Vidhi Shah
Bachelor of Engineering (B.E), K. J. Somaiya College of Engineering, Mumbai University, Mumbai, India
Prasanna Shete
Associate Professor, K. J. Somaiya College of Engineering, Mumbai University, Mumbai, India

Abstract:
MANET[1] (Mobile Ad-hoc Network) is a temporary network in which every node is free to move independently and communicate with each other without relying on any centralized system. During communication it is obvious that nodes will keep on losing its energy and finally drain off when there is no sufficient energy left to complete any operation. Thus, it becomes essential to take into account the nodal energy of each individual node before forwarding a Route Request packet. Several protocols have been defined in order to discover route between a pair of nodes out of which the performance of AODV [2] Routing Protocol proves to be better among other protocols. However there are drawbacks in it too, like it blindly forwards RREQ packets and none of the existing protocols have considered Node Battery to make a forwarding decision. Without an appropriate forwarding decision associated with each node, a fair amount of node battery is consumed. In this paper we propose a new protocol named Energy Efficient Ad hoc On-demand Distance Vector Routing Protocol (EE-AODV) which is an improved version of traditional AODV considering node battery as one of the parameter for making a forwarding decision. Performance differential is analyzed based on Throughput, End-to-End Delay, Jitter, Packet Delivery Ratio (PDR) and Residual Energy. Simulation of various scenarios was performed in Qualnet Network Simulator that concludes that the performance of EEAODV in terms of Network Lifetime is better than AODV at the same time having better Throughput and lesser Average End-to-End delay.

1. Introduction

As defined earlier that a MANET is a network of mobile nodes independent of a centralized architecture, they are free to move anywhere in the system. MANETs have some useful applications in military operations, emergency rescue operations, places where there is no preinstalled infrastructure-war and disaster zones, personal networking, etc. Mobile nodes such as Cell Phones, Laptops, PDA's, etc operate on batteries. The life of a node is directly proportional to the battery in the device operating at the node. During transmission of packets in a network, node energy is constantly consumed as long as the node is in the network and until it has not yet been drained off. Traditional AODV does not consider the node battery while finding an optimal path and blindly forwards RREQ packets while reduces the life of the nodes and thus of the entire network. Our proposed system first verifies whether the individual node has sufficient energy to participate in communication by applying a threshold. Secondly if this is not true each individual node will compare its Residual Battery with the Average Energy of the Network. The second control is important because we cannot discard a node based only on its energy since this node can be one of the vital nodes in the path between the source and the destination. When these controls are satisfied, it is only then that the node will forward RREQ packets to other nodes. If it does not have the required energy, it will discard that node and transmission is performed using other nodes in the network which has a fair amount of energy left. This will always ensure that the nodes with more amount of energy are taking part in routing and energy critical nodes conserve their energy.

The remaining paper is organized in the following way. Section 2 deals with Related Work in the context of optimizing traditional AODV. Section 3 briefly describes the working of traditional AODV Routing Protocol whereas Section 4 deals with the working of our proposed routing scheme i.e. EE-AODV. Section 5 is the Experimental Setup where we discuss the simulation environment. Section 6 compares AODV and EE-AODV. Further, Section 7 comprises of the conclusion of our proposed scheme. Finally, Section 8 contains the references that were required in order to have a better understanding of various concepts.

2. Related Work

In this section we introduce various optimization schemes to AODV to bring about efficient routing in Ad-hoc networks.

M. M. Chandane, S. G. Bhirud and S.V. Bonde have optimized the AODV Routing Protocol by considering two new metrics like Energy Cost to find energy critical sensor nodes and Energy Efficient Path. They proposed an efficient routing protocol named as Distributed Energy Aware Routing Protocol [6] (DEARP) for Wireless Sensor Networks. This approach generates routing paths in a decentralized manner. This scheme considers energy efficiency and available energy in each sensor nodes to avoid early power depletion. In this routing scheme, energy critical nodes do not take part in routing. Here, the energy critical nodes preserve their energy and are meant for sensing purpose. This delays energy depletion and thereby extends the network lifetime. In this approach, threshold value considered is 80% of the average energy value of the entire network for a node to make a forwarding decision. In each round of the routing process, this threshold value needs to be recalculated. Source and Destination node are not considered while considering average energy of the network since they are bound to participate in any communication. Using this optimization scheme they have successfully increased the lifetime of the network.

Another optimization scheme to the traditional AODV routing protocol was made by Jin-Man Kim and Jong-Wook Jang which focused to maximize the life time of the network [7]. The networks life time is increased by applying Energy Mean Algorithm by considering the node energy. A traditional AODV constructs a route path by using basic route discovery algorithms regardless of a node's energy status. In that case, energy consumption rises dramatically if a node holds many paths, which will force the node to fail to participate in the network. In order to extend the entire network lifetime by reducing the energy concentration on a certain node in the network and distributing it to the whole network, the energy of each node and the entire network should be considered. Their proposed system enhanced AODV considers energy remaining in the nodes participating in the path between the source and the destination. This information is then accumulated and added to the RREQ message using a new field added to the RREQ message (using 11 bits of the reserved filed). Now the RREQ receiving node does not send the RREP immediately but waits for a particular time and adds the energy of the nodes participating in the path. The mean energy of network on the participation path is obtained by dividing the whole energy calculated into the number of nodes participating in the network, which is obtained using the hop counter.

Also, the paper [8] gives a good understanding of various optimization schemes to the conventional AODV scheme which explained to us the extent to which optimizations can be carried out.

3. AODV

AODV [2] is a dynamic reactive routing protocol where the route discovery process is initialized only when there is a need to transmit the data from one host to another, but the valid route between them is not present. AODV does not maintain routing table for those nodes that are not a part of the communication. It is an improvement of DSDV [3] and DSR [4] that combines the properties of both. In the route discovery process of AODV, two important control messages namely RREQ [2] and RREP [2] are used. RREQ packets are flooded in the entire network until it reaches the destination where forwarding of RREQ stops and a reverse path to the source is established. Finally, the Data is delivered to the desired destination host using the forward path. This is shown in Fig. 3.1 and Fig. 3.2.

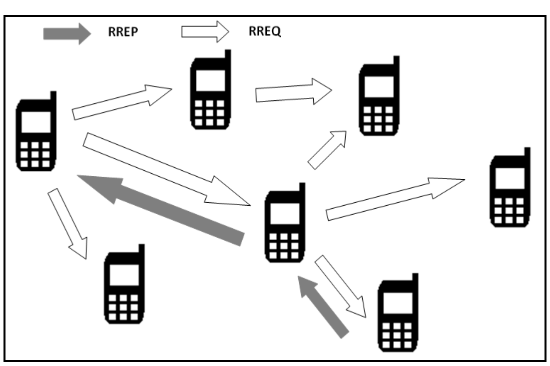


Figure 3.1

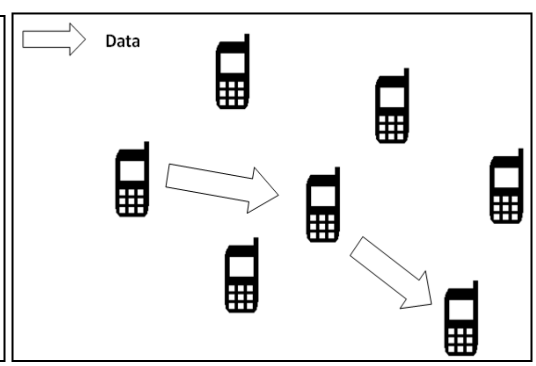


Figure 3.2

When a source wants to send message to destination, it will first check the route table to determine the existence of route. If the route exists in the routing table, data is transmitted through that route. Otherwise source node generates the RREQ packet with hop count initially set to zero. This RREQ packet is broadcast to the neighboring nodes of the source and eventually to each neighbor thereafter. Neighboring node may be the destination node or a node that has a route to the destination or an intermediate node. When a neighboring node receives the RREQ packet, it will first set the reverse path for the RREP and increase the hop count by one. RREQ packet checks whether the node has a route to the destination. Its stored route is valid only if the destination sequence number of stored route is greater than or equal to the destination sequence number of the received with less number of hop count. Else RREQ is forwarded to its neighboring node until destination or a route to the destination is received. If the source receives more than one RREP, it selects the one that have greater sequence number and less number of hop count.

4. EE-AODV

Traditional AODV routing mechanism uses the RREQ and RREP control messages for Route Discovery process. Thus, for any communication, a node broadcasts RREQ message to its neighbor. However, if the intermediate node does not have sufficient battery left to complete the two way communication, it may not be able to forward the RREP message on the reverse path. Hence, the source node would have to rebroadcast the RREQ message in order to search a path for communication to the destination node. This leads to increase in end-to-end delay of packets. This paper explains our research to find out how to extend the node lifetime by efficiently consuming limited battery in mobile nodes. Each node has a certain amount of initial battery assigned to it, in our case it is assigned to 10 mAhr (milli-Ampere hour). Our algorithm for EE-AODV extracts the individual Residual battery. The intermediate nodes in our scheme will not forward the RREQ packets instantly if there is a route to destination. Instead, it will first extract the residual battery for that node and secondly the Average Energy of the Entire Network. If the node receiving the RREQ has enough battery left only then it will forward RREQ's. We also introduce a Residual battery threshold, say Th. This threshold is calculated as fifteen percent of the initial battery.

- Threshold, Th = 0.15 * Initial-Battery
- AVG = Energy (Network) / No. of Nodes
- Following flowcharts explains our routing scheme:
- S: Source Node D: Destination Node

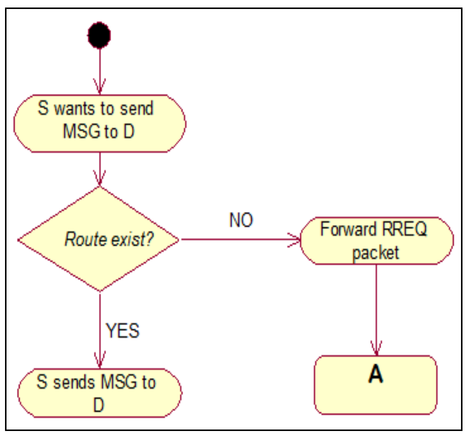


Figure 4.1: At Source Node

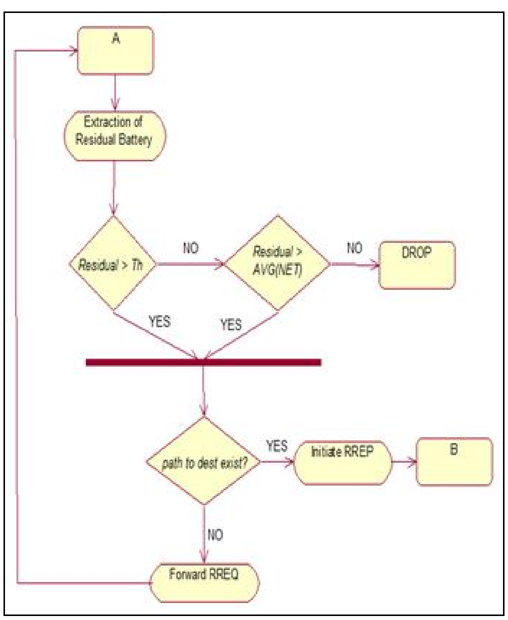


Figure 4.2: At Intermediate node

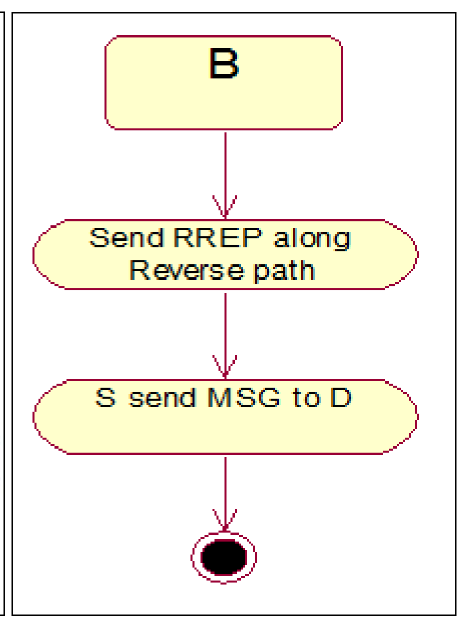


Figure 4.3: At Destination node

For a node to take a forwarding decision, it is important that it has energy greater than or equal to this Th. If the residual battery is greater than Th, it can be concluded that intermediate node has sufficient energy to forward RREQ message and will successfully reach destination node. If the residual battery is less than Th, the intermediate node checks whether it has energy greater than or equal to AVG. This control was important to apply since putting a hard control will not allow a node to communicate further in any of the communication even if that node might be a vital member in the path from source to destination. When these controls fail, the node will simply drop the RREQ packet and will save its energy by not participating in the communication. The above process is iterative until the broadcast is successful. This algorithm will help to decrease the unnecessary rebroadcasting of RREQ message and increases the node lifetime.

5. Experimental Setup

We have used Qualnet 5.0 Network Simulator to perform experiments and validate our scheme. For each and every scenario we have kept the number of nodes as 49 with varying data rates keeping the base rate as 32kbps and thereafter doubling it for subsequent scenarios. Nodes are placed using a grid layout of 49 nodes with 200m distance between adjacent nodes. The traffic used in each of the scenario between the source and the destination is CBR (Constant Bit rate). The simulation environment can be summarized in terms of a table as shown below.

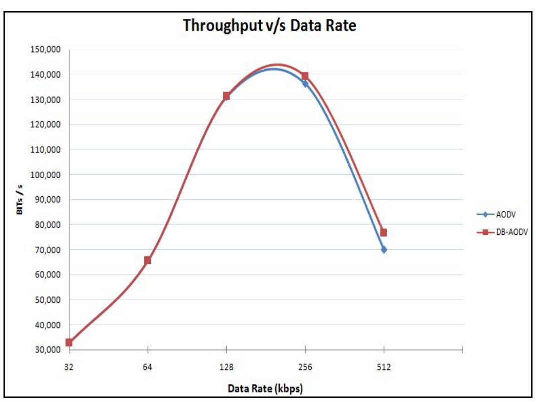
PARAMETER VARIABLE	PARAMETER VALUE
Channel type	Wireless Channel
MAC type	802.11
Battery model	Linear Model
Energy Model	MicaZ
Initial Battery	10mAhr
Area	1500 x 1500 cm
Number of nodes	49
Traffic	CBR
Payload Size	512 bytes
Interval between packets	Varying
Simulation Time	3 minutes

Table 5.1 Simulation Parameters

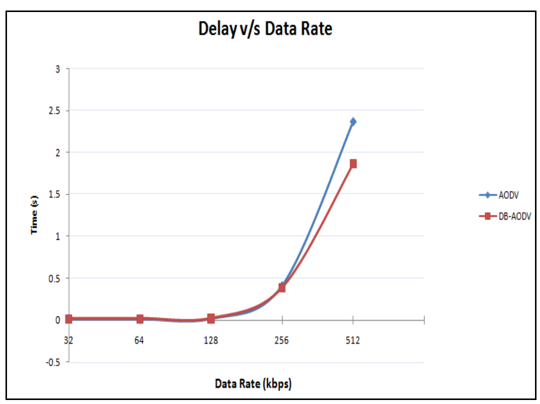
In addition to the above parameters some of the nodes in the scenario were marked as critical nodes. Some critical nodes were placed near to the source and destination to get better results and some of them where placed far away.

6. Comparison of AODV and EE-AODV

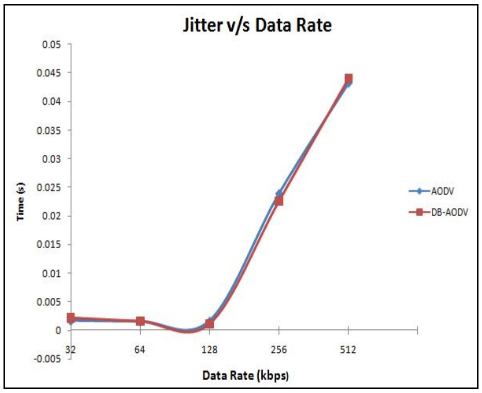
In this section, we evaluated results of EE-AODV with the AODV. We implemented these in Qualnet Network Simulator to check the effectiveness of our proposed routing scheme. Analysis of these two routing schemes is done by plotting graphs as shown below.

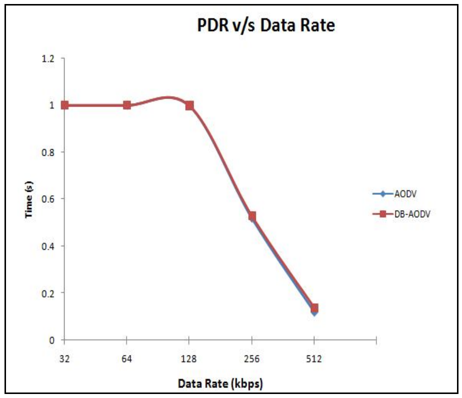


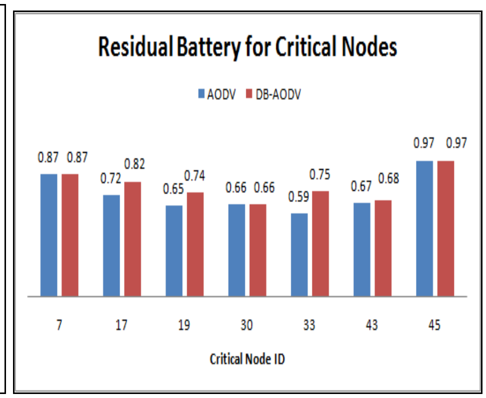
Graph 6.1 Throughput



Graph 6.2 End-to-End Delay







Graphs 6.1 Jitter
Graphs 6.2 Packet Delivery Ratio (PDR)
Graph 6.3 Residual Battery for Critical Nodes

7. Conclusion

This section talks about the effectiveness of our proposed routing scheme. From the results obtained in section 4, it is evident that EE-AODV has a better network at the same time having a better throughput and a lesser average end-to-end delay. From the above graphical results it is clear that when the data rate exceeds 128 kbps i.e. the saturation point for AODV, EE-AODV still performs well. Also, there is an improved Jitter and PDR. From Graph 6.5, it is clear that once the nodes become critical, it does not take part in routing and preserves its residual energy and hence are used for sensing purpose [7]. The nodes whose residual energy does not fluctuate much are those nodes that are placed away from the source and destination whereas the critical nodes nearer to the source and destination conserves their remaining energy by not forwarding RREQ's further. This avoids early power depletion of critical nodes, thereby increasing the network lifetime. In AODV, nodes keep on losing their energy irrespective whether the node is critical or not until the simulation is not over. In contrast, nodes in EE-AODV will first check its residual energy and only then it makes a forwarding decision. If it has sufficient energy, it forwards the RREQ to the next node; else it will simply drop any further incoming RREQ's. With this routing scheme the network lifetime is significantly increased. In addition, there is also a strong decrease in the average number of RREQ's forwarded by each node especially by the critical nodes which is an added benefit in our optimization scheme.

8. References

1. S. Corson, J. Macker, "Mobile Ad hoc Networking (MANET):Routing Protocol Performance Issues and Evaluation Considerations"
2. Charles E. Perkins, Elizabeth M. Royer, "Ad-hoc On-Demand Distance Vector Routing (AODV)", Proceedings of IEEE Workshop on Mobile Computing Systems and Applications, February 1999.
3. Charles E. Perkins, Pravin Bhagat, "Highly Dynamic Destination-sequenced Distance Vector Routing (DSDV) for Mobile Computers", Proceedings of ACM SIGCOMM, 1994.
4. C. Perkins & S. Das, "Ad hoc On-Demand Distance Vector (AODV) Routing Request for Comments (RFC)": 3561 July 2003.
5. David B. Johnson and David A. Maltz, "Dynamic Source Routing in Ad Hoc Wireless Networks", "A chapter in the book Mobile Computing", edited by "Tomasz Imielinski and Hank Korth, Kluwer Academic Publishers", 1996.
6. M. M. Chandane, S. G. Bhirud, S.V. Bonde, "Distributed Energy Aware Routing Protocol for Wireless Sensor Network", International Journal of Computer Applications (0975 – 8887) Volume 34– No.3, November 2011.
7. Jin-Man Kim and Jong-Wook Jang," AODV based Energy Efficient Routing Protocol for Maximum Lifetime in MANET", International Conference on Internet and Web Applications and Services, IEEE 2006.
8. Prasanna J. Shete and R. N. Awale, "Routing Protocols for Multi-hop Ad Hoc Networks: Operational Challenges and Design Optimizations", International Journal of Computer Applications (0975 - 8887) Volume 84 No. 5, December 2013.
9. Qualnet Network Simulator, Version 5.0.2, User's Manual and Qualnet Documentation.
10. http://www.scalable-networks.com