Effect of Node Mobility and Traffic to Energy Behaviour of Adhoc Routing Protocols

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Abstract
To prolong the network operational time, a lot of attention has been paid towards designing energy aware routing protocols. Selection of energy efficient routes, while minimizing the overhead incurred in the selection of the routes is the principal concern in designing energy aware protocols. Some existing energy aware routing algorithms can optimize the energy use. But there are certain limitations as the existing algorithms suffer with expensive overheads involved in collection, storage and exchange of the state information. These algorithms can be further refined in order to make them scalable. Wireless ad hoc networks usually depend on mobile battery operated devices that communicate over the wireless medium. These computing devices need energy conservation so that the battery life is enhanced. Since battery power is constraint, the wireless communication is the short continuous operation time of mobile terminals. Thus energy awareness is an important criteria for developing new ad-hoc routing protocols in Mobile Adhoc Networks (MANETs). This paper presents the mobility and traffic impact on energy consumption behavior of two adhoc routing protocols Adhoc On Demand Distance Vector Routing (AODV) and Dynamic Source Routing (DSR). Both of the protocols are simulated and compared over different network scenarios for various energy related performance parameters. Simulation results shows that for some of the parameters DSR is a better choice in terms of energy consumed and left after a simulation round but for some parameter like exhausted number of nodes AODV is a better choice.

Keywords
Routing, Adhoc networks, AODV, DSR, Energy, NS-2

INTRODUCTION
The power awareness is important [1,2,3] in ad hoc network/ routing protocol design, due to the limited energy of the battery operated mobile nodes of MANETs [4]. For design and development of routing techniques, initially the main considerations were Bandwidth efficiency and end-to-end delays. Now the power awareness has become the centre point of concern for ad hoc routing protocol design. Therefore, a thorough energy-based study of the performance of communication techniques, is required.

Some routing algorithms [5,6,7,8] can work while avoiding the proactive overheads required for topological information. Such on demand approaches are required for energy efficient routing. In this paper, only on demand protocols have been analyzed on the basis of their energy characteristics, so that selection of a better base protocol may contribute towards finding energy efficient routing paths.

In the literature [9,10,11] , a lot of work has been carried related to energy aware routing. Most of them modify some of the on demand routing protocol. Laura et al. [12] has proposed an Energy and Delay Constrained Routing in MANETs, where the route discovery phase includes energy saving and timely delivery of data packets. This algorithm utilizes residual energy and queue length at each node, buffer information as a traffic load characteristic and its use to limit the battery power consumption and end to end delay. Senouci et al. [13] has proposed three power aware extensions to the traditional AODV protocol, named Local Energy Aware Routing (LEAR-AODV), Power Aware Routing (PAR-AODV) and Lifetime Prediction Routing (LPR-AODV), for balanced energy consumption in MANETs. An Energy Efficient variant of AODV for low mobility adhoc networks was proposed by Chen et al. [14], in which the node energy consumption of the overall network is reduced by dynamic control of the transmission power through a novel route cost metric. These algorithms try to reduce the nodes energy consumption by routing packets using energy optimal routes. Chi Ma and Yuanyuan Yang [15] present a Prioritized Battery Aware Routing protocol (PBAR) based on a simplified battery model to measure the battery status. The protocol is sensitive to the battery status of routing nodes and can avoid energy loss. Authors have used the experimental battery data from actual laptop and cell phone to evaluate the performance of their protocol.

Considering the above work done on energy aware routing, it is observed that most of the energy aware protocols take existing on demand routing protocols as base protocols. Therefore, the selection of the base protocol is crucial to the optimality of the energy awareness. In this paper, a rigorous simulative analysis for AODV and DSR, two on demand routing protocol, has been done for different energy related parameters under varying network conditions, mobility and traffic load.

ROUTING PROTOCOLS USED FOR ANALYSIS
AODV and DSR are the base protocols that have been analyzed on the anvils of energy parameters. The following section discusses the working of these two protocols.

ADHOC ON DEMAND DISTANCE VECTOR ROUTING *(AODV)*
The Ad hoc On Demand Distance Vector routing protocol [16] builds routes between nodes only on demand. AODV sets up routes using a route request / route reply query cycle. When a source node wants a route to an unknown destination, it broadcasts a route request (RREQ) packet across the network. Nodes receiving this RREQ packet update their information about the source node and set up backwards pointers in routing

table to keep track of the source node. In addition to the other information like source node's IP address, the most recent sequence number for the destination of which the source node is aware of , is also contained within RREQ. A node may send a route reply (RREP) if it is either the destination or if it has more recent sequence number as compared to that contained in the RREQ. If this is the case, it unicast a RREP back to the source. Else, it rebroadcasts the RREQ. If any node receives a RREQ which it has already processed, it does not forward it and discards the RREQ. The nodes set up forward pointers to the destination, as the RREP propagates back to the source. Once the source node receives the RREP, the path has been set up and it may start to forward data packets to the destination. The source may update its routing information for a destination, if the source receives a RREP containing a greater sequence number or RREP with a smaller hop count.

The route will be maintained, as long as it remains active, that is, if the data packets periodically traveling from the source to the destination. Once the source stops sending data packets and it becomes inactive, the links will time out and eventually be deleted from the intermediate node routing tables.

If a link break occurs, the upstream node propagates a route error (RERR) message back to the source node to inform it about the now unreachable destinations. After receiving the RERR, the source node can restart route discovery, by using sequence numbers to ensure the freshness of routes. AODV has the advantages to be loop-free, self-starting, and it scales to large numbers of mobile nodes.

DYNAMIC SOURCE ROUTING (DSR)

Dynamic Source Routing [17] is another poular on demand routing protocol, in which routing takes place in two phases: route discovery and route maintenance. The key property of DSR is the use of source routing. During Route Discovery, a sender node sends a packet to a destination node and obtains a source route to destination. Route discovery is performed by flooding the network with route request (RREQ) packets. Each node receiving a RREQ packet, rebroadcasts it, unless it is the destination or it has a route to the destination in its route cache. Such a node replies to the RREQ with a route reply (RREP) packet back to the original source node. The RREQ builds up the path traveled across the network. The RREP routes itself back to the source by traversing this path backward. Route Discovery is used only when source attempts to send a data packet to such a destination, whose route is unknown. These paths are stored in a route cache. The data packets carry the source path in the packet header.

Route Maintenance is the mechanism by which source node is able to detect, if there is a change in network topology, such that it can no longer use its route to destination. If any link on a source route is loose out, the source node is informed using a route error (RERR) packet. The source wipes out any route using this link from its cache. A new route discovery gets started by the source if this route is still required. Acknowledgment packets are used to verify the correct operation of the route links. Dynamic source routing makes excessive use of source routing and route caching.

SIMULATION FRAMEWORK AND RESULTS

The Network simulator NS-2 [18] has been used to observe the energy behavior for AODV and DSR protocols with respect to the mobility of the nodes and traffic load on the network. Different Simulation parameters which are being used for a 50 node network over AODV and DSR protocols are shown in Table 1.

Table 1: Simulation Parameters

Simulation Area	1000 × 1000 m^2
Protocols used	AODV and DSR
power consumption for Transmission	1.6 W
power consumption for Reception	1.2 W
Speed of the nodes	1 m/sec to 15 m/sec
Number of sources	10-45
Network size	50
Energy supplied to each node	100 joules
Mobility Model	RWP
Data Rate	2 Mbps
Transmission Range	250 mtr.
Traffic Source	CBR
Packet size	512 byte

The results of the simulations performed on AODV & DSR, when the network consists of CBR traffic sources are presented in this section. The comparison of the two protocols with respect to varying speed of the mobile nodes for different performance metrics is as follows:

Total Energy Consumed

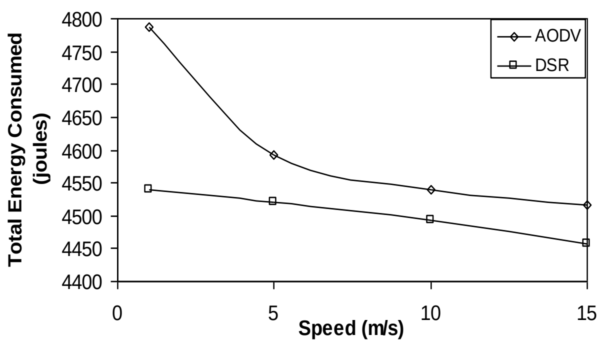

Fig 1: Total Energy Consumption against different speeds of the Nodes

Fig. 1 shows the energy consumption behavior of AODV and DSR protocols with varying speed when the initial energy supplied to the network in each scenario is 5000 Joules. It is observed that, AODV consumes more energy compared to DSR. Thus DSR is a better protocol in terms of energy consumption in varying mobility scenario.

Total Energy Left with the Network

Total Energy left is the total amount of energy left with the network after a simulation run. As depicted in the Fig 2, more energy is left with DSR protocol as compared to AODV. Hence, DSR is an energy efficient protocol as compared to AODV while mobility is varied from 1 m/sec to 15 m/sec..

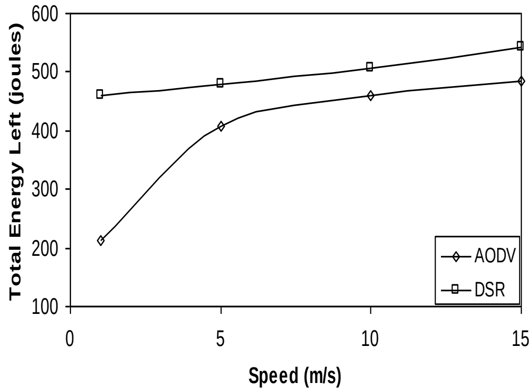

Fig 2: Total Energy Left vs. Speed of the Nodes

Number of Exhausted Nodes

This is the number of nodes that die-out at the end of each simulation.

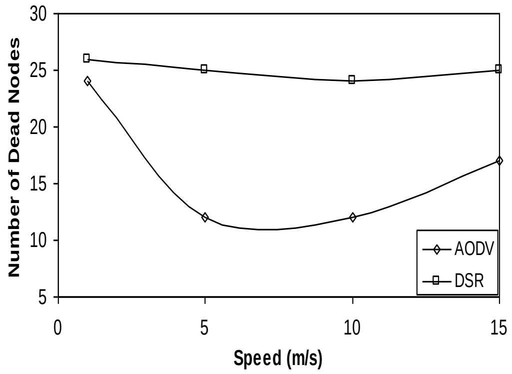

Fig 3: Number of Dead Nodes vs. Speed of the Nodes

Fig. 3 and Fig. 4 show the number of exhausted nodes for AODV and DSR after simulation with varying mobility and traffic respectively.

As shown in Fig 3 for the different values of speed, the average no. of dead nodes for AODV is less than that for DSR. At both high and low speeds AODV outperforms DSR.

It can be observed from Fig 4 that for varying numbers of sources, except moderate traffic, again AODV is a better choice as compared to DSR if number of dead nodes is the criteria of selection.

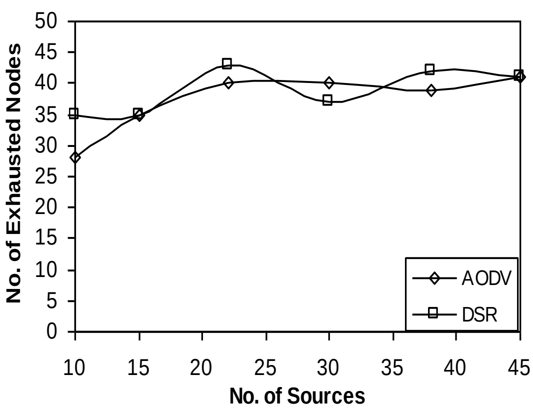

Fig 4: Exhausted nodes Vs Number of Sources for Pause time 0 seconds and 50 nodes

Average Energy Left per Live Node

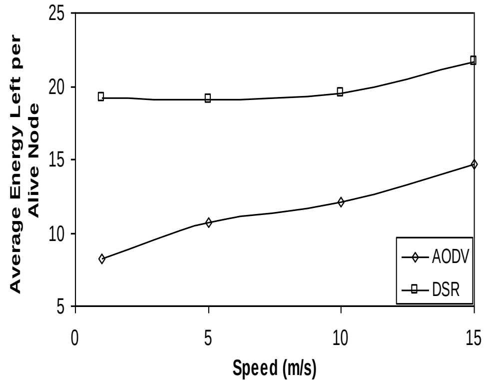

Fig 5: Average Energy Left per Live Node vs. Speed of the Nodes

This metric is calculated as the ratio of total Energy left with the network after each simulation run and the number of nodes active till the end.

It is observed in Fig 5, while varying speed, AODV has less energy left per node, on an average, compared to each node in DSR. Hence at different mobility DSR gives better results.

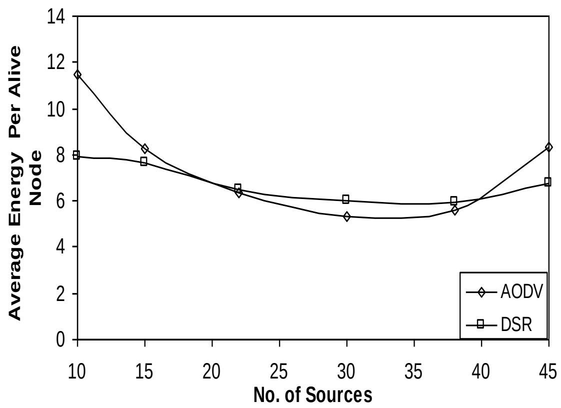

Fig 6: Average Energy per Alive Node Vs Number of Sources for pause time 0 seconds and 50 Nodes

In Fig. 6 a larger amount of energy is left per alive node in case of DSR for moderate traffic, when the nodes are moving continually. For low and high traffic, performamce of AODV is better than DSR for Average energy left after the simulation run.

Network lifetime

This is the time in seconds till half of the total number of nodes gets exhausted for a network.

Fig. 7 is representing the performance of AODV and DSR protocols for varying traffic. It can be seen in Fig 7 that for varying sources, DSR has a higher network life for heavy traffic while for lesser traffic AODV provides better network life.

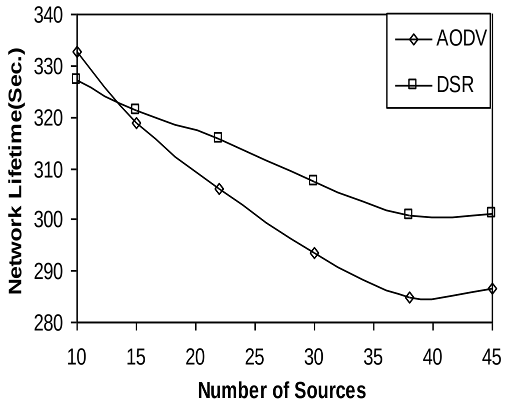

Fig 7: Network Lifetime Vs Number of Sources for pause time 0 seconds and 50 Nodes

CONCLUSION

Nodes in MANETs survive on their limited energy, so the energy conservation is an important issue on evaluating the performance of the adhoc routing protocols. In this paper, energy consumption based analysis of AODV and DSR protocols is done. This analysis is helpful to make a fair selection a base protocol for different network scenarios.

Performances of both the protocols have been measured in terms of various energy related parameters. It is observed through simulation results, that in an energy critical scenario, DSR is a highly energy efficient protocol for most of the considered parameters during simulation. AODV outperforms DSR in terms of total live nodes at the end of a simulation under varying mobility of nodes.

In this work, the emphasis is on evaluating the amount of energy consumed and conserved to route the same traffic using different protocols for varying mobility and traffic loads of nodes over Random Way Point Mobility Model only. However there are other mobility models over which the performance of these protocols can be evaluated. This will again be helpful for the development of upcoming energy efficient protocols.

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