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Effects of Nodes Mobility on the Energy Consumption of Routing Protocols (AODV, DSDV) in Adhoc Networks

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Abstract. Provision of routing mechanism is the elemental concern in adhoc networks. Various routing protocols have been devised and are in use. Quest for the best is in progress and have highlighted certain limitations associated to every protocol. Assessments of routing protocols by their performance in the usage of bandwidth, route selection, delay, packet delivery ratio and throughput have been the main concerns for researchers. Mobility of nodes is a very charming characteristic of adhoc networks, however, it has an allied issue that its nodes are mostly limited battery powered. Routing protocols have a definite influence on the overall energy consumption of the nodes. Energy consumption is an equally important concern to be addressed in evaluating the existing or developing new routing protocols. This research will evaluate two well-known routing protocols AOVD and DSDV on basis of energy consumption. The affects of nodes mobility on the energy consumption levels of these routing protocols will remain the main focus. All the simulations will be made in NS 2.35, and will have these two different scenarios *i.e*. adhoc network with static nodes and adhoc network with mobile nodes.

Keywords: adhoc networks, energy consumption, NS 2.35, AODV, DSDV

Introduction

Adhoc networks or mobile adhoc networks (MANETs) are mix of various kinds of portable and wireless devices, like palmtops and laptops, where these devices are located in such an arbitrary manner that nodes can change their interconnections randomly and frequently (Aggerwal *et al*., 2014). Adhoc network does not observe any core management as compared to broadly in using cellular networks such as Global System for Mobile Communications (GSM) (Ilyas *et al*., 2017). Briefly, Adhoc network is an assortment of wirelessly connected nodes where the topology may vary dynamically. Nodes themselves dynamically discover their counterparts to make a network, where they are wirelessly connected and form a casual topology (Perkins *et al*., 2008). The random movement of nodes is allowed in adhoc networks, which again can manage themselves randomly, thus allowing swift and unpredictable topology changes (Ade *et al*., 2010). Nodes of adhoc networks operate both as host and router simultaneously. Nodes within the range of transmission of each other can talk directly, while transmission through intermediate node takes place in a case out of transmission ranges nodes. Adhoc networks demonstrate some silent features like variable topologies, unfixed capacity links, bandwidth restrictions, constricted physical security and energy constrained procedures (Cano *et al*., 2000). These silent features are the reasons, that protocols devised for wired networks cannot be straight forwardly used in wireless networks (Omari *et al*., 2010). Mobility has changed the world of communication but a limited powered node is an allied problem. Nodes use their battery power to transmit information across the network and the quantity of energy utilized by these nodes depends on the design of routing protocols. One thing is clear, more information passed through a node, more will be the energy usage at that node. In such networks most of the nodes have inadequate storage, computational resources and energy and based on these restrictions, the type of routing protocol to be used is decided (Barati *et al*., 2012). Furthermore, in adhoc networks intermediate nodes are also used to ensure communication between the nodes which are out of transmission range of each other, resulting into extra usage of the energy of the overall

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network. Many protocols are in use in adhoc networks, and many researchers have worked on their performance based on throughput, delay, jitter and even energy, yet energy domain research cannot be considered ample. Further research is needed to lessen the energy exploitation of nodes in adhoc networks. This study is aimed to address the effects of mobility of nodes on the energy consumption of adhoc on Demand Distance Vector (AODV) and Destination Sequenced Distance Vector (DSDV) Routing protocols.

Adhoc routing protocols. Adhoc routing protocols can generally be categorized as proactive, reactive and hybrid routing protocols (Boukerche *et al*., 2011). Proactive protocols also called table driven protocols to retain the routes all the time among the nodes even in the condition when the routes are not presently in use (Kumar *et al*., 2012). Every node retains at least one but can be more, routing table to hoard the routing information. Routes updates are propagated in the entire network to retain consistency, in case of any variation in the network topology. Reactive protocols also called on demand routing protocols are entirely different kinds of protocols than proactive protocols (Kaur *et al*., 2012). These kinds of protocols create a route on the desire of the source. Whenever, a source node wants to communicate with a destination node, for which source has no route entry in the routing table, a route discovery mechanism is initiated. This process discovers all the possible routes between the source and destination. A route is selected based on certain parameters for communication between source and destination (Hong *et al*., 2002). There is another class of routing protocols called the hybrid routing protocols, which incorporate the flavours of both the proactive and reactive routing protocols. Zone routing protocol (ZRP) is an example of this class of protocols.

DSDV. DSDV routing protocol is based on distributed Bellman-Ford routing algorithm and belongs to proactive routing protocols (Vetrivelan *et al*., 2008). In DSDV, all the nodes of the network retain a routing table. The routing table contains the entries of all the possible destinations and routes and to differentiate the defunct routes from the latest ones, a sequence numbering mechanism is used. Periodic updates of the routing table are propagated in the whole network that keeping the routing table of each every node updated and consistent. The process of periodic updates creates massive control traffic in the network. DSDV uses two types of route update packets to lessen the affect. (1) Full Dump Packet that is propagated occasionally whenever there is an infrequent movement of nodes in the network. (2) Incremental Packet only conveys the information that has amended after the last time full dump had occurred (Ramesh *et al*., 2010).

AODV. AODV routing protocol belongs to the on demand or reactive routing protocols. It facilitates self initiating, dynamic and multi-hop navigation between the nodes desiring to uphold an adhoc network. AODV facilitates in rapidly acquiring the routes for fresh addresses and does not need nodes to store the routs that are stale. Although it is considered to be an augmentation of DSDV routing protocol, it is completely different because it's working is loop-free (Daas *et al*., 2015). It avoids the "counting to infinity" problem of Bellman-Ford Algorithm and offer fast convergence in case of topology changes of ad hoc network (Ilyas *et al*., 2017). AODV requires fewer number of broadcasts as compared to DSDV, because it creates routes on demand and it is totally different approach to that of DSDV. Using AODV, if a node wants to send a message to any node, but does not know the route to that destination node, route discovery mechanism is initiated to trace the destination node.

Related work. MANET routing protocols have been evaluated based on different parameters by many researchers, but evaluation of these protocols based on energy consumption finds comparatively less attention in the literature. Besides the scarcity of literature on this topic, the available literature has certain margins, like some of the researchers have discussed only those protocols that belong to the same group of protocols. Network density (number of nodes) has been a ground for a study (Barati *et al*., 2012), revealing that in terms of energy conservation the performance of AODV, DSDV and DSR is nearly similar in small networks. DRS and AODV performance was better in medium and large sized networks, while TORA was found incompetent. The researchers in (Mekhlafi *et al*., 2011), studied Routing Information Protocol (RIP) from proactive group and DSR form reactive group of protocols based on energy consumption along with other parameters. Only the number of nodes was changed for energy studies, which showed that RIP is better than DSR. Energy usage of only reactive protocols has been studied (Kanakaris *et al*., 2010), using average usage of energy and routing usage of energy as parameters for evaluation. The results of the study reveal that energy usage has firm relation to the factors employed in the simulations. Further, it concludes that in energy conservation DSR performed well in low and high load networks, while AODV was better in static network. A detailed study to some extent has been made (Rouidi *et al*., 2016) of two protocols selected from each group of proactive and reactive protocols. Their study concludes reactive protocols better than proactive protocols in terms of energy conservation in high traffic load and mobility.

Simulation environment. This part of the text describes the setup of experimental work and the results obtained from the simulations. Ubuntu 16.4 a LINUX distribution is installed on a virtual box to use as an operating system due to reason that the simulation software is highly stable in LINUX environment (Issariyakul *et al*., 2009). The final version of Network Simulator with the name NS2.35 is used for the simulations because it runs efficiently over Ubuntu 16.4.

Simulation setup. To achieve the goal of this research work, the general parameters shown in table 0.1 were set. Depending on the scenarios some modifications were made, like for 1st scenario, the nodes were kept static or with mobility between 0 to 2 meters per second. The speed of nodes was changed by 5 meter/second during different phases of study in 2nd scenario.

Energy model. Energy utilization is a very imperative parameter in evaluating the adhoc networks protocols. Every node consumes certain amount of energy while it is part of some network. Assessment of routing protocols in terms of energy utilization certainly needs some kind of energy model. In such a model every node has a predefined energy level and also defines the factors involved in energy consumption. The energy model has been designed and incorporated in Network Simulator (NS2). This model enables all the nodes to be assigned a certain fix level of energy at the start of the simulation (Kumar *et al*., 2016). It reads the node's energy during the simulation and informs the nodes about their instantaneous level of energy. The energy related parameters set for simulation work are shown in Table 2.

Table 1. Simulation parameters

Protocols	AODV, DSDV
Topology area	680 m x 680 m
Mobility model	Random waypoint
Propagation model	Two ray ground
Type of antenna	Omni directional
Simulation time	250 seconds
Number of nodes	Different in different case studies
Simulation area	680 m × 680 m
Speed	0,1,2,3,4,5,10.15.20,25,30 m/s
Mobility model	Random waypoint
Traffic type	Transmission control protocol (TCP)
Application type	File transfer protocol (FTP)
Packet size	1500 bytes
No of connections	Varies in different cases
Range of transmission	250 m
Range of interference	550 m

Table 2. Energy parameters

Initial energy	100 J Per node
Transmit power	900 m W
Receive power	700 m W
Idle power	600 m W
Sleep power	100 m W

Results and Discussion

We are analyzing the energy consumption of nodes while they are static or nearly static (very low speed) and moving (relatively high speed). The whole process was divided into two scenarios and is discussed below.

1st Scenario. Although mobility is an elemental property of MANET, but to investigate the effect of mobility over energy consumption in nodes by routing protocols I was decided to make the nodes' static in first scenario. Static means either complete still or moving with speed of a meter or two per second. An adhoc network with any number of nodes simulated with different routing protocols can lead us to find under which protocol the nodes are consuming more or less energy. As we cannot change the speed of nodes in this scenario to a greater extent, so another factor the network density in terms of a number of nodes was also involved in this investigation.

Figure 1, shows the relation of a number of nodes to the residual energy of nodes, but number of node is not of elemental concern in this figure. We are concerned with the residual energy of nodes in case of AODV and DSDV. Residual energy values of most of the nodes are a bit higher than that of AODV.

Rather than individually plotting each graph for different network densities, a combined result is generated in Fig. 2. It shows that for network densities between 5 nodes to 15, the residual energy levels of nodes for AODV and DSDV are nearly same. When the network density increases beyond 15 nodes the residual energy levels nodes for DSDV are a bit higher than that of AODV. This gap becomes more visible as the number of nodes increases.

Figure 3a good realization of the energy consumption parameter. It depicts that the average energy consumption of nodes with routing protocol DSDV is lower than AODV. Furthermore, it shows that average energy consumption decreases for both protocols as the density of the network increases. This decrease in average energy consumption is more in DSDV as compared to AODV.

2nd Scenario. This investigation scenario is based on adhoc networks with the same network density in terms of number node, but the elemental factor of mobility in terms of node's speed is addressed. Considering the network density, in this case, will change the domain of this research work that is why it is left for future work.

Figure 4 is the realization residual energy of nodes with routing protocols AODV and DSDV concerning speed of nodes. It is clear in the first scenario that AODV consumes more energy when the speed of nodes is approaching to a static condition. Five meter/sec is not a speed approaching to the static state of nodes. The

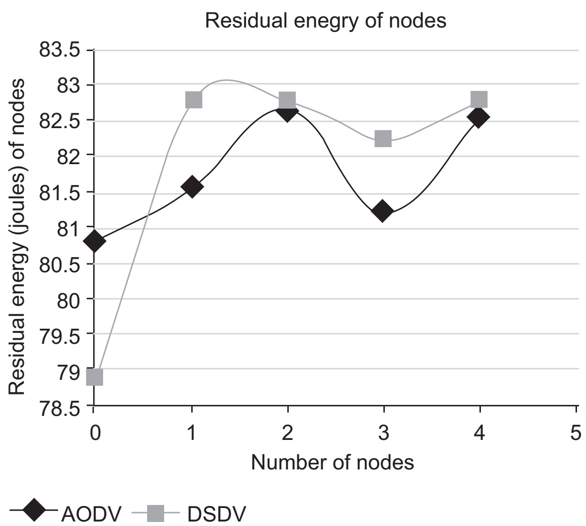

Fig. 1. Residual energy of nodes (1st scenario).

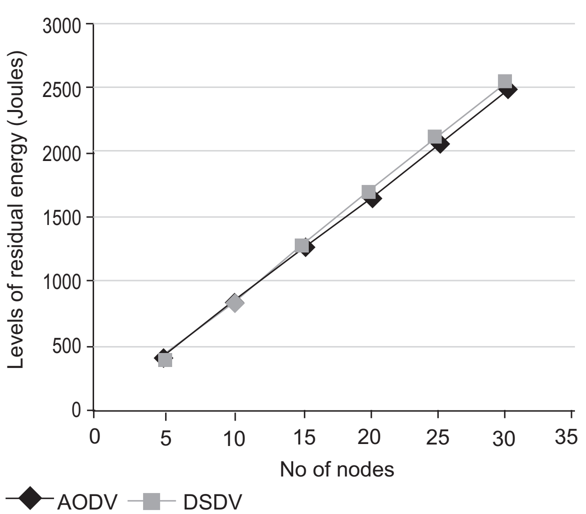

Fig. 2. Comparison of total residual energy (1st scenario).

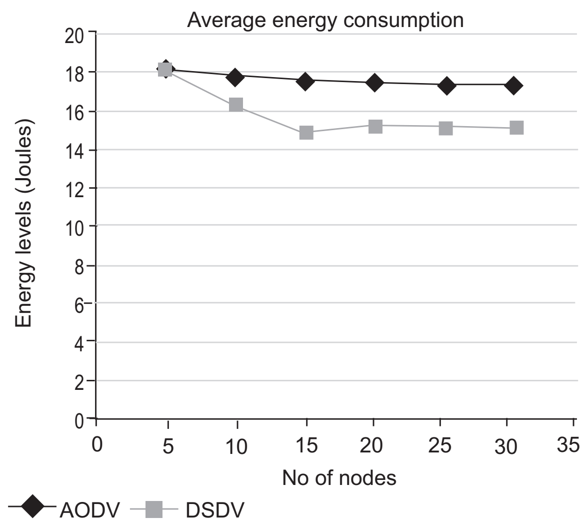

Fig. 3. Average energy consumed per node (1st scenario).

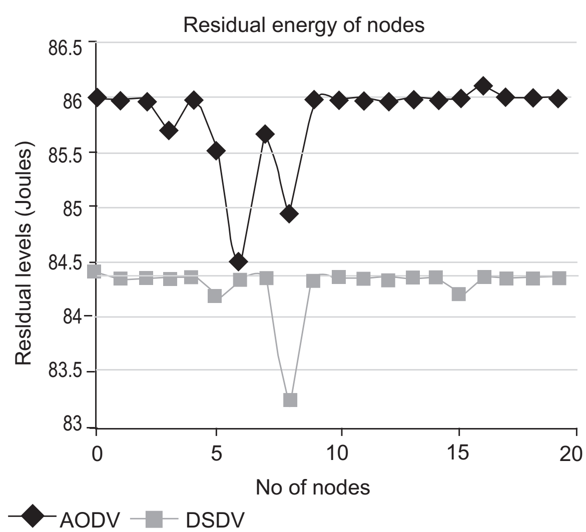

Fig. 4. Residual energy of nodes with speed 5 m/s.

result obtained for a node speed of five meter/ second depicts that routing protocol as AODV, the nodes are retaining more energy as compared to the nodes with routing protocol as DSDV.

It is clear from Fig. 5 AODV remains at the upper side of performance in terms of lower consumption of energy. The network running on AODV protocol retains more energy as compared to a network that is running on DSDV. Further, it is depicted that at low speeds the network running over AODV is retaining more energy, and this value of residual energy decreases as the speed of nodes increases. At lower speed of nodes a network with DSDV as routing protocol have higher residual energy compared to increasing the speed.

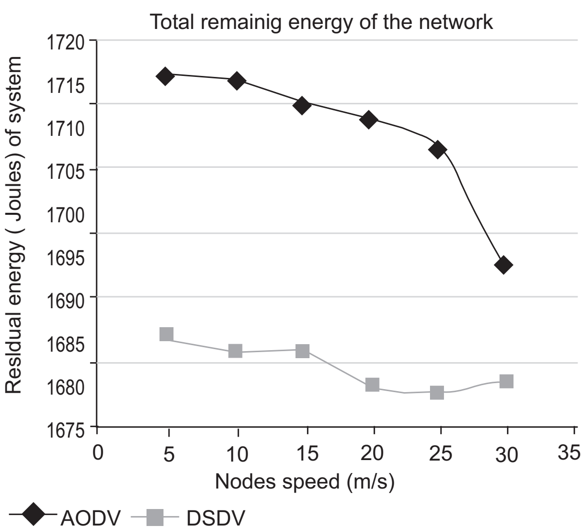

Fig. 5. Total remaining energy of network with different node's speed.

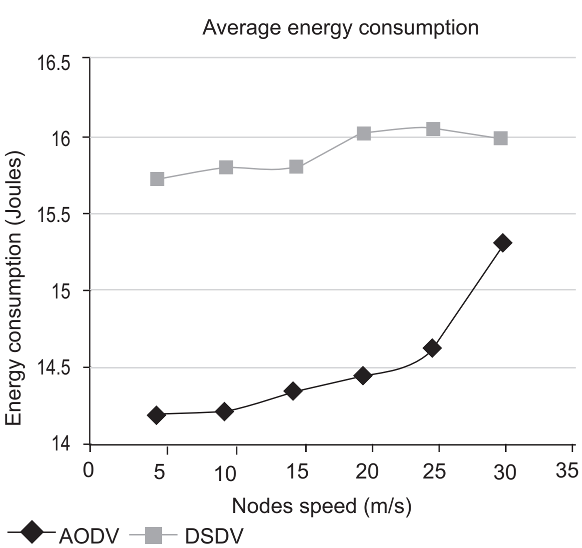

Fig. 6. Average energy consumption per node with a speed change of 5 m/s.

Finally, Fig. 6 is would help us to conclude the 2nd scenario. It shows that with a speed change of 5 m/s the nodes in case of DSDV are consuming more energy as compared to AODV. Furthermore, it is depicted that this energy consumption of AODV is increasing more vigorously compared to DSDV. Although the energy consumption of DSDV remains more all the time than AODV, but a vigorous change in energy consumption with increasing speed is not noted.

Conclusion

Adhoc networks with low mobility or complete static nodes and governed by DSDV the nodes consume less amount of energy compared to the nodes in similar networks but with AODV as routing protocol. This difference of residual energy between the two protocols is not big enough to conclude one of them is better than other. It can be stated that both AODV and DSDV performance in terms of energy usage is comparable in Adhoc networks with complete static nodes or even low mobility. In mobile Ad hoc networks (MANETs) the picture becomes clearer and AODV comes out to be a better protocol in terms of less energy consumption than that of DSDV. However, with increasing node speed the energy consumption of DSDV shows consistency although it is higher than that of AODV. The vigorous increasing difference has been noted in the energy consumption of AODV with increasing node speed.

Conflict of Interest. The authors declare no conflict of interest.

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